TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

JOONA KUNNARI

TRACK & TRACE SOLUTION FOR ROAD CARGO IN PAPER INDUSTRY

Master of Science thesis

Examiner: Assistant Professor Heikki Liimatainen
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ABSTRACT

JOONA KUNNARI: Track & Trace Solution for Road Cargo in Paper Industry
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The purpose of this thesis was to find out what is the most suitable track & trace solution for road cargo in paper industry. The research objective was to propose a solution or technology that provides the data and information according to the requirements. The customer organization was UPM, a global forest industry company leading the forest-based bioindustry by creating new and sustainable bio-based businesses and products.

Both theoretical and empirical research was conducted to reach the research objectives. The research was conducted as a pragmatic, mono method qualitative study. The theoretical research was a literature review which focused on track & trace solutions. Existing track & trace solutions were researched, and their features, advantages and disadvantages were listed. In addition, supply chain and supply chain management were studied. Empirical research was conducted through semi-structured interviews. Three persons from the customer organization participated in the interviews. The main discussion topics were the information needs of the customer organization, and the benefits they expected the solution to bring. Analysis of the interviews was conducted inductively, and results grouped on the high level by research question themes. The themes were identified and findings from the theoretical and empirical researches were compared and combined. Based on the findings, conclusions were made, and the research questions were answered.

The customer organization's requirements for the track & trace solution were solved, as well as the existing solutions on the market today. It was found that the most suitable solution for UPM would be a cloud-based mobile app that provides real-time location data, and that that can keep them up with the digitalization. The solution's technology should be based on GPS & GSM. Other communication technologies are also possible, but GSM has been proved to be very reliable. This kind of solution could be later on developed to an Internet of Things solution. Later they could add other data collection technologies to the service, and as the technology develops other analyzing methods could be taken into use as well. The solution should also be custom-made according to UPM's needs and preferences. It is a lot easier to develop the solution if it is made according to their needs, and the integration to their existing systems will be easier. Also, they are not tied to certain carriers if they develop a solution that carriers just take into use, rather than integrating into certain carriers' fleet management systems. A custom-made solution might be more expensive than integrating into an existing one, but the benefits are greater.

TIIVISTELMÄ

JOONA KUNNARI: Paperiteollisuuden tiekuljetusten seuranta ja jäljitys
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Tämän diplomityön tarkoitus on löytää sopiva paperiteollisuuden tiekuljetusten jäljitys- ja seurantaratkaisu. Työn päämääränä on ehdottaa ratkaisua tai teknologiaa, joka tarjoaa vaatimusten ja toiveiden mukaista dataa ja informaatiota. Asiakasyritys työssä on globaali metsäteollisuusyhtiö UPM, joka kehittää uusia ja kestäviä biopohjaisia tuotteita.

Tutkimus toteutettiin teoreettisesti ja empiirisesti. Tutkimus suoritettiin pragmaattisena yksimetodisena kvalitatiivisena tutkimuksena. Teoreettinen tutkimus oli kirjallisuuskatsaus liittyen jäljitys- ja seurantaratkaisuihin. Työssä tutkittiin nykyisiä jäljitys- ja seurantaratkaisuja sekä niiden ominaisuuksia, hyötyjä ja haittoja. Lisäksi tutkittiin toimitusketjua ja toimitusketjun hallintaa. Empiirinen tutkimus sisälsi puolistrukturoituja haastatteluja. Kolme asiakasyrityksen työntekijää osallistui haastatteluihin. Aiheina olivat asiakasyrityksen informaatiotarpeet ja hyödyt, joita he odottavat ratkaisun tuovan. Tutkimuksen analyysi tehtiin induktiivisesti ja tulokset ryhmiteltiin tutkimuskysymysten teemojen mukaan. Teemat tunnistettiin ja empiirisen tutkimuksen löydöksiä vertailtiin ja yhdistettiin teoreettisen tutkimuksen löydöksiin. Näiden löydösten perusteella johtopäätökset saatiin tehtyä ja tutkimuskysymyksiin vastattiin.

Asiakasyrityksen vaatimukset jäljitys- ja seurantaratkaisusta selvitettiin. Lisäksi markkinoilla tällä hetkellä olevat ratkaisut tutkittiin. Työssä saatiin selville, että paras mahdollinen ratkaisu UPM:lle olisi pilvipalveluun pohjautuva mobiilisovellus, joka tarjoaa reaaliaikaista paikannustietoa ja pitää heidät digitalisaation tasolla. Ratkaisu voisi pohjautua GPS- ja GSM-teknologioihin. Myös muut viestintäteknologiat ovat mahdollisia, mutta GSM-teknologia on todettu hyvin luotettavaksi. Tällainen palvelu voitaisiin myöhemmin helposti kehittää eteenpäin esineiden internetiin pohjautuvaksi ratkaisuksi. Teknologian kehittyessä he voisivat myöhemmin lisätä palveluun erilaisia datan keräys- ja analysointiteknologioita. Palvelu olisi hyvä olla räätälöity täysin asiakasyritykselle heidän tarpeiden ja mieltymysten mukaan. Palvelua on jatkossa huomattavasti helpompi kehittää, jos se on tehty pelkästään heitä varten. Myös integraatiot heidän omiin nykyisiin järjestelmiin on helpompi toteuttaa täysin uuden palvelun pohjalta. Lisäksi he eivät ole sidottuja mihinkään kuljetusyritykseen, jos he kehittävät oman ratkaisun, sen sijaan, että integroituisivat joidenkin kuljetusyhtiöiden kalustonhallintajärjestelmiin. Heille räätälöity palvelu on todennäköisesti kalliimpi vaihtoehto kuin integroituminen johonkin olemassa olevaan, mutta hyödyt ovat räätälöidyssä palvelussa huomattavasti suuremmat.

PREFACE

Writing this thesis has been a challenging process at times, and the planned timetable has changed many times. Writing a thesis and working at the same time was not the best choice that was made. However, the process finally reached an end with the support from many persons.

I would like to thank Sari Karppala and Antti Ilovuori from UPM for this opportunity and their guidance during the research. Especially with Sari's help, the topic and scope of the thesis were defined in a way that it would support UPM's objectives and expectations. They have also provided ideas and support throughout the process, and helped to find and contact the interview participants. I would like to thank the interview participants for their contribution to this thesis.

Assistant Professor Heikki Liimatainen from Tampere University of Technology has also provided ideas and support throughout the process. I greatly appreciate the help and would like to thank him for this.

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Joona Kunnari

CONTENTS

1. INTRODUCTION

1.1 Research background and topic

One definition of supply chain management (SCM) is that the right item is in the right quantity at the right time at the right place at the right customer for the right price and in the right condition (Mallik 2010). However, because of the uncertainty, complexity, and other factors involved, many of the real supply chains have mismatch problems related to supply-demand. Such problems are overstocking, stockout, and delivery delays which have long been popular research topics in the business management literature (Wong et al. 2012).

In the era of globalization, supply chains and especially logistics, plays a very important role. Globalization has caused supply chain networks to become more and more complex. Logistic and transportation professionals have to deal with multiple channel partners who may be located far away from each other's and who request a greater diversity of products than earlier. Hence, the fulfillment of customers' demands with good quality products, on time product delivery and top-quality logistics services becomes difficult to reach. Enterprises have usually taken into use different approaches that help them to manage the supply chain activities such as production scheduling, material sourcing, warehousing and distribution of products. (Poon et al. 2009, p. 8277.)

Kaihara (2003) and Liu et al. (2005) say that a supply chain is a dignified information sharing channel used by all the different parties: suppliers, production, warehouses, distributors and customers to ease the key business operations of the sale, production and delivery of products. Although, supply chain management's main basis is to integrate efficiently the material flows and all information related to them to the supply and demand processes (Soroor & Tarokh 2006). Hence, as the supply networks expand globally, enterprises need to work together with customers, suppliers and even competitors in different time zones and cultures across multiple organizational boundaries. It is overwhelming to manage the allocation of inventory, production and transportation resources to satisfy the demand within these conditions. (Simchi-Levi et al. 2004.)

When supply chains become more and more complex and challenging, companies need to introduce services, mobile solutions and applications that satisfy many similar goals. Areas of product integrity and visibility, risk reduction and compliance must be affected by companies. At the same time, they need to keep their supply chains running smoothly and at full speed. Tracking and tracing the goods and assets in-transit improves transparency and visibility of the supply chain. Nowadays the ability to track and trace prod-

ucts is necessary to flawless and solid supply chain management. Traceability helps the company to improve their supply chain's efficiency, product safety and security. It also allows them to manage risks on all levels, on-time delivery performance, troubleshooting of customer issues, and regulatory compliance. (He et al. 2008, p. 1364.)

He et al. (2008, p. 1365) noted in 2008 that more and more companies are demanding the track and trace of items and products because of its ability to improve efficiency, visibility and transparency. However, IBM (2017) claims that nowadays less than half of companies currently track their assets, even though logistics is still one of the costliest aspects of global trade. Although, by investing in tracking and tracing, companies could lower the cost of logistics because it would, for example, increase the transparency of the supply chain. When the recipient knows where their product is and if it is delivered on time, it grows their confidence towards the company and the delivery experience. It does not matter if the recipient is a consumer or a business. In business to business (B2B) deliveries, transparency not only reassures the customer, but it also streamlines the work processes of supplier and customer. (Consignor 2016.)

It is critical for B2B customers to receive their deliveries on time, so that they can carry out their daily operations. Therefore, it benefits the recipient if they can track the shipment, since then they are able to plan their operational activities in respect of the delivery time, and also see if the shipment is delayed, lost or damaged. It also allows the supplier to start proactive measures in case something happens to the shipment. In the best case, the actions have been carried out before the customer even notices that something has happened. Tracking & tracing increases customer satisfaction but it also decreases the supplier's workload as there are fewer customer inquiries regarding shipments. The increased transparency gives the supplier an advantage when they negotiate agreements with their carriers. This way track & trace not only benefits B2B customers, but equally the supplier himself. As the demands on logistics and delivery increases, track & trace should be an integral part of all deliveries both in business to business and business to consumer. (Wong et al. 2012.)

Many companies have outsourced their transportations and logistics operations. They may use even hundreds of different carriers to deliver their products to customers. In such a case, it might be very time consuming and hard for a company to track shipments since the data is coming from various different carriers. However, there are cases showing that it is a lot easier to manage this issue if the company invests in a shipping system that gathers all the tracking data in one place. The data needs to be standardized, sorted, visible and usable. A centralized platform or system enables these requirements. Naturally, the system should be integrated into the company's information systems, including warehouse management system and enterprise resource system. This allows a centralized way to manage the data, and also allows all the necessary employees to track their deliveries from one place throughout the supply chain. It is most useful to track the products in real-time. Of course, it is not always possible to do that. In addition, many

companies do not even need the real-time data due to various reasons. But nowadays tracking the products in real-time is easier than ever before, mainly because of the rise of the Internet of Things (IoT). (Wu et al. 2016, pp. 395-396.)

Extraction of data in real time, or at least near-real time, has been a challenge for transportation and logistics companies, especially the ones that are global. In order to solve this, low-cost, connected devices and more sensors are needed. They will enable real time asset tracking. The Internet of Things might be a solution to this problem. Of course, there are also other ways to track products and assets, but the IoT provides a totally better solution for this issue. The Internet of Things is a system where mechanical and digital machines, computing devices, objects, animals or people are related to each other. All of them have unique identifiers and they are able to transmit data over a network without interacting (a human-to-human or human-to-computer). A thing in the Internet of Things can be, for example, a person with a sensor monitoring the health, a refrigerator that informs when it is empty, a car that alerts the driver and the maintenance service when the scheduled or spontaneous maintenance approaches. It can also be any natural or manufactured object with an IP address and which can be provided with the ability to transfer data over a network. IoT has emerged when wireless technologies, micro-electromechanical system, the Internet and microservices got closer to each other. This has helped to break the boundaries between information and operational technology, allowing unstructured data generated by machines to be analyzed for insights that will lead to improvements. (Witkowski 2017.)

IoT is a technology that can give the most to supply chains. Shipments can be traced throughout the delivery process, which speeds up implementations. IoT can work proactively when the stock is low and place orders to restock products automatically. Equipment monitoring can also be used to predict when service and maintenance is needed. Every party of the supply chain need visibility and access to accurate, up-to-date information at every point along the way. That information is required to optimize the processes of logistics and transportation. Internet of Things will improve visibility of products in the supply chain, enabling supply chain managers to see data for products, materials handling equipment, vehicles, and warehouses from any device, such as Global Positioning System (GPS) and Radio Frequency Identification (RFID) readers. These devices have been used in tracking and tracing before the term IoT was invented. They are just enhanced by advanced technologies, sensors, and a strong informed supply network, which give businesses the ability to predict, correct, and even prevent problems such as inventory outages, failed equipment, safety hazards and late deliveries before they occur, keeping their supply chains running at optimal efficiency. (Johnson 2016.)

With the help of IoT, business areas like operations and finance can gather new type of data and benefit from it. Informed decision making, and improved customer experience can be gained by the insights that IoT brings. All of this brings us to business intelligence. The quality and quantity of data plays a huge role in the gained insights. They

define how good the insights are. Earlier, logistics goals were to deliver the products as expected and on time. Nowadays, Internet of Things allows real time tracking of all products and assets such as containers, machinery, fleets and so on. This leads to improved quality of data and ultimately to improved quality of decisions. The data about the device itself, equipment status and performance can be improved as well. This way routes can be optimized, and maintenance of machinery and fleets can be predicted. So, IoT will not only bring better visibility to supply chain and enhanced customer service, it will also bring savings when the vehicles and assets are maintained on time and used as optimized. (Gordon Wood 2017.)

Many industries are already benefiting from track and trace utilization with more and more industries and companies joining every day. It is already in use, for example, in car manufacturing, medicine, security, retail and construction industries. However, transportation and logistics is the most important area for tracking and tracing solutions. The main reason is that the benefits are massive. (Wu et al. 2016, p. 397.) As the world has globalized, it is extremely important that companies have transparent operations and supply chains. Before companies invest in track and trace solutions, they need to determine what they want to accomplish by defining the data they need to collect. Failing to define this will most likely lead the entire initiative to fail. After the first investment has been done, it is possible to modify the solution afterwards, so it is not necessary to build the whole solution in one go. (Radishofski 2008.)

Companies, especially in the logistics sector, are becoming more and more aware of the benefits of tracking and tracing. The greatest benefit most probably is that the efficiency of supply chain will grow considerably. Identifying waste areas is a lot easier if materials and products can be followed through the supply chain and plant. It creates big cost for manufacturers, and by pinpointing those problem areas the entire operation will benefit. Also, the ability to check the usage of materials becomes easier. Efficiency is the key to the rising cost of raw materials. Expenses can be cut down if companies eliminate unnecessary buffer materials. By tracking the materials, manufacturers can see the actual usage and then predict and prepare themselves for any unlikely situations. (Jakobs et al. 2001.)

Sustainability and being a ‘green’ company is becoming more and more important way to stand out from the mass of businesses. Today companies are more environmental-conscious, and they want to be aware of their supply chain’s carbon footprint. Tracking the products through the whole supply chain is also very important because it helps the companies’ invoicing. If the products are tracked and the customer receives a real-time location and delay messages, it can lower the number of claims from the customer as the transparency is wider and the customer can prepare themselves in advance. It is not always guaranteed that the intended recipient receives the package or that it has arrived on time or intact. Even declaring the package as “received” does not guarantee that. Auto-

mation picks up where package carriers leave off and it enables the ability to track packages in real time. (Schrauf & Berttram 2016.)

Supply chain tracking and tracing brings many benefits for a company, and faster exception management is among them. Responding to unplanned events before they turn into bigger problems is critical in exception management. With the help of RFID, faster exception management can be supported by providing timely acquisition of data and better synchronization of information and material flows. RFID may help to automate also exception management, and especially some aspects of it such as shipment data adjustment, invoice reconciliation, and the sending of alerts. Better troubleshooting is also an issue that should be raised when talking about benefits of tracking products. Daily internal delivery logs and manifests can be easily created by companies. Also, urgent alerts can be sent out and products can be rerouted if they are assigned to alternate recipients. Accountability can be increased by gaining advanced reporting. Naturally, these benefits will result in more satisfied customers. It also grows a reputation for reliability and credibility, which may result in a growing number of customers. (Tajima 2007, p. 266.)

If an organization has not used any track and trace solution in their supply chain earlier and they take one into use, the errors on delivery will probably increase substantially. However, this should be seen only as a positive thing since it will highlight all the failings, and allow the organization to see the true volume of their errors on delivery. Fortunately, it will also help them to trace the issues back to where they arise. After the issues have been solved, a huge increase in the number of correct deliveries should follow. This will ultimately lead into grown number of happier customers as they will receive their shipments on time. In case the shipments are delayed, the customer helpdesk will always know where the products are, and they can let the customer know beforehand when they can expect to receive them. Many man-hours can be saved every day because all of this can be prepared in advance, and the accuracy and speed at which this data is available is very high. (Zetes 2007.)

The research topic has been chosen to answer the needs of UPM, the company for which the research is conducted. UPM wants to find a way to know in real time when the cargo has been delivered to the customer. This information helps the company to improve their invoicing. In addition, it helps UPM to ensure that the product is delivered to the customer by the requested time. They have tried several years to find a solution to that problem. There are few main reasons why the suitable solution has not been found yet. First of all, the solution has to work automatically. For example, a few years ago UPM tried a solution where the truck drivers were intended to send a text message to the phone number that was printed on the delivery note. That plan did not work at all. Another reason is that the solution has to be relatively cheap. Since the product itself, paper reel, is inexpensive, the tracking system has to be inexpensive as well. In addi-

tion, UPM has outsourced its paper reel transportations. They use hundreds of carriers which is why finding a suitable tracking and tracing solution is quite challenging.

1.2 Research problem and questions

The main goal of this thesis is to propose a road cargo tracking and tracing system suitable for UPM's needs. It is critical to find out what information UPM needs and how do they match with the available solutions. It should also be noticed that how does the most suitable system affect to UPM's existing supply chain.

The objectives of the research can be expressed as the following main research question:

- What kind of road cargo tracking & tracing system is suitable for UPM's needs?

Several sub-questions help to answer the main research question. These are investigated, and they are in line with the objectives of this study:

- What information does UPM need when tracking its deliveries and why?
- What track & trace services exist and how suitable are they for UPM?
- Which track & trace technologies provide the information needed?
- How does the deployment of the tracking system affect UPM's supply chain?

The purpose is to research and find out the most suitable solution, but this research does not notice what happens after the solution has been chosen. The integration and implementation phases are not in this research's scope. Also, the management of change is an important part of system implementations, but this thesis does not research it.

The research questions are answered in this thesis by conducting a literature review about the existing track & trace solutions and their features. Also, an interview questionnaire is formed and three persons from the customer organization are interviewed. After that, the results from theoretical part are compared to the findings from the empirical part. Based on the findings a conclusion is drawn and a suggestion of the most suitable solution is made.

1.3 Research methodology

In this chapter, factors related to research strategies and methods are described. It is important to understand exactly what is done when the research is started. (Saunders et al. 2009, p. 107). This research's most important aspects are presented in the Figure 1 by utilizing the research onion by Saunders et al. (2009, p. 108).

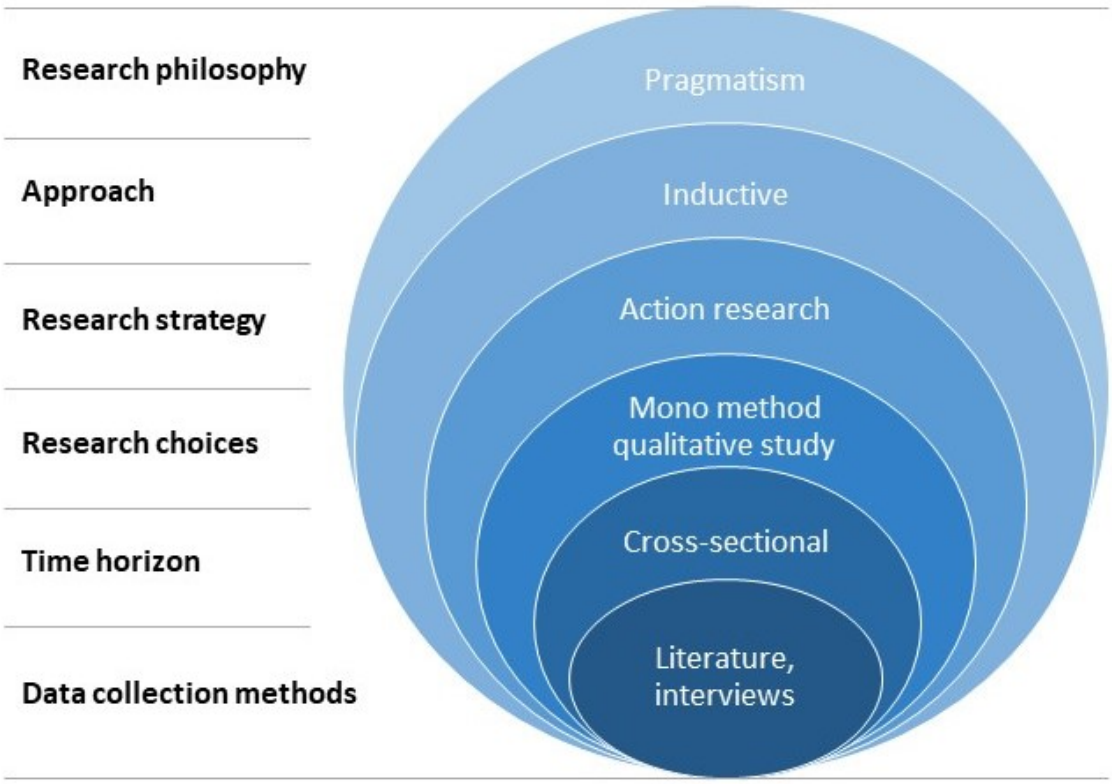

Figure 1. *Research methodology described with the research 'onion'.*

The 'onion's' outer layers create a base for methodology choices used in the inner layers. The outer layers are a guide for the research's point of views and for the research methods. It means that the thesis and the chosen philosophy should be in-line. (Saunders et al. 2009, p. 106.) It is important to choose the correct methods as they dictate how valid and reliable the research can be considered. All possible biases and errors related to subject and researcher needs to be considered by the researcher. It is also important that the researcher does not confuse causal relationships with other unrelated events. These events might affect the results. (Saunders et al. 2009, pp. 156-157.)

The most outer layer of the onion describes the research philosophy. Pragmatism is chosen to be the philosophy for this study. It emphasizes the practical nature of information. The philosophy was selected due to the practical nature of this research. Different orientations that combine action with practical approach on the creation of the information are also included in pragmatism. (Saunders et al. 2009, p. 109 & 119; University of Jyväskylä 2011.)

Inductive approach is taken when analyzing the research results. Inductive analysis enables many features. It is easier for the researcher to relate their data to the studied context as well as construct theories suitable to this context. After that, their own theories can be compared to literature (Saunders et. al 2009, p. 61). The validity and reliability

of the research's findings are supported by previous research of the chosen topic (Hirsjärvi et al. 2007, p. 19).

Action research is chosen to be the research strategy in this thesis. The current situation at the customer organization's will not be the focus of this research. The main point is to iteratively involve the organization's people in the development of the process they are affected by. If this thesis' possible change effects are wanted to be facilitated, it is required that employees are involved through the research process. (Wand & Wang 1996, p. 88; Saunders et al. 2009, pp. 147-148.) It is very important especially in a large and busy supply chain organization, which is the location of this research. Employees' motivation to participate in a change implementation is strengthened by the opportunity to be part of that. Also, the pressure inside the organization increases the motivation to participate. (Saunders et al. 2009, p. 148.) The action research process is described in the Figure 2.

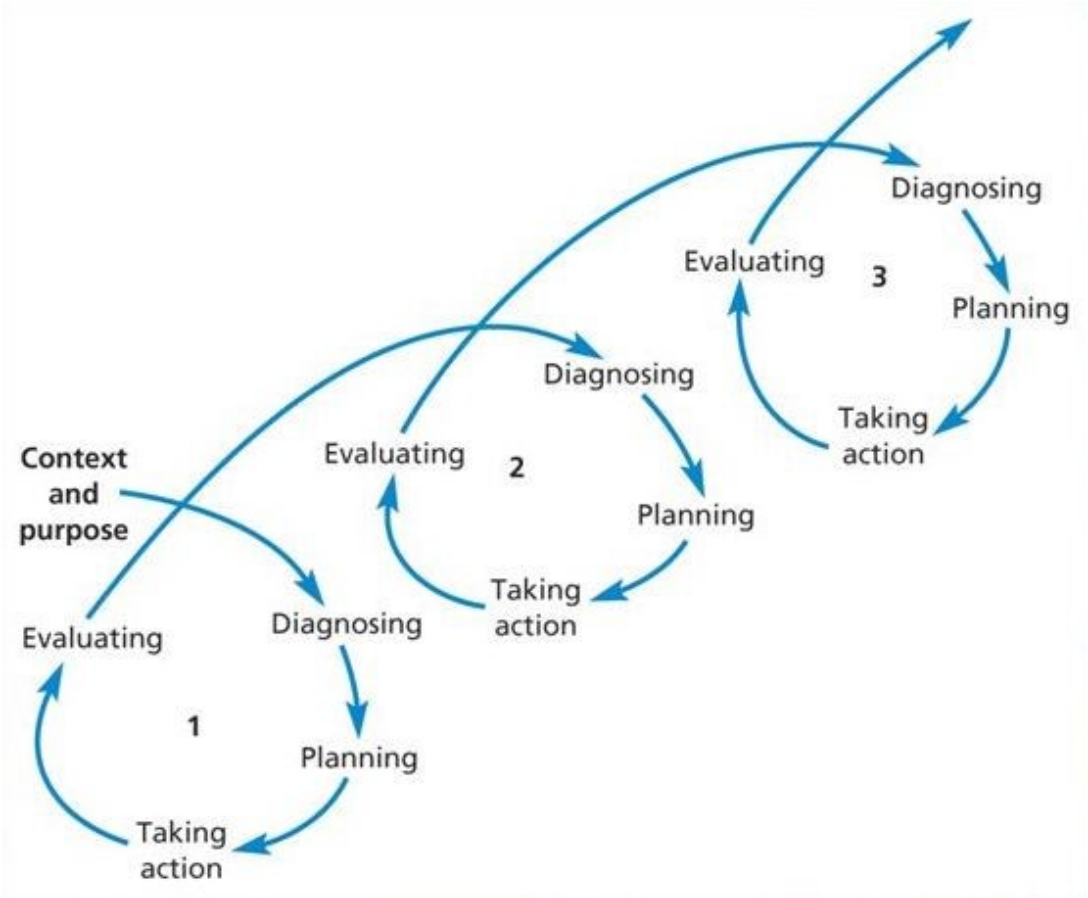

Figure 2. *The action research spiral (Saunders et al. 2009, p. 148).*

Action research is normally problem centered and practical oriented. Researcher and the target of the research co-operate, and they are actively part of the change process. Action research targets at changing the social reality rather than just explaining or modelling. It is possible that the change is completely different than what was expected, and it can be adapted or not. (Saaranen-Kauppinen & Puusniekka 2006.)

Literature review will be the data collection method of this thesis' theoretical research. The main point of the literature review is to find out how other researchers have already answered the research questions. Evaluating critically the sources and their reliability for this thesis is one part of the literature review. The source material needs to be objective, and the researcher should always analyze them objectively. (Saunders et al. 2009, pp. 65-66.) Objectivity is ensured by examining the materials critically and by having critical attitude towards them. In the literature review, it is also possible to reveal gaps in existing research, which can help to identify further research needs. (Hirsjärvi et al. 2007, p. 19.)

The primary sources of this thesis' literature review are academic journals and books, which can be considered as secondary literature sources (Saunders et al. 2009, p. 69). Basic search engines in the Internet are also used to help include the most recent material and to expand the point of views. These materials are used even though they are not always considered to be scientific research. These materials may include information about how other companies have implemented track & trace solutions and practices, so it is a good way to do empirical benchmarking. Case studies from track & trace service providers may also be found. These materials are created by track & trace professionals, so they can be seen as best practices of the consultants. It is important to find the most up-to-date methods and solutions that are in use. Therefore, the additional material is also used. However, scientific and professional publications, and the university library's databases and materials are primarily used. Key words for searches include "track & trace supply chain", "track & trace logistics", "IoT track & trace", "RFID track & trace" and "transport track & trace". Other similar terms and combinations of them are also used to search material. Research material will be gathered from the following databases:

- Elsevier Science Direct
- Scopus
- IEEE Xplore Digital Library
- Emerald Insight
- The International Journal of Logistics Management
- Journal of Supply Chain Management

Interviews are the main data collection method in this thesis' empirical research. The customer organization's internal requirements for the solution are solved with the interviews. Also, possible ideas for the solution can be found out in the interviews. Interviews as an empirical research method produces qualitative data. The results from a qualitative study needs to be classified into categories or themes as it is not in a standardized format (Saunders et al. 2009, p. 482). The use of a single data collection technique in empirical research and analyzing the results with qualitative procedures is known as a mono method qualitative study (Saunders et al. 2009, p. 151).

Research for this thesis will be conducted from as many stakeholders as is considered relevant. The interviews will be conducted as one-to-one qualitative interviews. They are considered to be the best suitable method when the researcher needs to understand the deduction and arguments behind the respondents' answers. It is very important that the interviewer can ask for specifications on the interviewee's replies. It improves the quality and depth of the collected data and helps to create a common understanding between the parties. (Hirsjärvi et al. 2007, p. 200; Saunders et al. 2009, p. 324).

The interviews are chosen to be semi-structured. That gives the interviewer a chance to vary the questions and how they are asked between the interviews if needed. It also gives the opportunity to clarify the answers into open questions as it adds significance to the data. (Saunders et al. 2009, p. 324.) However, the interviewer also needs to take care that the questions' framework and theme does not change between each interviewee. Otherwise the research questions cannot be answered properly. The objective of the interviewer is to gather as valid and reliable information as possible while keeping the goal of the research in mind (Hirsjärvi et al. 2007, p. 203).

The interviews were conducted in the customer organization during November 2017. The interview outline is presented in Appendix A. The research questions were the basis for the interview's main themes. The details discussed in the interviews were based on the theoretical findings from the literature. Interview candidates were initially approached by UPM. Then, requests to participate in the interviews were emailed to the candidates by the researcher. Also, a short introduction on the thesis and research objectives was emailed. Three persons from the customer organization agreed to participate in the interviews. The interview participants were located around the world, so all interviews were conducted as online calls. In the interviews, notes were taken but also verbal recordings were made after the participants' approval. The recordings were stored for later reference, observation and analysis. Anonymity of the participants and the collected data was confirmed and therefore no further info about the interviewees is mentioned in this thesis.

The methodological objectivity is consistent and logical with this thesis' theoretical and empirical research. Meaning that all points of views will be presented in the research. Also, viewpoints that are in conflict with the researcher's own viewpoints need to be presented. In addition, the research description explained in this chapter will make sure that other researchers can replicate the research and achieve about the same results. (Hirsjärvi et al. 2007, pp. 292-293.) It is also necessary to notice that the results can change by the smallest changes in circumstances (Saunders et al. 2009, p. 328).

The time horizon for this thesis is chosen to be cross-sectional as the research is performed during a few months which is a relatively short timeframe. Cross-sectional researches are studies of a certain phenomenon at a certain time, while studies that are carried out during a long period of time are longitudinal. (Saunders et al. 2009, p. 155.)

In this thesis, the customer organization's present situation is researched and analyzed. Also, conclusions are based on the findings during the research's time.

1.4 Research structure

Figure 3 shows the structure of the thesis. Chapter 1 describes the introduction, research background and methods. Chapters 2 and 3 concentrate on existing literature and theory. In those chapters it is studied how previous researches have answered the research questions. Findings from the literature support the results and help to draw conclusions from the empirical research's findings. Chapter 2, Supply Chain, focuses on the structure and operation of supply chains, and their digitalization. Chapter 3, Track & trace solutions, concentrates on the existing track & trace solutions and how they are used in supply chains, logistics and transportation.

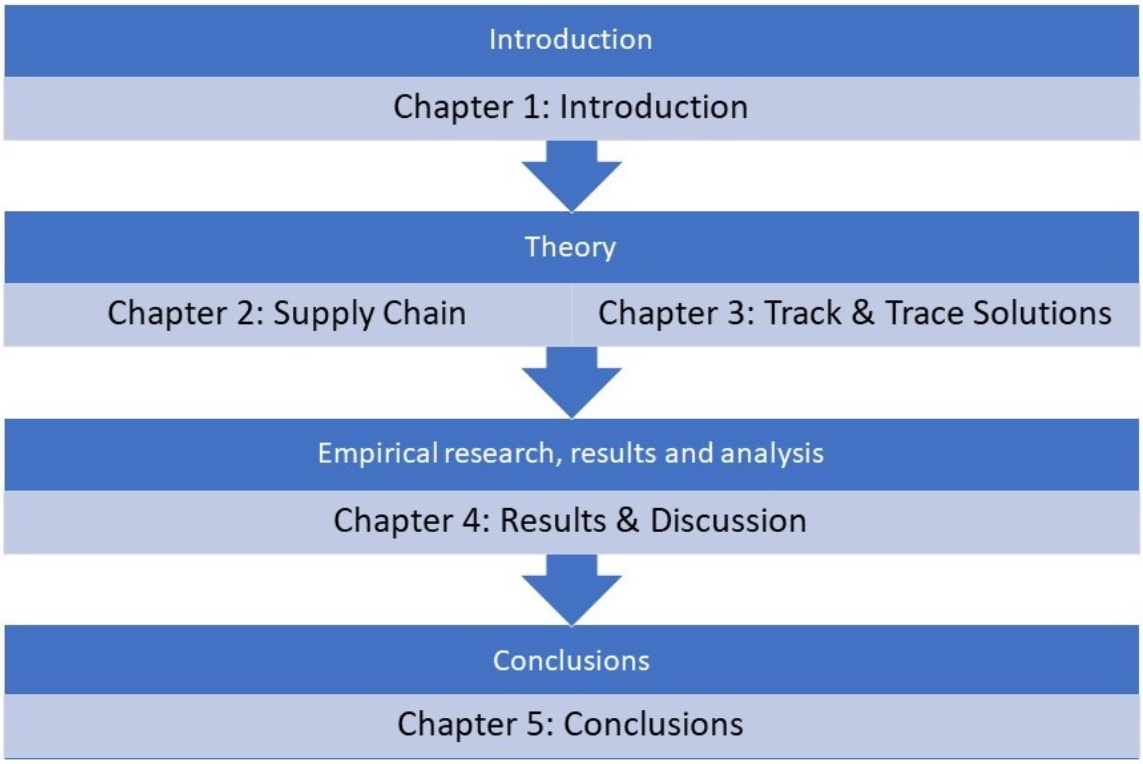

Figure 3. *Thesis structure.*

Chapter 4 presents the findings from empirical research and combines the findings with theoretical findings. If the existing literature's findings support the empirical research's results, it helps to verify the research's success and validity.

Chapter 5 draws conclusions and summarizes the answers to research questions. The research's success and further research topics are also shortly discussed.

2. SUPPLY CHAIN

2.1 Supply chain

The definition of supply chain has not changed considerably through time. La Londe & Masters (1994) say that supply chain is a set of companies that pass materials forward. Supply chain consists of companies or organizations that are part of the products journey from manufacturing until it is in the hands of the end customer. (La Londe & Masters 1994, pp. 38-39.) Stadtler et al. (2014) says that supply chain is comprised of two or more organizations that are legally separated, and they are linked by financial, material and information flows. So, organizations producing end products, logistics service providers and end customers are all part of the supply chain. (Stadtler et al. 2014, pp. 3-4.)

Supply chain definitions usually highlight at least two flow types that appear through the value chain. The flows are product, material, service and information. (Dimitriadis & Koh 2005, pp. 545-546.) Stevens (1989, p. 3) says that supply chain is a system that consists of parties linked together through feedback flow of information and forward flow of materials. These parties are usually raw material suppliers, distribution services, customers and production facilities. Towill (1997, p. 38) also says that materials can flow downstream and information upstream. Stevens (1989, p. 3) and Towill (1997, p. 38) both agree that these two flows must be integrated into every involved company in the supply chain to gain the desired collective advantage. Kearney (1994) and Poirier & Reiter (1996) add the financial flow in to the above-mentioned definition. These three flows are the most common ones, but some definitions also include a fourth. Tyndall et al. (1998) suggest that the four flows are product, information, cash and process/work, while Stank et al. (2001, p. 63) say that product/service value, cash, information and market accommodation comprise a supply chain. Despite of the exact number of flows in the supply chain definition, they all need to be coordinated appropriately to achieve the wanted advantage compared to competitors.

Mentzer et al. (2001, p. 4) say that a supply chain has three or more organizations or individuals which are directly involved in the flows of finance, service, product and information. From this definition, we can specify three scales of supply chain complexity: direct, extended and ultimate supply chain. The simplest form is direct, and it includes only a supplier, company and customer which are involved in the down- and upstream flows of financials, services, products and information. The next form, extended, includes also suppliers of the direct suppliers and customers of the direct customers, which are involved in the same flows as in the direct chain. Ultimate supply chain consists of all the organizations involved in the up- & downstream flows, from the

first supplier to the last customer. In addition to direct and extended versions, ultimate includes, for example, a third-party logistics company, a market research firm or a financial advice provider. It should be noted that managing a supply chain does not affect its existence. (Mentzer 2001, pp. 4-5.)

It is very important to notice that information flow is seen as a part of supply chain. Singh (1996) says that overall customer satisfaction cannot be achieved if information does not flow through the entire supply chain. Dimitriadis & Koh (2005, p. 546) agrees with this and adds that information flow is the most important part of the chain, because it comes before all other flows and it needs to be effectively managed before sales and any other business activity can happen. Communication of all essential information should be continuous between everyone who is involved in the supply chain. It is absolutely necessary if, for example, cultural differences are to be overcome. (Singh 1996, p. 30.)

2.2 Supply chain management

The supply chain itself is pretty useless unless it is managed properly. Supply chain management (SCM) definitions varies between different researchers. Nevertheless, two main points are common with almost all of the researches. (Harland 1996, p. S3.) As it was mentioned earlier, supply chain consists of a number of different flows. The first common point in supply chain management definitions is that these flows need to be integrated between different companies and stakeholders through the whole value chain. The second point is that the relationships between those companies and stakeholders have to be managed and developed so that the flows work optimally. (Min & Mentzer 2000, pp. 765-766.) Dimitriadis & Koh (2005, p. 546) add that the final objective of SCM is that the supply chain is whole and coherent, and that collective competitive advantage is gained. This leads undoubtedly to a more satisfied customer. Earlier every company tried to develop individual competitive advantage and did not care so much about the total performance of the supply chain. The new collective way of doing business has reached companies and they have realized that a common advantage will also result in an individual advantage. (Christopher 1998.)

Logistics and logistics management is often thought as a synonym for supply chain and supply chain management. Logistics is a much older term than supply chain. SCM has first appeared in the literature in 1982 (Oliver & Weber 1982). Before that the whole way of doing business was somewhat different than today. At that time, logistics was defined to be the process of planning, controlling and implementing the flow and storage of raw materials, in-process inventory, finished goods and any related information flow from the origin point to consumption point in order to conform in customer requirements (Council of Logistics Management 1986.) It was thought just as a certain part of a company. There was less cooperation between companies than nowadays. Supply chain management includes major cooperation and integration of flows between

companies. It is a good example of globalization. When the world became “smaller” along globalization, companies realized that by cooperating with their partners might result in a more satisfied customer and collective competitive advantage. As businesses and investment funds started to move beyond domestic and national markets to other markets around the globe, it developed lots of new competitors, and companies were forced to enhance their businesses and logistics operations were among the first ones to start with. (Cooper et al. 1997, pp. 1-2.)

2.3 Paper reel supply chain

The supply chain of a paper reel is very similar to any other industrial product, and the journey from the paper mill to the end customer contains several stages. After the paper is produced and cut to a specified width and web length, the reels go to a packing plant. When they are packed, they are transported to the warehouse, which usually is located in the same area as the mill, but it might also be elsewhere. Sometimes the reels might also be transported straight to the customer right after they are packed. From the warehouse the reels are loaded to trucks or trains. In many countries, they are delivered to the end customer on roadways or railways. But in Finland, the reels are usually delivered to the port where they are stored and loaded to ships. At the end port the reels are stored again and loaded to trucks or trains and delivered to the end customer. (Lehto et al. 2009, pp. 67-68.)

The reels might be stored more often during its way from the mill to the customer. Warehousing should be done efficiently, and the reels should be stored in such a way that each reel is readily available in the first in-first out principle so that the stock turnover can be followed. Of course, the reels should also be stored in a correct environment. For example, humidity and temperature should be within the margin according to the manufacturer. (Lehto et al. 2009, pp. 67-68.)

In addition to material flow, paper reel supply chain also includes the flows of information and finances. All flows can go upstream or downstream. Examples of upstream information flow might be the request for quotation, monthly schedules, purchase order, quality complaints or reports on supplier performance flows. Downstream info might be, for example, offer, presentation of company, confirmation of purchase order, reports about what has been done on deviation, dispatch details or invoices. (Carlsson et al. 2006.)

He et al. (2008) says that if supply chain wants to be successful, constant interaction needs to happen between supplier and customer. This applies similarly to paper reel supply chain. Usually, other partners such as distributors, dealers, retailers and logistic service providers are involved in the information network. Material can also flow upstream, for example, if the reel needs to be returned. Finances flow usually upstream, but downstream is also possible, for example, as debit notes. All in all, in paper reel

supply chain it is very important to manage all flows properly and to make sure that every party gets the information they need on time. (He et al. 2008, p. 1364.)

2.4 Supply chain integration

Supply chain management has evolved massively because of advances in information system technology. That is why all parties of supply chains are now able to work tightly together to optimize the performance. Realized return can also be shared with the partners. Information sharing enables the tight coordination and it can be done because of the advances in information technology. During the last few years, companies were required to work on new supply chain strategies because of more complex supply networks, increasing product diversity and shorter product life cycles. These strategies, which are called supply chain integration, demand supply chain partners that are more coordinated and collaborated than before. (Lee & Whang 2003.) Especially information integration is found as a typical example of a new era supply chain management. Practically it means that information is shared widely among members of the supply chain. (Simchi-Levi et al. 2000; Ho et al. 2002; Rai et al. 2006.)

Simchi-Levi et al. (2000) say that all data that might affect the actions and performance of other supply chain members should be shared, and ideally it is accessible in real time without significant effort. Rai et al. (2006) suggest that, particularly, delivery schedules and possible delays in the deliveries should be shared with the whole supply chain. Lee et al. (2000) adds that when delivery schedules are shared, it will most likely improve operational efficiencies as coordination of allocated resources, activities, and roles across the supply chain are also improved. But it also requires that production is well scheduled, and that information is shared as well. (Lee et al. 2000.) Lee & Whang (2003) say that sharing information can have lots of benefits, for example, reduced bullwhip effect, earlier problem detection, faster response and better trust across the supply chain. This kind of supply chain integration will be much easier to implement with the help of digitalization.

2.5 Supply chain digitalization

Supply chain management's digitalization has grown massively since 1990s. Communication between supply chain partners is a good example of digitalized world. (Lancioni et al. 2003, pp. 214-215.) The traditional way where every step of the chain is discrete and siloed, is drastically changing into a fully transparent ecosystem. This will make supply chains more proactive against disturbances in the chain. It will happen by modeling the whole network, creating "what-if" scenarios and adapting the chain in real time as circumstances change. (Schrauf & Berttram 2016.)

Gathering technologies and building capabilities are very important components when creating a digital supply chain ecosystem. However, it is even more important to find

the right people and carry out and manage the change in the organization's culture. This transformation is really challenging especially in big organizations, because you have to change the way that people are working and thinking. (Schrauf & Berttram 2016.)

Digital supply chain's objective is that supply networks are open for everyone involved. There is very big probability for distraction in the traditional supply chain, mainly because of lack of complete and real-time information. Outsourcing also makes it more challenging to comprehend the supply chain fully, because it will blur the transportation network's visibility and it makes it harder to reduce troubles when they show up. This is why digital supply chain aims at opening the network for everyone to see. Business to consumer markets are demanding companies to provide this kind of visibility and more information about their shipments' arrival times with up-to-date updates. Business to business markets also expect continuously updated and trustworthy transportation information since it will result in a considerably higher customer satisfaction. This level of transparency is not easy to achieve but once it is reached the benefits are remarkable. (Schrauf & Berttram 2016.)

Transport tracking devices are seen as very important part of the visible logistics framework and digital supply chain. Data that is collected from the devices is most useful when it is combined with data from other sources as well. That kind of data could be searched from traffic, news feeds, weather and even from social media. All of this data is brought into single platform and linked within it. It is analyzed and simulated many times, so it is fully optimized. An effective track and trace system is the backbone of supply chain's visibility. It must be such that it allows any member of the supply chain to find out any shipment's status at any time and point in its travels regardless of the mode of transportation. This info could be captured from enterprise resource planning systems or straight from the carrier. Global positioning system (GPS) devices provide the location, and field sensors provide, for example, temperature and humidity of the shipment. This data can be obtained from many different sources, like suppliers, warehouses and transporters. That is why it is really important to keep an eye on the quality and interoperability of the data. (Schrauf & Berttram 2016.) Lancioni et al. (2003) noticed that companies who started monitoring their products' on-time arrivals using digitalized processes, made considerable savings on their costs for carriers and enhanced their customer service. Lost shipments and shipper claims were also reduced. (Lancioni et al. 2003, pp. 214-215.)

2.6 Internet of Things

Society will move toward an "always connected" paradigm because of multiple technological advances. Such advances are, for example, open standards, like IPv6, that allow unique addressing schemes and networks, both wireless and wired, that reach everywhere. Internet of Things (IoT) is one of the numerous concepts referred as Future Internet. Basic idea of IoT is that objects are connected through the Internet. All objects

are uniquely identified, and their positions and statuses are known. Services and intelligence are added to this massively expanding Internet, which embeds digital and physical world, eventually impacting on our personal, social and professional environments. (Coetzee & Eksteen 2011.)

At the moment, the main driver behind the supply chain digitalization is the IoT. It is generated by swift enhancements in modern wireless communication. It receives a huge amount of attention and is predicted to bring advantages to multiple application areas such as manufacturing, transportation and health care. (Buckley 2006.) The term Internet of Things was first presented by Kevin Ashton in 1999 in the context of supply chain management (Ashton 2009). Though, in the last years, the term has included a lot more applications, almost anything you can imagine. Evolving technology has changed the definition lately, but the main goal is still to make computer sense information without human intervention. Nowadays there are several definitions of the IoT, but they differ from each other only slightly. (Buckley 2006.) Gubbi et al. (2013) say that in the Internet of Things actuating devices and sensing are interconnected. They enable the sharing of information through platforms that are in a unified framework. It develops a general operating overview for allowing innovative applications. Cloud computing is the basis for this unifying framework, and data analytics, information representation and seamless ubiquitous sensing enable all of this. (Gubbi et al. 2013, pp. 1645-1646.)

A network of interconnected objects will replace our current Internet. The new network will use sensing to collect information from the environment and it will interact with the physical world. In addition, it will use current Internet's standards to provide services for data transfer, analytics and applications. Transformation of our current Internet into a fully integrated Internet of Things will happen with the help of Radio Frequency Identification (RFID), Bluetooth, Wi-Fi and telephonic data services. It will lead to interconnection between people at unforeseen speed and scale. Next drastic change is going the be when objects create a smart environment with each other. (Buckley 2006; Gubbi et al. 2013, p. 1646.)

A smart connectivity with existing networks in addition to context-aware computation using network resources, is an essential part of IoT. It can be seen already now that a ubiquitous information and communication networks are here. It is enabled by growing presence of Wi-Fi and 4G-LTE (Long-Term Evolution) wireless network. Although, if IoT is wanted to be fully integrated, it needs to be possible to connect every existing object to Internet. This will allow embedding of intelligence into our environment. The technology needs to be hidden. Meaning that users do not want to know if the technology is there and how it works. That is why there needs to be a shared understanding about IoT's users and appliances. In addition, pervasive communication networks and software architectures need to express and process the contextual information to its relevant position. Also, the analytics tool need to aim for smart and autonomic behavior.

All of these requirements can be fulfilled only after context-aware computation and smart connectivity are accomplished. (Miorandi et al. 2012, p. 1498.)

At the moment, there are 9 billion devices connected to each other and the number is likely to reach 24 billion until 2020. Approximately two billion people globally use the Internet for browsing, accessing multimedia content, sending and receiving emails, using social media, playing games and so on. In the next phase, the objects and machines start using Internet as a platform to compute, communicate and coordinate with each other. It will become a seamless fabric of classic networks and objects in the next decade. It will allow the content and services to be always available. New ways of interacting, working and living will be invented because of IoT. It will also bring multiple amount of new applications. (Miorandi et al. 2012, pp. 1497-1498.)

IoT will revolutionize information and communications technology (ICT) and the lives of millions of people. The drastic change that Internet of Things will eventually result in, includes the need to consider again ordinary approaches that were used in computing, networking and service management. From an abstract view, the IoT has three main points related to the ability of smart objects to communicate, be identifiable and to interact. The devices can communicate either with each other, or with end-users and other entities in the network. The main challenge ahead of us is to develop technologies and solutions that enable such a vision. (Gubbi et al. 2013, p. 1646-1647.)

The IoT is based on the smart objects at a single component level. It complements the existing entities in the Internet domain (for example, terminals, hosts and routers). There are a few definitions to those smart objects. They need to:

- Possess a physical structure and a group of related physical features (for example, size).
- Possess a minimal group of communication possibilities, such as the capability to be found and to receive and reply to messages.
- Have a unique way to be identified.
- Be associated with minimum of one name and address. The name needs to describe the object and a human need to be able to read it. The address is for communication purposes and it is a machine-readable.
- Do basic computing. This can include more complex computation, such as service discovery or network management tasks. But it can also include easier tasks like matching an incoming message to a predefined footprint like with passive RFIDs.
- Possibility to sense physical phenomena (for example, temperature or electromagnetic radiation) or to trigger actions that has an effect on the physical reality like actuators.

The last point mentioned is the most essential. It makes the difference between smart objects and entities traditionally considered in networked systems. A smart object can be created either as an object or manufactured product or by inserting electronic tags like RFID tags or sensors into non-smart objects. (Gubbi et al. 2013, p. 1650-1651.)

It is inevitable that IoT will also revolutionize transportation and logistics. There are many problems and issues in transportation that IoT can solve and help dealing with. The main contributor to traffic noise pollution is urban traffic. It also significantly contributes to cities' air quality deterioration and greenhouse gas emissions. Traffic jam directly causes major expenses on economic and social activities in many cities. Supply chain productivity and efficiency, for example, just-in-time operations, are seriously impacted by these jams as they cause delays and failures to delivery schedules. In case the traffic information can be provided dynamically, it results in better planning, improved scheduling and better freight movement. (Miorandi et al. 2012, p. 1498.)

Internet of Things in the transport section will enable the use of extensive wireless sensor networks (WSN) for real-time monitoring of travel times, route choices, queue lengths, traffic noise emissions and air pollutant. At the moment, inductive loop vehicle detectors mounted at the intersections provide traffic information. It is probable that IoT will replace those sensors. In the future, it will also endorse the improvement of scenario-based models that are used when planning and designing of mitigation and alleviation plans, and also improved algorithms for urban traffic control, for example, multi-objective control systems. Relevant and real-time traffic information can also be presented to travelers as IoT combines the information above with data from urban traffic control systems. (Miorandi et al. 2012, pp. 1498-1499.)

In-transit visibility will play a significant role in the future supply chain as IoT will impact it massively. There are many moving parts and parties in the logistics ecosystem. Items and products are handled and transferred between all of these parties. A few examples of them are the manufacturer, suppliers, the distribution center, retailer and customer. As there are so many parties in the chain, an agile and informed supply network which provides products' location is required. It is not a new thing to track assets. Barcode scanners have been used by freight and shipping companies to track and manage their inventory. As the technology improves, the old scanners become out-of-date. The new technologies can collect data from various type of items as the old scanners could do it only on specific ones. When advanced asset tracking solutions are paired with IoT technologies, they can provide much more essential and useful data. (Macaulay et al. 2015, pp. 18-19.)

3. TRACK & TRACE SOLUTIONS

3.1 Track & Trace

The usage of track and trace solutions has grown considerably in the last few years mainly because of new technologies, falling prices and that their scope across the globe has become larger. Also, increasing battery life in the small devices has made the implementation of track and trace systems more popular than ever. (Schrauf & Berttram 2016.) Several real-time data management techniques are available that can facilitate information sharing. A few of these techniques can provide object location information. (Poon et al. 2009, p. 8279.) The biggest motivation for a properly managed supply chain is to remove barriers as it enables sharing and synchronization of valuable information with business partners. The level and timeliness of material visibility is very important in supply chain's success. The different track and trace solutions help enterprises to share information. They also help them to avoid the supply chain management bullwhip effect. (Kouvelis et al. 2006; Delen et al. 2007.) It means that the variance of orders can be larger than that of sales and the distortion usually increases as one moves upstream in the supply chain (Lee et al. 1997).

3.2 RFID

Radio Frequency Identification (RFID) was invented in 1948 but it took many years till the technology was cheap and reliable enough to large-scale use. Recently this technology has grown significantly because of the convergence of lower cost and increased capabilities of RFID tags. (Roberts 2006, p. 18.) Now it is widely used in supply chain management and other industries as well. At the moment, it is considered to be one of the most popular track & trace solution in use. RFID is wireless and in its simplest form it is seen similar concept to bar coding. A typical system consists of three components: an RFID device (tag), a tag reader with an antenna and transceiver, and a host system or connection to an enterprise system. (Domdouzis et al. 2007, p. 350.) The tag collects the real-time data and sends it via radio waves. All the relevant information about the product or shipment is stored in the tag which is detected and recorded by the reader. (Zhu et al. 2012, pp. 153-154.)

There are two kinds of RFID devices: the ones with power supply and the ones without. Unpowered devices are known as passive tags and they are usually read only. A device with power supply is known as active tag and it is generally a read/write device. Active tags are more expensive and bigger than passive. They also have a limited life due to the use of battery. But still they can last at least 10 years. But generally, the active tags have

larger memories and also have considerably larger range of operations. The range of RFID tags vary from 30cm to 9m depending on the frequency of the tag. Lower frequencies penetrate non-metal objects better and higher work better on metal objects. (Roberts 2006, pp. 19-20.)

RFID is widely used, for example, in medicine, aeronautics, construction, car manufacturing, retail, security and, of course, logistics and supply chain management. Most of these industries use RFID because of its ability to track products. RFID can be used together with GPS to get real-time tracking and tracing anywhere in the world. It can also be combined with different sensors, so it is possible to get information about the products condition and environment. (Domdouzis et al. 2007, pp. 352-353; Sun 2012. p. 108.)

The solutions and devices that RFID provides can today be considered a mainstream communication technology, as it has a number of deployments, particularly in logistics and goods sector. It is expected that RFID will pay a key role when identification technology is enabled in IoT. As it is integrated with sensing technologies, it brings also multiple issues and challenges. Until now, RFID has been mainly used for identification and tracking of objects embedded with an RFID tag in vertically integrated and isolated systems. In the future, they need to be part of a wider system in which the identification is only one piece of a larger workflow. This has not been fully explored yet and it needs more investigation and experiment. (Miorandi et al. 2012, p. 1500.)

3.3 RFID in supply chain management

The use of Radio Frequency Identification in supply chain management and logistics has been increasing significantly in the recent years. It has a crucial part in supporting supply chain and logistics processes because the technology allows it to identify, track and trace data throughout the supply chain. One important thing that makes RFID so useful, is that it can be used almost everywhere. Initially, it was used for enhancing backroom inventory management processes, but nowadays the usage has spread a lot. It is still used to identify items in warehouses, but it is also useful on the entire shipping route. If it is properly used throughout the supply chain, it can cut ordering lead time and cost on inventory control, help avoid stockouts and enhance the number of inventory turns. It can also help reduce transportation costs when it is used in tracking and tracing the transportations. (Sun 2012, pp. 108-109; Zhu et al. 2012, pp. 152-153.)

Keen & Mackintosh (2001) say that RFID has the capability to add value through the whole supply chain and business relationships that are related to it. RFID can also make crucial parts more mobile. These parts such as information, documents, communications and people are necessary when making business processes more efficient. Keen & Mackintosh (2001) argue that mobile commerce technologies', where RFID is included, unique value come from the capability to make many steps, such as people, information

and documents mobile. It is an essential part of making supply chain more effective within a business process design. This kind of ability is called process freedom. Kalakota & Robinson (2002), however, say that it is more valuable if information is made more visible through supply chain by mobile commerce technologies. Nevertheless, RFID has the ability and is used in supply chain management for both of these reasons. It can liberate considerable amount of human labor from certain workflows to more challenging stages. It can also ease the possibility of making all parties part of the information chain. (Angeles 2005, p. 57.)

In the retail industry, RFID is used mainly in two major business processes: distribution and transportation. Distribution in retail business uses RFID, for example, when receiving products. Tag readers are mounted in certain points in the distribution center or warehouse and they read the tags when they arrive. The tag readers forward the info to the host system which updates automatically the inventory quantities. The incoming products will also be automatically matched against the correct purchase order and differences will be identified much more easily, and this will all happen without manual labor involved. The information that the host system receives contains a unique product number that identifies it. But it will also contain time of the arrival, so it is useful when different supply chain parties need to be aware of the arrival and departure times. RFID will also help to find and identify the products inside the distribution center or warehouse. This means that it will speed up the processes because barcodes do not need to be scanned manually anymore. (Angeles 2005, pp. 57-58.)

Transportation in retail business uses RFID to track products and assets through the supply chain. Reader portals are placed in crucial parts of the chain in supplier shipping docks, consolidators, freight forwarders, pool points and distribution centers. The tracking systems are updated automatically when items with tags pass through the readers. The retailers can track the movements of the shipments and the vessels they are transported in, from the point when it is dispatched from the supplier until it is received by the retailer. The responsible persons receive alerts if the shipments and products stay at certain parts longer than expected. RFID speeds up transportation processes and free human labor to something more productive work. Safety stock inventory levels do not need to be as high as before as the products move quicker through inspection points. Information visibility also increases, and retailers can respond better to uncertain issues and exception-handling cases. (Angeles 2005, pp. 58-59; Sun 2012, pp. 108-109.)

3.4 RFID in paper industry

It is proven throughout the world several times that RFID improves supply chain productivity. Nowadays, also paper industry has been able to exploit the potential of RFID. (Nummela et al. 2009, pp. 195-196.) When traditional barcode identification systems are used, the code and data about the reel disappears as barcode is removed along

the wrapping. But with RFID systems, it is possible to identify every reel throughout its lifecycle. (Lehto et al. 2009, p. 66.)

Usually the safest place to put the tag is on the reel core between the core and the paper. In this way, the code that identifies the reel stays intact through its lifecycle from the mill to the end user. The outside of the core under the wrapping is generally the best place for the tag. The reason is that the tag might be damaged in the inside surface of the core because some reel handling machines have a shaft that go through the core. Paper industry would benefit from the usage of RFID just like most of the industries, because it provides real-time information like handling locations of the reel. It would improve the quality control and the supply chain visibility since the origin of the reel is known from its beginning till the end. (Lehto et al. 2009, pp. 66-67.)

Passive UHF (ultra-high frequency) RFID systems have been noticed to be the best in paper reel identification. This technology provides benefits such as proper read range of the paper reels from wanted directions, different potential tag antenna variations, cost-effective microchips, somewhat compact reader antenna sizes especially for clamp-truck integrated readers, and the possibility to use globally standardized RFID technology. (Ukkonen et al. 2006a; Ukkonen et al. 2007a; Ukkonen et al. 2007b.) But, of course, there are several challenges to be confronted and overcome before this technology can be applied to paper reel identification. The biggest issue is that a well-functioning and application specific tag antenna is really hard to find. (Lehto et al. 2009, p. 67.) Though, other studies show that these types of antennas have already been invented and that they are in use (Ukkonen et al. 2006b; Bacheldor 2007). The problem with the antenna is that as passive tags do not have an internal source of energy, they must get all the energy from the electromagnetic radiation emitted by the reader. The placement between the core and the paper is problematic because the paper suppresses the electromagnetic wave and that is why energy harvesting is difficult. Another issue is that as the electromagnetic wave goes through paper, its wavelength decreases. This has an effect on the electrical dimensions of the tag antennas. Also, few other things have to be solved before this type of system can be taken into use: it needs to be decided where the reels are identified, the data content of the tag's microchip has to be defined, integration to the existing data management systems need to be done, and reader units and antennas that are integrated to vehicles need to be developed. (Ukkonen et al. 2006b.)

As RFID is considered to be one of the most popular and used track & trace technology, it may suit UPM's needs as well. Nowadays it is relatively affordable as the prices have decreased during the last few years. It is very easy to use once it is integrated to the existing systems. Using RFID requires no action from the users as the information is read and transmitted automatically when the tags bypass the readers. In that way, it may suit UPM's needs as one of the requirements is that the workers and truck drivers should not spend any extra time on using the track and trace solution. Although RFID has been investigated in paper industry and it is already in use in pulp business (Confidex 2012),

there are a few issues that need to be solved and tested properly. For example, it may still be challenging to find a well-functioning tag and to find the right place for it. Also, it is mainly used inside a limited area, so it is not possible to use it as a tracking device if the area goes, for example, beyond a warehouse area. The biggest issue with RFID is that it is not a real-time tracking solution when used on its own. It needs to be combined with another technology in order to get real-time data. In addition, RFID is quite old technology, so it is not state of the art when talked about digitalization. The advantages and disadvantages of RFID have been collected into Table 1 below.

Table 1. *RFID advantages and disadvantages.*

Solution	Advantages	Disadvantages	Sources
RFID	Relatively cheap, popular and well investigated.	Not yet widely used in paper business, not a real-time solution (needs to be combined with other technologies), relatively old technology, mainly used inside a limited area.	Keen & Mackintosh 2001; Lehto et al. 2009; Sun 2012.

3.5 RFID & GPS

RFID brings many benefits when it is used for inventory and material handling purposes inside warehouses. But after it leaves the warehouse, the track is often lost until the next identification's location. Between identification points, there is not usually any tracking which may raise the risk of missing, delay and off-loading particularly when the cargo is crucial. The main challenge for logistic companies is the tracking and tracing of deliveries, since there are many parties involved and all of them need to be checked separately in order to get the updated information during the delivery process. Many parties of receiving and sending sides are included in this process, for example, sales executive, operation, warehousing, customer service and transportation staffs. This undoubtedly takes time and resources, and also disturbs the regular daily routines of the parties, because they cannot focus on their own roles. (Wang et al. 2008, pp. 294-295; He et al. 2009, pp. 1-2.)

GPS has been used to track mainly vehicles and other expensive equipments, but the tracking of cargo and the products on the pallet, case and item level, has been growing

over the last few years. If a truck breaks down, GPS provides location of the truck and it is possible to get the shipment moving again quickly. (He et al. 2009, pp. 2-3; Deshmukh et al. 2016, pp. 1715-1716.) Global Positioning System (GPS) consists of 24 satellites creating a network. It was originally developed by United States for military purposes, and later allowed for commercial use. The satellites periodically emit short pulses of radio signal to GPS receivers. The signal is received from at least three satellites to calculate distance, and the receiver uses a triangulation technique to calculate its two-dimension (latitude and longitude) position. In case altitude is also needed to be calculated, at least four satellites are needed. Average speed and direction can also be computed after the location is found out. Hence, GPS is a crucial technology when device wants to know its position. Many advantages have helped GPS to spread in many life applications. The GPS satellites are spread all over the world and they provide the data for free. GPS devices are very inexpensive, and they can be integrated into other devices easily. (Chadil et al. 2008, p. 393.)

GPS systems can nowadays also provide many different applications like route planning and guidance, map matching, wireless communication and digital map database. If GPS is used indoors, it does not provide accurate location info because the receivers cannot communicate well anymore with the satellites. (Al-Khedher 2011; Deshmukh et al. 2016, pp. 1715-1716.) RFID and GPS technologies both have their own features, benefits and purposes. Different parties use them generally as separate entities. But there are greater benefits to achieve, in case both technologies could be combined. Inbound and outbound logistic scheduling can be eased if GPS mapping systems are linked to enterprise resource planning systems. It results in many great benefits, for example, flawless visibility, improved reliability of inbound and outbound load and unload decision making, dynamic goods routing, improved transport capacity and optimization in urban areas, and automatic exception reports on-line shipment decision support. In case these technologies are integrated, complete resolution for tracking supply chain can be provided. (Wang et al. 2008, pp. 295-296; Prasanna & Hemalatha 2012, p. 726.)

By using RFID and GPS together it is possible to send information about the product and its conditions along with its location. But if these two are used together, a communication capability is still needed. Since GPS cannot transfer the location data between devices and RFID's communication range is measured in meters, there must be a communication service that transfers the data to a centralized system. Usually the data is sent through GPRS (General Packet Radio Service) or Wi-Fi. The data can also be transferred through GSM (Global System for Mobile Communications) as an SMS (Short Message Service) to a recipient station. SMS technology has become popular because it is inexpensive, reliable, easy and accessible way of transferring and receiving data. Of course, the information can be transferred via RFID at the next tag reader, but they are usually placed so far away from each other that the location of the product would not be real-time anymore. (Mohan et al. 2009; Al-Khedher 2011.)

There are still several integration issues at both hardware and middleware levels. RFID and GPS need to be used together and their data needs to be stored to a database. As the two devices are integrated, the information of RFID tags can be transferred to GPS receiver. RFID tags can also collect data with sensors from environmental conditions like temperature, humidity and shock. It is usually collected from perishable, high-security or expensive products. Then GPS receiver stores the essential information of cargo to the inventory databases. It is also possible to upload and display all the information over the web through query and capture interfaces. (He et al. 2009, pp. 2-3; Arebey et al. 2010, pp. 1-2.)

RFID cannot practically be used as a real-time tracking solution. But that obstacle is overcome when it is combined with a GPS device. So, it helps to remove that barrier, but other challenges that RFID's deployment has, are still present. If the GPS device is attached with the RFID tag, the size, naturally, grows and it might be even more difficult to find a suitable place for the device. However, if it is not necessary to track a single paper reel, then the placement is not a problem. In case this study's customer organization needs a real-time data about the deliveries, then the combination of RFID and GPS may be an appropriate choice. When these technologies are used together, the benefits are wider, for example, dynamic goods routing and increased transport capacity and optimization in urban areas. These may be helpful also for UPM. But the negative side of these technologies is that a communication capability is still needed since neither of the technologies can transfer the data widely. The advantages and disadvantages of RFID & GPS have been collected into Table 2 below.

Table 2. *RFID & GPS advantages and disadvantages.*

Solution	Advantages	Disadvantages	Sources
RFID & GPS	Real-time tracking solution.	Needs a communication technology that transfers the data.	Wang et al. 2008; He et al. 2009; Deshmukh et al. 2016.

3.6 GPS & GSM

Many of today's track and trace systems rely on GPS and GSM. Main reason is the reliability and cost-efficiency of these systems. Basically all smartphones includes these technologies. Nowadays more and more people have smartphones and as people become more familiar with them, their influence on society grows at the same time. Smartphones have a huge amount of different applications and that is the main driving force for their accelerated growth. Vehicle tracking and tracing systems have also made

their way to smartphones. There is a lot of applications to choose from and they are very easy to use. That is one very important reason why they can be easily utilized in tracking a vehicle. (Lee et al. 2014, p. 353.)

In vehicle tracking systems, location of the vehicle is one of the most important components. It should provide the location and time information anywhere on earth. GPS is the ultimate option compared to other alternatives in usability, price and accuracy. GSM and SMS technologies are commonly used for wireless data transmission. As the SMS technology is used through GSM network and modem, it provides a user with vehicle location information. (Lee et al. 2014, pp. 353-354.) SMS technology is very popular because it is very inexpensive. It is very easy, reliable and handy way to transfer and receive data.

The Global System for Mobile telecommunications (GSM) standard was developed in the 1980s to handle the problem where numerous telecommunication systems could not be coordinated together. Ever since, GSM has been adopted around the world, and it has been developed continuously, allowing higher data rates and new features in the networks. There are a few important features that make GSM very popular and widely accepted still today: Improved spectrum efficiency, inexpensive mobile sets and base stations, international roaming, excellent speech, compatibility with Integrated Services Digital Network (ISDN) and other telephone company services and support for new services. (Mohan et al. 2009.)

General Packet Radio Service (GPRS) is an improvement of GSM networks that supports packet switched data services like web browser and email. It is also an improvement to existing GSM data services, for example, SMS. GPRS utilizes the existing GSM network infrastructure as it uses available time slots during each frame transmission. Therefore, GPRS can efficiently provide data services as it does not overload the existing network. It can transfer data at the maximum rate of 115.2 kbps. Because GSM has a very large coverage area, GPRS has become the biggest data service network which is always on. Therefore, it suits very well for a real-time tracking management system. (Chadil et al. 2008, p. 393.)

Using GPS & GSM technologies along with smartphone applications is an effective and affordable tracking solution for vehicles. There are multiple free applications available that can be used for tracking purposes, for example, Google Earth and Google Maps. (Lee et al. 2014, p. 354.) But according to Chadil et al. (2008) it is much better option to build your own application as different companies and parties have their own demands and priorities. A vehicle tracking system composed of these technologies can have, for example, the following features:

- It can locate a vehicle by using an in-vehicle device in real-time using the GPS module.

- It can transmit a vehicle's ID and location information to a web server after a defined time interval using the GSM and GPRS module.
- Storing and managing of vehicle's location information to a database.
- Information can be accessed whenever a user requests it. It can also be monitored in real-time by using, for example, Google Maps application.

It can be seen above that the only components needed are a GPS module, a GSM/GPRS module, and a server and database to receive the data. GPS and GSM module can also be combined, for example, a smartphone usually includes both. The data can also be accessed through an existing logistics system. (Chadil et al. 2008, pp. 394-395.)

Some companies or parties may need a more accurate positioning than GPS can offer. In addition, when GPS is used in cities that have lots of population, it is not very efficient method because large buildings block, deflect and reflect the satellite signals. This causes blind spots in GPS which is a severe problem. These problems can be overcome by utilizing parallel GPS and GSM positioning technologies. GSM positioning can manage the blind spot problem of the GPS positioning, so by using both of these technologies, the accuracy and availability can be set to a much higher level. It is shown that the accuracy of GPS can be improved as much as 70% by using GSM positioning as well. (Thong et al. 2007; Mohan et al. 2009.)

By combining a GPS device with a longer-range communication technology, for instance SMS or GPRS, you get a reliable and cost-efficient tracking system. It is very common nowadays and there are multiple track & trace applications for smartphones. It means that this solution is easier to be implemented as more and more people have smartphones already and everybody can follow the traceable deliveries and products. That is why this could be a very feasible solution to UPM. This solution could be also further developed into an Internet of Things solution. In case there is not a suitable application on the market already, for sure, a tailor-made can be done according to their needs. The device does not need to be attached to the paper reels because it is possible to utilize the existing smartphones or built-in devices in vehicles. The only noteworthy barrier in this solution is that in case the transportation companies don't have smartphones or similar devices, everything has to be purchased and it will be quite expensive. The cost may become a problem in case this solution is chosen and taken into use in a country or region where modern technology is not in use. The advantages and disadvantages of GPS & GSM have been collected into Table 3.

Table 3. *GPS & GSM advantages and disadvantages.*

Solution	Advantages	Disadvantages	Sources
GPS & GSM	Real-time tracking solution, can utilize the existing smartphones and their applications, can be custom-made according to company's needs, can be developed later on, easy to implement.	Expensive unless there are existing devices that can be utilized.	Thong et al. 2007; Chadil et al. 2008; Lee et al. 2014.

3.7 Fleet Management System

Vehicle tracking creates a basis for fleet management systems (FMS). It manages a company's transportation fleet. The aim of a fleet management system is to improve the efficiency and quality of the industry by identifying major obstructions on the road and tracking real-time locations of their fleet on a map. (Lee et al. 2014, p. 353.) Fleet management systems grow rapidly. One reason for the rise of this industry was the increasing oil price. Transportation and logistics needed to increase its effectiveness since the costs were rising remarkably. By knowing in which condition and where the vehicles are, and by optimizing their routes and cargo, in other words managing the fleet, companies are able to cut the costs, minimize risks and improve efficiency and productivity of their fleet. Smart allocation of resources is the key element of fleet management. (Thong et al. 2007; Chadil et al. 2008, pp. 393-394.)

Fleet management system is used as an umbrella term for operations whose aim is to improve the overall performance of a transportation company's fleet in terms of, for example, fuel economy, utilization level and maintenance costs. Using fleet management system results in better vehicle and driver follow up, better transport coordination, more accurate scheduling, faster and more precise invoicing, and faster assistance in case of a vehicle breaks. It is used in many sectors like industrial and security. Lots of companies are tracking and optimizing their fleet. GPS is a crucial part of a fleet management system. Luckily, today it can be found from many life applications. The location data is provided free from the satellites all over the world. (Mohan et al. 2009.)

There are two types of fleet management systems: On-line and off-line systems. In the online system it is possible to track the vehicle's location in real-time. The system transfers data by using base stations or by cellular networks. The offline system provides the tracking data afterwards when the vehicles return to their base. Usually the fleet management system consists of three parts. The first is the unit integrated to the vehicle. It is integrated with the GPS and other embedded systems. The next part is the communication devices. These devices transfer the data to the centralized system. The third part is the fleet management software. It can either be in the base station or in a web server. The online systems transfer data to the centralized system by SMS or GPRS. The receiver can be any computer able to receive SMS or connected to the Internet. (Aljaafreh et al. 2011, pp. 130-131.)

Fleet management system can utilize many of the different track and trace technologies and devices. Especially today many of the systems in use collect data also from the vehicle and the driver. Integration of telecommunications and informatics (telematics) is used generally by larger fleets. But systems for small and medium fleets are also designed. Telematics systems bring benefits with the intelligence they can provide. They monitor drive's behavior by tracking events like rapid acceleration and hard braking. Some systems provide instructions to drivers on how they could improve their driving. This way accident rates and injuries can be decreased. (Mohan et al. 2009.)

Usually the larger the fleet is the more data from a vehicle is collected and utilized. According to Aljaafreh et al. (2011), in large fleet management systems artificial intelligence techniques are used to take decisions about drivers and vehicles. It also diagnoses remotely vehicle problems. This kind of system can be used for inter-vehicle communication and traffic law enforcement. These systems are usually consisted of two main parts. The first part is the system embedded to the vehicle, and the second is the web-based information system. The in-vehicle system includes different technologies that collect the data, for example, RFID, GPS, OBD (On-board diagnostics) and Wi-Fi or GPRS which transmit the data. The web-based information system stores and analyzes the collected data from vehicles. It can be accessed from anywhere through the Internet. The system can handle lots of vehicles with less overhead. Fleet management systems that are automated and web based, can provide totally new workflow planning and organizing possibilities. This happens as they:

- Run a well-structured database.
- Guarantee easy and fast access to information.
- Guarantee data protection.
- Improve dispatching.
- Present good interactivity and flexibility.

A web based fleet management system can nowadays make many decisions related to vehicles and drivers. The system allows large organizations to optimize distribution of

their vehicles and drivers. It allows also the reporting of mileage, fuel consumption, vehicle's maintenance problems and driver performance, assignment and status. The system can do a statistical analysis for fleet optimization, and it is usually designed for big fleets. (Aljaafreh et al. 2011, pp. 131-132; Lee et al. 2014, p. 354.)

In addition, it is easier to predict and be prepared for delays in transportations with the help of fleet management system. Naturally, there are situations that cannot be prepared for, like accidents or rapid changes in weather. But as there is lots of data collected in the system, for example, traffic jams can be anticipated better, and they can be avoided or at least the information about them can be shared easily with all the stakeholders. Fleet management systems are of course big investments but in the long run they will pay themselves back. Especially in case of large fleets it is considered as a very profitable and cost-effective purchase. (Thong et al. 2007; Chadil et al. 2008, pp. 393-395; Mohan et al. 2009.)

A fleet management system utilizes all the previously mentioned solutions. It collects the data with, for example, GPS and RFID and it sends it with GPRS or SMS. The difference is usually in the software that handles all the received data. It may be custom-made to the company and it is usually a lot bigger than a smartphone application. In most cases it also handles much more data and vehicles. Small companies can of course have a fleet management system as well, but it is mostly bigger companies' system. It is very useful for companies as they can utilize all the benefits that the fleet management system brings. In case the company does not have their own fleet and they have outsourced their transportations, they could just utilize the carriers' existing fleet management systems. They could have access to the systems and the data that is related to them, or the carriers could transmit the data to the company. In any case, there needs to be some kind of integration with the carriers' systems. It also requires proper communication and a trust between the parties. If there are lots of carriers, this might not be the most feasible solution, as it would require a vast amount of work to integrate separately with every carriers' system. However, if multiple carriers have a common system, it decreases the amount of integrations. Another disadvantage is that a customer using certain carrier's fleet management system is tied to that carrier. The advantages and disadvantages of a fleet management system have been collected into Table 4.

Table 4. *Fleet Management System advantages and disadvantages.*

Solution	Advantages	Disadvantages	Sources
Fleet Management System	Utilizes existing technologies, can be custom-made according to company's needs, can be integrated to company's other systems, real-time solution.	Expensive, vehicles need to be company's own or otherwise need to cooperate with the carriers, customers using the carrier's system are tied to that carrier.	Mohan et al. 2009; Aljaafreh et al. 2011.

3.8 Internet of Things solutions

IoT is expected to bring the next generation of track and trace by making it faster, predictive, more secure and more accurate. Logistics providers will have a clear visibility on the movement of goods throughout their life cycle. It will also provide item-level condition monitoring to make sure that goods arrive unharmed, in time and at the right place. IoT will also provide a new level of transport security and visibility. Telematics sensors transmit data from trucks and products about their location, condition whether any thresholds have been crossed and if a package has been opened. Many of the existing solutions are stand-alone solutions which are not connected to any other solutions. All new solutions and platforms should be created so that they combine existing solutions. This way control of end-to-end integrity could be enhanced. Track and trace solution providers should also try to develop solutions which can be integrated and used together as it would help and benefit every stakeholder and party. (Macaulay et al. 2015, pp. 19-20.)

When sensors and communication technology are combined, it is possible to track the changing status of a product through the Internet. In the future, nearly every electronic device around us will be connected to the Internet. These objects are then allowed to cooperate, connect and communicate with people and each other to reach common goals. It is expected that IoT will offer an encouraging solution to change the entire transportation systems and automobile services. (He et al. 2014, p. 1588.) Speed & Shingleton (2012) suggest that car registration plates should be used to connect different things. When vehicles are equipped with effective sensing, communication, networking and data processing potential, they can use IoT technologies to exploit the potential and share underutilized capabilities among vehicles on the road or in the parking lots. Inter-

net of Things provides, for example, the possibility to track vehicle's existing location and predict its future location. (Speed & Shingleton 2012, pp. 11-12.)

IoT technologies are useful for monitoring real-time product availability and maintaining correct stock inventory in retail business. Users can also utilize the technologies after they have bought the products by retrieving all data related to them automatically. IoT can also be used to limit thefts and counterfeits if they provide the products with an exclusive identifier and a full and accurate definition of the product. (Coetzee & Eksteen 2011.)

In the food industry, bio-sensors combined with RFID can help controlling production, quality and shelf life degradation of the product. Bio-sensors can monitor the product's temperature and bacterial composition while RFID can identify and track it. In every industry, it is vital that the quality of the product is guaranteed through the supply chain and lifecycle. These technologies can be utilized in any other industries as well so, for example, paper or pulp products can be monitored during the transportation. (Miorandi et al. 2012, pp. 1510-1511.)

Inventory management is a major utilizer of RFID technologies throughout the supply and delivery chain. It is based on RFID's ability to identify and track products. However, those applications are built in a rather ad hoc fashion, hence, they are only partly integrated into supply management systems. RFID is mainly used to manage and monitor the movement of items through a supply chain. The tags are placed to the items or to the containers that carry them, and the readers are placed to the facilities that need to be monitored. With the help of IoT, enhanced flexibility can be provided in terms of readers positions, and at the same time seamless interoperability can be provided between RFID applications that the supply chains' different parties are using. (Miorandi et al. 2012, p. 1500.)

Cloud-based GPS and RFID are vital when discussing about in-transit visibility. They can provide location, identity and other information to every allowed user regardless of time and place. This is crucial when IoT is used to improve supply chain. These technologies provide data that can be utilized when providing a full visibility through the product's supply chain. GPS and RFID enable shipping automation and delivery as they predict the exact arrival time. They also help monitoring the product and its environment since the quality of the product cannot change during the transport. All of this can be done with the help of IoT. An RFID tag is placed to the product, the vehicle is equipped with GPS and a communication device, data is transmitted to the cloud, and the user receives info about the product itself and its location, data about the driver and the vehicle as well as traffic and weather conditions. (Macaulay et al. 2015, pp. 20-21.)

All the stakeholders can be provided with higher order intelligence if the real-time sensor data is combined with environmental data. This way all the stakeholders can be

aware of the situation and they can make productivity improving decisions based on the actual information. This way decisions can be made before anything crucial happens and the supply chain becomes proactive instead of reactive. A good example is a traffic jam. The information about it is much more valuable if it is provided before the transportation starts. The implementation of IoT can enhance the visibility of the supply chain as it provides this kind of context-aware intelligence. (Speed & Shingleton 2012, pp. 12-13.)

Totally new IoT-based vehicle data clouds are arising as wireless sensor network, cloud computing, RFID, satellites, and other intelligent transportation technologies are combined. They will bring many benefits to businesses like reducing traffic jams, managing traffic, recommending car repair or maintenance, and predicting increasing road safety. Intelligent transportation systems are expected to be improved with IoT technologies. Some work has already been conducted. For example, car manufacturer BMW's iDrive system monitored the environment using various sensors. It monitored the road condition and vehicle location in order to provide driving directions. (He et al. 2014, p. 1589.) Leng & Zhao (2011) suggest a system called IIO-VMS (Intelligent Internet-of-Vehicles Management System) that monitors and manages traffic in real-time and collects traffic information from outside environments continuously. Vehicles could then receive that information as it would help them to make the right route choices. Zhang et al. (2012) made a monitoring system that tracks refrigerator trucks' location using IoT technologies.

It is already visible that IoT technologies can be found from multiple digital devices like navigation systems, mobiles and vehicles. A good example of this is Bluetooth technology. Bluetooth devices emit signals with a singular MAC ID (Media Access Identification) number that Bluetooth sensors in the coverage area read. If the readers are placed in different locations, the devices' movements can be identified. If the data received from Bluetooth devices is combined with other data like bus GPS or traffic signals, lots of research problems can be dealt with. A few examples of these problems are reliable and accurate transport network state information, identification of crucial intersections and vehicles' travel time on high-capacity roads. It is extremely important to take care of and research more privacy issues when using IoT technologies. (Lin et al. 2005.)

In order for the IoT based applications to spread globally, it is crucial to pay attention and manage the security aspect. Privacy, authenticity and confidentiality should be taken care of in the system-level or otherwise IoT solutions would not be adopted on a large scale by relevant stakeholders. In the initial phase IoT applications such as RFID security issues were usually managed in an ad hoc way. The reason was that those applications were integrated only vertically and only one entity controlled the components. The security becomes a more challenging issue when an open IoT ecosystem involves different stakeholders in each application scheme. There might be cases where one actor holds the sensors, one takes care of the data and its processing, and other ac-

tors provides other services to end users based on the data. In this kind of cases multiple security issues may arise. (Miorandi et al. 2012, p. 1509.)

It is a crucial part of the security to take care of data confidentiality because it demonstrates that the data can only be accessed and edited by verified persons. It is very important especially in the areas and sectors where the data needs to be protected because it helps to improve market value and competitiveness. It is very important to notice that users and objects can both access the data. Therefore, both of these groups' accesses need to be determined and maintained carefully. The other main security issue is privacy. It determines when data that is related to individuals can be accessed. The biggest reason why privacy is so crucial part of IoT lies in the technologies used. Wireless communication plays an important role and it may contain risks. Exchange of data through wireless networks raises the risks of abuse because it is easier for outsiders to access the data. Masking attacks and eavesdropping are also possible when using wireless communication. Therefore, privacy is a real and important issue to deal with as it may delay and slow down the improvement of the IoT. (He et al. 2014, pp. 1587-1588.)

So far supply chain has been a linear and step by step process, but the Internet of Things will very likely develop it to a seamless and data insight driven flow. IoT will change supply chains in many areas, especially in logistics. It will happen as communication, innovation and improved customer experience are enabled. IoT based technologies and platforms bring GPS and other transactional data together, so that they can provide supply chain decision makers a simple analysis and understanding which help them to make better decisions. Furthermore, weather forecasts can be combined locally with route schedules which will enable reactive and more precise routing and scheduling decisions. With the help of IoT, food spoiling can be decreased during transports. The health of the inventory can be monitored the whole time and when necessary, precautionary steps can be done. (Palmquist & Leal 2016.)

In the future, intelligent transportation systems will probably be based on IoT-based vehicle data clouds. Their goal is to make driving safer and more pleasant, and also transportation of goods more ecological and efficient. Though, the integration between these data clouds and IoT is still in the making and it should be studied a lot more. In order to make these clouds beneficial, lots of improvement need to be done in multiple services, and they need to be integrated with vehicular data clouds. Such services are, for example, traffic management, remote monitoring, business intelligence, road navigation, information and entertainment, and urban surveillance. There are still many global standards missing and many challenges concerning privacy, scalability, security, quality and reliability of service. Different parties and stakeholders such as cloud service providers, governments, car manufacturers, academia and standardization groups need to collaborate tightly in order to implement these vehicle clouds and to integrate them with multiple systems and devices. Despite all of the complexity, IoT can offer huge opportunities for automobile industry. There are lots of technology innovations waiting to be

developed, and IoT can also enable infrastructures for advancing vehicle data clouds. (He et al. 2014, pp. 1593-1594.)

Internet of Things applications would definitely be a long-term track & trace solution. It utilizes plenty of existing technologies and equipments. As it seems that everything is going inevitably towards the usage of IoT, it could be a wise decision to choose it at this point. Naturally, it needs to be estimated that how much benefits it would bring, but most likely the benefits will only grow as time goes on. It might also be that most of the profit and advantage it brings is not even known yet. Many companies using IoT can also improve their image as IoT is a trend topic at the moment (Marr 2016). Choosing the IoT option probably requires either an own fleet or a very close cooperation with the transportation companies. With the Internet of Things, all of the data collection technologies are connected to a centralized system that combines the data, presents it in an understandable form and suggests how to utilize it best. IoT will probably be an expensive choice, but it would be a very profitable investment as it has already been shown that it has a great potential for the supply chain and transportation sector. The advantages and disadvantages of Internet of Things have been collected into Table 5 below.

Table 5. *Internet of Things advantages and disadvantages.*

Solution	Advantages	Disadvantages	Sources
Internet of Things	A long-term investment, a huge potential and all the benefits are not even known yet, utilizes existing technologies, massive image improvement to the companies using IoT, real time solution.	Expensive, requires a lot of work.	Coetzee & Eksteen 2011; Speed & Shingleton 2012; Palmquist & Leal 2016.

3.9 Electronic Consignment Note

Consignment note is a shipping agreement between the consignor and the carrier of the shipment. This standardized and correctly completed agreement needs to go along when consignment move from starting point until it reaches final destination. This agreement specifies the cargo details. It includes, for example, the consignor's name, the carrier,

the consignee, number of packages, condition of goods, weight and particular instructions. This document is especially needed if something is lost or goods are damaged. The sender, also called consignor, is responsible of preparing the note. When filling out the form, attention must be paid to the use of correct terminology, as discrepancies and errors may invalidate it. The consignment note also firmly establishes the conditions of transport, because it will normally contain "general transport conditions" that supplement the contractual provisions already agreed between the sender and the carrier. When the carrier receives the consignment of goods for shipment, the carrier signs the consignment note, making it a proof of receipt of consignment as well. Consignment notes come in various practical formats for various modes of cargo transport. For inland road and boat transport, it is often known as a bill of lading (B/L). For cross-border road transport in Europe, it is called the CMR-note (Convention des Marchandises Routiers). (Baughen 2012.)

Rules for transporting goods internationally are covered by the United Nations Convention for the carriage of goods, the CMR. In 2008, United Nations signed a protocol concerning the use of electronic CMR (United Nations 2008). This protocol defines the legal framework and standards for using electronic means of recording and storing consignment note data, making information transfer faster and more efficient than with the traditional paper-based systems. The e-CMR reduces the scope of error in dealing with identification and authentication of signatures by setting some rules for a reliable signature. (Bakhtyar & Persson 2011.)

Even though it is not comparable, for example, to GPS in tracking and tracing a product, it will still most probably help companies to make their supply chain and transportation more efficient. With e-CMR, transport operators are now able to input data electronically and store logistics information and exchange data in real time with a mobile device. It is very important to input the data on time and in real-time, as then the agencies instantly receive information on the goods being transported. Therefore, any required following actions happen faster and at less cost. The sender of the product will be able to expedite their billing as they will have real-time information about the product's arrival to the customer. The consignor will also be able to react faster in case of something needs to be corrected during the transportation or after the arrival to its final destination. The utilization of e-CMR also reduces the environmental impact of global trade by increasing efficiency, using less paper, hence, minimizing archival requirements. It minimizes human errors and can adopt multi-language platforms for seamless international application. (Baughen 2012; Mazzoli 2017.)

Electronic consignment note might be a very cost-effective choice to track the delivery, especially if the transportation company already has this in use. This way the company can receive the arrival times of the products in real-time. But this requires an integration to the transportation company's system so that they can transfer the data to the company. As this option does not provide real-time location data, it is not possible to transfer

information about possible delays that occur during the transportation. But in case the only requirement is that the arrival time of the product is transferred to the company in real-time, then this would be a very potential solution. The advantages and disadvantages of electronic consignment note have been collected into Table 6 below.

Table 6. *Electronic Consignment Note advantages and disadvantages.*

Solution	Advantages	Disadvantages	Sources
Electronic Consignment Note	Cost-effective, easy to implement.	Does not provide real-time location data, requires an integration to the transportation company's system.	Bakhtyar & Persson 2011; Baughen 2012; Mazzoli 2017.

3.10 Conclusion of the solutions

According to the literature sources, all of the solutions could be plausible for the customer organization. Some kind of conclusions can already be drawn from this chapter, naturally, depending on the needs of the customer organization. The electronic consignment note would probably be the best solution in case there is not a need for real-time location data. However, by implementing Internet of Things solutions, the customer organization would be choosing a long-term solution. Supply chains and the whole transportation sector will be revolutionized by IoT in the near future. That is why it might be a good option to start investing in it already. All the solutions and their advantages and disadvantages have been collected into Table 7.

Table 7. *Track and trace solutions' advantages and disadvantages.*

Solution	Advantages	Disadvantages	Sources
RFID	Relatively cheap, popular and well investigated.	Not yet widely used in paper business, not a real-time solution (needs to be combined with other technologies), relatively old technology, mainly used inside a limited area.	Keen & Mackintosh 2001; Lehto et al. 2009; Sun 2012.
RFID & GPS	Real-time tracking solution.	Needs a communication technology that transfers the data.	Wang et al. 2008; He et al. 2009; Deshmukh et al. 2016.
GPS & GSM	Real-time tracking solution, can utilize the existing smartphones and their applications, can be custom-made according to company's needs, can be developed later on, easy to implement.	Expensive unless there are existing devices that can be utilized.	Thong et al. 2007; Chadil et al. 2008; Lee et al. 2014.
Fleet Management System	Utilizes existing technologies, can be custom-made according to company's needs, can be integrated to company's other systems, real-time solution.	Expensive, vehicles need to be company's own or otherwise need to cooperate with the carriers, customers using the carrier's system are tied to that carrier.	Mohan et al. 2009; Aljaafreh et al. 2011.

Internet of Things	A long-term investment, a huge potential and all the benefits are not even known yet, utilizes existing technologies, massive image improvement to the companies using IoT, real time solution.	Expensive, requires a lot of work.	Coetzee & Eksteen 2011; Speed & Shingleton 2012; Palmquist & Leal 2016.
Electronic Consignment Note	Cost-effective, easy to implement.	Does not provide real-time location data, requires an integration to the transportation company's system.	Bakhtyar & Persson 2011; Baughen 2012; Mazzoli 2017.

4. RESULTS & DISCUSSION

4.1 Information needs

To solve the research question "What information does UPM need when tracking its deliveries and why?" interviewees were asked that what kind of info do they need and how often should it be available. They were also asked that who needs this information and why. From a theoretical view, it is presented in Chapter 3 that what kind of data do the existing track & trace services provide.

All interview participants were pretty clear and straightforward about the information needs. UPM expects more transparency from the track & trace solution in respect of truck & shipment statuses on the way to their customers. They can already track their products if they are shipped by sea or air, and now they want to have a similar transparent information flow in truck deliveries. At the moment, it is possible to track the location of truck delivery products on a package level, although it is not in real time. They can only see if the package is in a specific warehouse or in transit (and in which truck). Technically the tracking is done by scanning the barcode. Now they want to develop the truck level tracking. So, the data they need is just the location of every truck. As they already know that in which truck the packages are, after they receive the location of the trucks they will know exactly where the certain products and packages locate. Since UPM tracks already the products on a package level, it is not needed to think about the placement of the tracking solution on the paper reel. Every reel does not need its own tracking device so just one device per truck should be sufficient.

When the track & trace solution sends the location data to UPM, it also needs to send some kind of identification code of the truck or the load its carrying. When the solution sends the identification code, it can be combined in their systems with the existing data. This way they can find out where the specific products are located. Two of the participants also mentioned that UPM wants to find out the shipments' departure and arrival times both at the warehouses and at customers. Another important information that they need to have are possible delays. If, for example, the truck is stuck in a traffic jam and it cannot arrive to the customer on time, information needs to be sent to UPM and to the customer as well. At the same time, a new estimated arrival time has to be informed. So, it is very important that the solution provides reliable data, and that UPM can always provide up-to-date arrival estimation to the customers.

All interview participants said that the data provided by the solution should definitely be real-time or at least almost real-time. It is not necessary for UPM to be able to track the

locations every second. It would be enough if the solution provides the location every 15 or 30 minutes. This is enough time for them to react if something happens to the truck and the estimated time of arrival changes. Also, if someone asks that where the truck is at the moment, it should be enough if they can tell where it was 15 minutes ago. In addition, the location data needs to be transmitted automatically. So, it is not enough that the truck driver sends the data or updates the status, it needs to happen without human reaction. However, they do also need the status updates by the driver. The status needs to be updated at least when the driver starts and stops loading at the pickup location and at the customer. The status updates from the driver might also be needed if something unusual happens underway. Information about when the driver reaches the destination could also be transmitted automatically. Geofencing might be a feasible solution for that purpose. However, as UPM has a vast number of customers and warehouses that would need to be equipped with geofencing, a more cost-effective option is the manual status updates by the driver. The carriers have also mentioned that they prefer the manual option where the driver can set the status for arrival and departure. They have also considered geofencing but in the beginning, they want to see how the solution works as it is planned now. It was also mentioned by one interview participant that a real-time solution is expected wherever it is possible and cost reasonable. Therefore, the proposed solution should be based on either a telematics system used by UPM's road carriers or on a mobile app.

According to the interviewees, there are multiple different parties who need the information that the track & trace solution provides. It is very important that the customer service receives the information. That way they can forward the info to the most important party, the customer. The customer service can utilize this data when creating the invoices. They are able to create the invoices on the correct dates as they receive real-time info about the arrival of shipments. Also supply chain teams should receive the info as they are the ones who plan and arrange the truck transports, and make sure that the customer receives the products on time. Two of the interview participants also mentioned that the logistics procurement team needs the arrival and departure times as it helps them to evaluate the service level of carriers when they bid and choose the carriers. When they have reliable data, they can find out the key performance indicators (KPI) and compare the amount of shipments delivered on time to the amount of shipments delivered late. It would be beneficial for all parties if the data does not need to be manually forwarded between them. So, every party should receive the data automatically. It increases the workload if, for example, the customer service needs to forward the info to every other parties. It might also cause lack of confidence if the info is transmitted through multiple parties.

Two of the interview participants mentioned first and foremost the improvement of customer service as the main driver for the implementation of a track & trace service. If a shipment is about to be late, it is extremely important to minimize the harm to the cus-

tomer and especially let the customer know about the delay. The info could be provided to the customer automatically but a contact from a customer service specialist might also be needed. Specially to let the customer know about the reasons for the delay. So, the delays should always trigger an automated alarm beforehand. It was also pointed out that every time a new location data is received, the system should update the estimated time of arrival. That way they can always compare the new estimation to the requested time of arrival, and they can always follow automatically if the shipment is on time. The automatic tracking data also helps UPM to check if the waiting time charged by the driver is correct. Sometimes the drivers need to wait at the pick up or drop off locations because of reasons that are not caused by them. It is important that UPM can verify this with the help of the location data, and do not have to rely solely on the driver's opinion.

One interview participant also mentioned that they would like to take the organization to a direction where all the basic processes would be automated and only exceptions are managed manually. Taking a track & trace solution into use is one step towards that goal. One participant also mentioned that UPM does not want to get involved to the trucks' navigation with this track & trace solution. It means that if a truck is late because of, for example, a traffic jam, the solution does not need to provide any navigation instructions. It only needs to provide the location data to UPM.

Another party who needs this information is the organization that bids and chooses the carriers. They need to be able to evaluate the carriers' service level and manage it in a way that it could be kept on a certain level. The track & trace solution provides them important key performance indicators which play an important role in the management of the mentioned service level. One participant mentioned briefly that the data provided by the track & trace solution could be used for big data analytics in the future as well. For sure, there is a vast amount of opportunities still unknown that the data could be used for later on.

4.2 Benefits and cost estimations

To solve the research questions "What track & trace services exist and how suitable are they for UPM?" and "How does the deployment of the tracking system affect UPM's supply chain?", interviewees were asked that what benefits do they expect the solution to bring. They were also asked about the solution's cost estimation and its suitability to UPM's existing information systems. From a theoretical view, it is presented in Chapter 3 that what kind of track & trace solutions exist. Chapter 4.3 answers the question about how suitable the existing solutions are compared to UPM's needs.

When asked about cost estimations, all interview participants mentioned that they have not made any specific business cases about this case. Naturally, they expect the chosen solution to be cost effective compared to the vast volumes of their road deliveries per year. One interviewee said that it is very difficult to do this type of business case and

that they should not use too much time on studying it. Naturally, they have made some estimations about the solution's integration and operating costs but not anything specific. The costs for the solution vary a lot and depend on many different things. Most of the costs comes from the interface building and integration phase. The operating costs are not expected to be very high compared to other cost elements UPM has in road freight. The costs vary between different track & trace solutions. If they could use an existing solution, for example, a carrier's fleet management system, the deployment would not cost as much as building a totally new one. Many carriers have their own fleet management system and it could be integrated into UPM's systems. In this option, they need to develop a transparent and deep cooperation with the carrier. This option would be cheaper and easier to implement than a solution built from scratch, for example, a mobile app. A custom-made app would probably have bigger implementation and operating costs. The truck drivers need to have a smartphone and subscription with the operator. The operating costs of mobile subscriptions may be expensive especially in Central-Europe if the trucks need to drive through multiple countries. However, if the app needs an Internet connection, the variable costs may be also low if the Internet use is included in the pricing. So, the pricing of the solution will not be the first thing that UPM checks, as long as it is not unreasonably high.

According to the interviewees, it is really hard to measure properly how the solution is going to pay itself back. The main driver behind this project is to improve the quality of customer service. It happens as they are able to be on time more often, increase transparency with the customers and act proactively with delayed deliveries. Being on time is a key element for most of their customers so they really want to improve that. The reliability of their deliveries is expected to rise as well as the quality of logistic services. This will hopefully bring more customer loyalty. One thing that they can measure better is the level and quality of their carriers and subcontractors. However, one participant mentioned that it is really hard to estimate beforehand how much will the customer satisfaction grow, and how much less reclamations and complaints will they have. So, they have not estimated any monetary value for this project and its payback. However, decrease of reclamations and complaints will naturally lower the costs. Also, there will be less exception cases which will decrease the costs as well. In addition, the costs will decrease as they do not have to spend so much time on exception management since the info can be transferred much easier and it is more reliable.

One interview participant also mentioned that it is really difficult to evaluate if the risen customer satisfaction will bring more money to the company. It is not sure if it will bring more customers or if they can raise the prices of their products. Hopefully, they will have better chances to get more business from the customer as their service level improves. It was also said that they think this solution is a "must have" by some of their customers. From that view, the solution will definitely give them clear return in future sales. One participant mentioned that one of the most important reasons for this project

is that UPM can keep up with the digitalization. Once this project has been finished, there are multiple possibilities to expand it later on. For example, they as a shipper could automatically collect relevant shipping data, costs, documents and so on.

All participants said that the chosen track & trace solution needs to be such that can be integrated into UPM's existing information systems and architecture. It is extremely important that it can be integrated especially into their ERP system. It would be good if the solution is a cloud-based system. All the location data and statuses need to be such that they can be transformed in a visual form. It is particularly important how the data is shown to other systems. Everyone who needs to have access to the data should see it. So, the solution should be such that does not restrict access rights so UPM can do it in their end. According to one interview participant, it might be a good choice if UPM has multiple track & trace solutions, especially in different countries. Mainly because there are so many different carriers and the volumes of their shipments are massive. In order to get all the benefits from the solution, the coverage of its usage needs to be over 90%. It means that over 90% of their shipments need to be tracked. In this case it might help them to get a bigger coverage if they had a few different solutions to choose from. It was mentioned that they have already taken this requirement to use the track & trace solution into account the last time they did a carrier bid process. So, the carriers are aware that this kind of requirement is coming, and they can prepare themselves beforehand.

4.3 Discussion

Here the empirical findings are compared and combined with the findings from the literature. Table 7 is used to help the comparison. Discussion about the findings and possible future development are also necessary to generate. The discussion contains research's own point of views which help to reach the conclusions.

4.3.1 Information needs

In the interviews it was noticed that UPM needs more transparency for their paper product's road cargo transportations. The info they expect it to produce is the location data of the truck and some kind of identification code. According to literature, all solutions except the Electronic Consignment Note provides the location data. That solution on its own is not a suitable choice as it requires an integration to the transportation company's system (Bakhtyar & Persson 2011). It can provide only the arrival time and it is not enough for UPM. The main purpose of that solution is not to provide the location data and therefore, it cannot be even fully compared to the other solutions in this research.

UPM expects the location data to be provided in real-time or at least in near real-time. According to the literature, almost all solutions are real-time. Only the Electronic Con-

signment Note and RFID are not real-time solutions. However, if RFID is used together with another solution, for example, GPS, then it covers the real-time issue. Although, those two solutions require a communication device if they want to be used as a real-time function. Therefore, it can be said that if RFID is desired to be used, it needs to be integrated with GPS and a communication technology, for example, GSM (Wang et al. 2008). Also, RFID is not a very long-term solution as it is not state of the art solution. It can rather be thought as an old technology, and as today the digitalization and technology improvements are so massive, it can be predicted that other technologies will outrun it sooner or later. It was also mentioned in the interviews that they expect a real-time solution wherever it is possible and cost reasonable, so the solution should be based on either a telematics system used by UPM's road carriers, or on a mobile app using technologies like GSM & GPS. Therefore, RFID would not be thought as the best possible solution for UPM. Although, if they want to invest in Internet of Things solutions, RFID could be part of it. It could be used in the trucks to provide data, for example, about the product and its conditions. This would probably be a feature that requires lots of investments from the carriers too, and they have to see the benefits for themselves. Otherwise the carriers do not want to invest on it.

The location data is expected to be updated every 15 or 30 minutes. Fleet management systems, GPS & GSM combinations and IoT solutions can all provide the data this often. They all also enable the manual status updates, which was another requirement. Actually, all of these three solution options can use the same technologies. The location is in most cases provided by GPS and the communication can be done, for example, with GSM. The main difference is the scope of the solution (how much data it gathers and so on) and how it is integrated into other systems. GPS & GSM could use an existing or a specifically made smartphone application (Thong et al. 2007). If it is the chosen track & trace solution, it could be further developed to be an IoT solution. As IoT actually is just many existing technologies used together, all the other track & trace options could be further developed as an IoT solution. They would just collect more data, and then all the data would be analyzed and exploited. But the latter part is actually the most important part of Internet of Things: how the massive amount of data is analyzed and utilized. Therefore, the full utilization of IoT would need lots of more research.

All of the solutions are depending on the communication technology. If the service is down for some reason, the data cannot be transferred. However, there is not a risk-free communication tool, so the possibility just needs to be minimized. The communication networks are very rarely down nowadays, at least not for a longer period of time. If the geofencing option is wanted to take into use later on, all solutions should enable it as the geofencing usually is based on GPS and cellular data. A mobile app using GPS and, for example, GSM network might be a good option if geofencing is wanted afterwards. An app would be a better option compared to fleet management system when talked about continuity and dependency. If they choose a fleet management system solution and in-

tegrate their own system to the carrier's, it is a lot harder to expand the solution to other carriers. It is possible that they would need to do a different integration with every carrier. A mobile app is very easy choice as then the truck drivers only need to download the app and they are ready to go. Of course, this might require more work and money, but it is definitely a longer-term solution.

The interviewees mentioned a few different parties that needs the information provided by the solution. The chosen solution does not have a big effect on this issue. Most probably the info is distributed to all the necessary parties through UPM's existing information systems, for example, ERP. Therefore, the track & trace solution does not really affect that as it only provides the location data to the existing systems which then combine the data with other info and present it in a readable form. Although, it was mentioned that they do need the arrival and departure times, so not only the location data when the truck is on its way. The interviewees also said that the carriers would like these status messages to be sent manually by the driver. Therefore, the chosen solution need to enable this. But it was already mentioned that all solutions allow manual statuses to be set. Of course, the data needs to be transmitted automatically in the information systems as well. This was one requirement said in the interviews. It increases the risk of misinterpretation if many parties need to forward the info manually. But as said, the track & trace solution does not need to involve in that operation.

The chosen solution needs also to be reliable so that all the necessary parties receives the data it provides. It was mentioned in the literature that IoT solutions are very reliable today (Palmquist & Leal 2016). However, the newest state of the art technologies might not be the most reliable ones if they have not been tested thoroughly yet. Therefore, it could be suggested that the new technologies that have been properly tested would be ideal. The oldest applications are not the best ones either if they want to succeed in digitalizing their business processes and functions.

The reasons for implementing a track & trace solution is also a topic that does not affect that much on the decision that which technology is taken into use. The main driver for the implementation of a track & trace service was mentioned to be the improvement of the customer service. As long as the chosen solution supports this, it is enough. It supports this requirement best by providing the location data reliably and in real-time. There were a couple of requirements also mentioned, for example, that an automated alarm should be triggered if the delivery seems to be delayed, and that the estimated arrival time should be updated every time a new location data is received. But these features are such that UPM's existing systems should perform these functions.

It was also said in the interviews that UPM wants to keep up with the digitalization, and that is one reason for this project. This also speaks for choosing a newer technology as the pace of development in the technology field is so fast. A solution equipped with older technique might be harder to update when needed. Also, the newer the technology

is the better they can keep up with the digitalizing world. UPM also wants to take the company to a direction where all the basic processes are automated. So, the track & traces solution needs to be as automated as possible as well. All of the possible solutions are automated.

It is most probably possible that the solutions could also provide navigation functions to the driver, for example, if there is a traffic jam ahead and it could be avoided. However, the interviewees said that UPM does not want to get involved to the trucks' navigation as they are not UPM's own carriers. So, this requirement does not affect the selection of the solution. Another requirement mentioned in the interviews that speaks of choosing a newer IoT solution, is that they have thought about how the provided data could be exploited further in the future. The solution could be used for big data analytics in the future. There are so many opportunities for the utilization of big data that it should be noticed when choosing the solution. The data volumes will grow, and at the same time ways to analyze it improves massively. It is also mentioned that businesses using and utilizing big data will see huge financial improvements in productivity benefits (Marr 2016). As logistics and supply chain management are one of the biggest industries to benefit from it, UPM could as well gain more advantage of it later on. Therefore, it would be wise to invest on it at this point.

Key findings: *Electronic Consignment Note does not meet the real-time data requirement. RFID is not the most recent technology, so if the customer organization wants to keep up with the digitalization, RFID might not be the best option. A custom-made IoT solution or a GPS & GSM solution would be a long-term investment as well as an investment on digitalization.*

4.3.2 Benefits and cost estimations

All the interviewees mentioned that they have made some rough cost estimations about this project. However, specific business cases or exact cost estimations have not been made or at least they were not mentioned in the interviews. Of course, they expect the solution to be as cost effective as possible. But according to the info received in the interviews, it can be said that cost is not the most important requirement when choosing the solution. Therefore, no solutions are left outside because to their price. As mentioned earlier, integration to existing systems would be cheaper than building a totally new solution. Therefore, a fleet management system or an existing mobile app would probably be the cheapest options. However, the cost is not a very convenient way to estimate the suitability of the solution. It is really hard to predict and estimate that how much money is the solution going to pay back. Therefore, it is hard to compare it to the solution's cost. More important is to find a solution that suits their most important need which is to raise the level of customer service. Nowadays, it is also very important to keep up with the digitalizing global world. Otherwise competitors and new solutions will outrun them. So, a custom-made mobile app that could be further developed will

probably cost the most, but it will bring more opportunities to them later on. It will also let them to keep the control and development of the solution in their own hands.

As said, the benefits of the solution are really hard to estimate beforehand. Because of that, and the fact that the benefits do not have much of an influence on the choice of the solution, no solutions should be left outside according to the estimated benefits. However, one thing that was mentioned in the literature about the benefits that the solution can bring, was improvement of company image. If customers and other parties notice that a company invests in digitalization and new technologies, it can improve the company's image (Marr 2016). Internet of Things and digitalization are so big topics today that it is inevitable for people not to see them. Nowadays when people or companies invest in new technologies, it creates and strengthens a positive image which can create more business to the company. Existing and potential customers might want to spend more money on such companies rather than the ones who are stuck with the old habits and technologies. Of course, only novelty is not enough, the new technology must have other benefits as well. But, for sure, it can help to draw attention.

All the interview participants said unanimously that the chosen solution needs to be such that can be integrated into UPM's existing information systems and architecture. This is extremely important requirement. The interviewees did not mention how easy or difficult the integration should be or how much should it cost. Therefore, it is sufficient as long as the solution can be integrated. Also, it was said that the solution should not restrict access rights. But if UPM's own systems handle the sharing of the location data, then it does not have to be taken into account when choosing the solution. However, it was quite challenging to find discussions about this topic from the literature.

Overall there were not many mentions about integrations or examples of integrations. However, it can be said that if the solution is built from scratch according to the customer's needs, it is easier to integrate than a ready-made product (Shingleton 2012). A custom-made solution can be made thoroughly according to customer needs. It is also easier to build the integration with a custom-made solution than an existing one. With existing systems an API (Application Programming Interface) needs to be developed if there is not one already developed. Again, it is easier to develop the integration and API according to only UPM's needs. Therefore, an IoT mobile app would definitely be a better choice than just an integration to an existing fleet management system.

It was also mentioned in the interviews that it would be a good addition if the solution is cloud-based. According to the literature, a cloud-based solution is nowadays much more secure than an on-premise software. The security aspect was not discussed in the interviews, but it is a topic that should be mentioned. The topic should be addressed at the latest when the solution supplier is chosen. The most important reason why cloud-based systems are more secure is that the cloud companies have responsibility to protect their customers and their data from any kind of security threats and breaches. If these compa-

nies would be breached, it would be devastating to their business. Therefore, the security is their first priority. Of course, the bigger and more famous the cloud service provider is the more better their security is (Linthicum 2014). So, again the mobile app cloud-based solution would be the best option as these requirements are compared to the literature.

Key findings: *Integrating to existing fleet management systems or mobile apps would be cheaper than building a new one. A custom-made solution is more expensive but a better choice when thinking about continuity. A cloud-based solution would be more secure than on-premise.*

5. CONCLUSIONS

5.1 Research conclusions

The objective of this thesis was to research what would be the most suitable road cargo track & trace solution for UPM's needs. The main research question was "What kind of road cargo tracking & tracing system is suitable for UPM's needs?", and to solve this, stakeholders were interviewed and previous research around the topic was investigated.

The first research sub-question was "What information does UPM need when tracking its deliveries and why?". From a theoretical view, it was researched that what kind of data do the existing track & trace services provide. A few of the most popular solutions were gathered and researched more closely. According to the literature, all of these chosen solutions provide mainly similar information. As their purpose is to provide location data, all but one solution provides that. Electronic Consignment Note is not actually a track & trace service, so it does not provide this data. However, it was researched because it does provide the departure and arrival times of shipments, and it was not sure in the beginning if this would be sufficient for the customer organization. Other solutions provide the location data, but they do have other differences.

From UPM's point of view, the most important info they need is real-time or at least almost real-time location data. RFID does not provide real-time data when it is used on its own. All other solutions fulfill this requirement. UPM also want's that the driver sets manual statuses when arriving and departing. All solutions should enable this. It was mentioned that there are a few different parties who need this information. However, this requirement does not influence the selection of the solution. The main reason for UPM to implement a track & trace product is to improve their customer service. There were a few other reasons as well, for example, to keep up with the digitalization. When these requirements were compared to the literature, it was noticed that an IoT based mobile app solution would be the most suitable option.

The second research sub-question was "What track & trace services exist and how suitable are they for UPM?". A few different solutions were found from the literature. The most suitable ones were chosen to be further researched. RFID, RFID & GPS, GPS & GSM, Fleet Management System, Internet of Things and Electronic Consignment Note were the chosen technologies and services. Their features, advantages and disadvantages were researched and listed in the literature review. It was noticed, for example, that RFID cannot be used on its own, but it requires a GPS and a connection service. Also, that Electronic Consignment Note does not provide real-time location data and

Internet of Things is expensive but a long-term solution. Afterwards they were compared to the requirements that the interviewees mentioned, and a suggestion of the most suitable solution is made later in this chapter.

The third research sub-question was "Which track & trace technologies provide the information needed?". When the researched solutions and technologies were compared with the requirements, it was noticed that almost all solutions provide the data and information UPM needs. The main requirement was that the solution needs to provide location data every 15 or 30 minutes. It was noticed that Internet of Things, Fleet Management System, GPS & GSM and also RFID & GPS with a communication technology, provide the requested location data. However, RFID is not needed if GPS is in use as it can provide the location data on its own. As UPM does not have its own fleet and trucks, they would need to integrate into their subcontractors' Fleet Management System if they want to use that service. It would be a cheaper choice but then they would be tied to one or more carriers, or a combined system they might have. Therefore, GPS & GSM or Internet of Things would be a better choice as they could develop them only for themselves, and then just choose the carriers who are willing to take the service into use.

The final research sub-question was "How does the deployment of the tracking system affect UPM's supply chain?". It was clear that the chosen solution needs to integrate into UPM's existing information systems and architecture. It needs to integrate especially into their ERP system. It might also be good if the solution is cloud-based. There were no more specified requirements about the integration of the system or its effect on their existing systems. Of course, it is expected that the solution only improves their supply chain. It should enhance their customer service but also their supply chain, especially during the last mile. The last mile is the part of the transportation where the trucks pick up the shipment from the last warehouse and deliver it to the customer. This is where the solution is needed. According to the literature, a custom-made service or solution might be easier to integrate than an existing one, for example, a Fleet Management System. Naturally, it depends also how the system is built. However, this speaks of choosing a GPS & GSM based solution or an Internet of Things based solution.

To answer the main research question "What kind of road cargo tracking & tracing system is suitable for UPM's needs?", the information from the answers to sub-questions is combined. From that info, the key conclusion drawn from this research is that the most suitable road cargo track & trace solution for UPM is a cloud-based mobile app that is based on GPS & GSM technologies, and which could be further developed to an Internet of Things solution. The communication technology can also be other than GSM, but it should be such that can transfer the data as often and reliably as requested. It can provide the information that UPM needs, and it can fulfill their other requirements as well. They should also invest in newer technologies as it would help them to keep up with the inevitable digitalization. When new analyzing methods arise, it is easier to develop this

kind of solution rather than a service based on older technologies like RFID. If a GPS & GSM solution is chosen, it requires a working Internet connection. Therefore, UPM just needs to take this requirement into account when choosing their carriers.

From the carriers' point of view, the fleet management system would be the best option as it requires the least effort from them. Then UPM would just need to integrate their own systems to the carrier's systems. However, as UPM does not have their own carriers, they should make the decision based on their own needs and desires. If UPM chooses the proposed GPS & GSM based solution, it requires certain actions from the carriers as well. They need to start using the solution that UPM chooses. If the solution is a mobile app, then the carriers just need to download the app. Naturally, they need a proper device for that, for example, a smartphone. As mentioned earlier, UPM has already taken this into account when they requested for bids from the carriers. So, they require the carriers to use the track & trace solution, and they know beforehand what to expect and how to prepare themselves. The biggest requirement for the carriers is the change in their working methods. They will need to perform certain actions that the solution requires, for example, change the status of the carried shipment when they pick up and drop off the shipment. This is an issue that UPM should carefully pay attention to. Especially, when UPM's earlier attempts to take an SMS based track & trace solution into use has failed, because the carriers have been reluctant to send the messages. Therefore, it might also be challenging to take this solution into use if it requires the truck drivers to manually set any statuses.

The solution should be custom-made according to UPM's needs. This ensures that it is made just like they want it and according to their needs and preferences. It is also easier to develop the solution later on for further needs when they have been involved in its development right from the beginning. This ensures the continuity of the development. A GPS & GSM based mobile app would the best option to start with. It is easy to develop it later on to an Internet of Things solution as it basically means just existing technologies gathering more and more data, and the data being analyzed with new methods. The communication technology can be other than GSM, but it has been proved to be very reliable.

5.2 Evaluation of the research and the results

There was pretty much material in the existing literature about different track & trace solutions. There was more research about older technologies like RFID, but not so much about Internet of Things. The material focused on the technologies' features and areas they are used in. However, there was not so much research about the integration phases. Although there was material about supply chains and logistics sector using track & trace solutions, paper industry was lacking from the research literature material. Therefore, the conclusions had to be drawn from the general logistics and supply chain research material. However, if the need is to track only the truck and not every product separate-

ly, there are not much differences between different industries and areas. But, of course, the results might have been slightly different if there would have been more research material about paper industry's supply chain, truck deliveries and its tracking and tracing.

The research lasted longer than what was expected and planned in the beginning. During the research, the customer organization did their own research about the topic. They started also a few track & trace pilot projects in different countries across Europe. Although these are only pilot projects, they will give UPM a very good understanding about how the chosen solutions work. Therefore, the results from this research might not be so worthy for them. However, if the results from this research are equivalent to their pilot projects, it will convince them even more that they are heading to the right direction and made a right choice. Nevertheless, they would have still needed pilot projects to test the research results in practice. This thesis gives a good indication of choosing a track & trace product for supply chain at a common level. But the results and conclusions are tailor-made for the customer organization, and therefore may not be applicable to all industries and organizations. Companies in the same industry and situation may find the results useful.

There were only three interview participants in this thesis' interviews. The amount was so low due to scheduling and availability reasons. However, the chosen interviewees were persons who have an essential part in the project, so they were just the right persons to participate. The answers of the participants did not vary much. Especially in the most important questions, all interviewees were unanimous. However, it might have impacted somewhat on the results if more interviewees would have been involved. Probably it would not have affected on the quality of the answers, but it would have brought more credibility to the research if the quantity would have been slightly bigger.

When the research's success is evaluated, it is normal to estimate how reliable the results are. It can be done by finding out if the empirical findings can be repeated under the same circumstances (Hirsjärvi et al. 2007, p. 226). The circumstances and baseline of the research may change between organizations and they may also change in the same company, so it may not lead to the exactly same results. The main reason for this is that the research is qualitative. Although, the key findings should be the same, and the reasons for possible differences should be able to identify. The description of the research and analysis methods in Chapter 1 target at improving the reliability of this research by describing the methods so that it could be repeated. The interview outline used is described in Appendix A.

When the research's validity is evaluated, it should be considered if the research methods achieved accurate and complete results for its purpose. Subjectivity or ambiguous interview questions causing difficulty for participants to interpret the way intended, may cause errors in the validity of the research (Hirsjärvi et al. 2007, pp. 226-227). Accessi-

bility for the researcher and suitability for this research were the baseline for the selection of this thesis' research methods. However, it should be noted that other methods may have also been suitable. The chosen methods were more familiar to the researcher and therefore chosen to this research.

When discussing the success of this thesis, the ability to reach the research objectives and answer the research questions should also be evaluated. In chapters 4.3 and 5.1, the answers to research questions were discussed. Also, it was discussed how the conclusions were reached. As the research questions were answered, it can be said that the main objective of the research was reached. A suitable solution for road cargo track & trace system has been successfully proposed based on findings.

5.3 Further research topics

A recommendation for further research to UPM is to validate the suitability of the chosen solution in practice and pilot projects. In this kind of solution implementations, the suitability of the solution should always be tested properly in pilot projects. Also, the development of technologies is so rapid today, that it should be noted if the project delays a lot. In that case, newer technologies should always be researched again.

It could also be further researched that how does the implementation of the solution effect on the carriers and their drivers. As the customer organization does not have their own fleet, it probably is not their most important priority to investigate the effects on the carriers. However, it is certain that somehow the implementation of new solution and new ways of working does impact on the carriers and drivers as well. It may require for the carriers to invest in the solution if, for example, they need to buy smartphones. They also need to change their working methods because they will have a new service to use in the work. Therefore, it would be interesting and necessary, at least for them, to investigate this topic. It would also be interesting to know how this implementation affects UPM's customers. As the main driver for this project was mentioned to be the improvement of their customer service, it certainly has an impact on the customers as well. Therefore, a further research on this topic might be important.

A topic that very often causes challenges and discussion is change management. It is also present in this case as a new service or a part of system is implemented along with new ways of working. Change management will play a crucial role and therefore it could be a relevant topic to be further researched. This thesis does not provide or recommend ways for change management's implementation. So, these topics should be identified when beginning the integration and implementation phases.

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APPENDIX A: INTERVIEW OUTLINE

- What information should the track & trace solution produce to UPM?
- How often should the information be available (should it be real-time)?
- Who needs this information?
- Why do you need this information (what are you planning to do with it)?
- Price estimate: How expensive can the solution be?
- What benefits do you expect the solution to bring? What kind of return on investment do you expect?
- How should the solution fit into UPM's existing information systems/architecture?