YRKESHÖGSKOLAN NOVIA

Improving Project Logistics by using IoT

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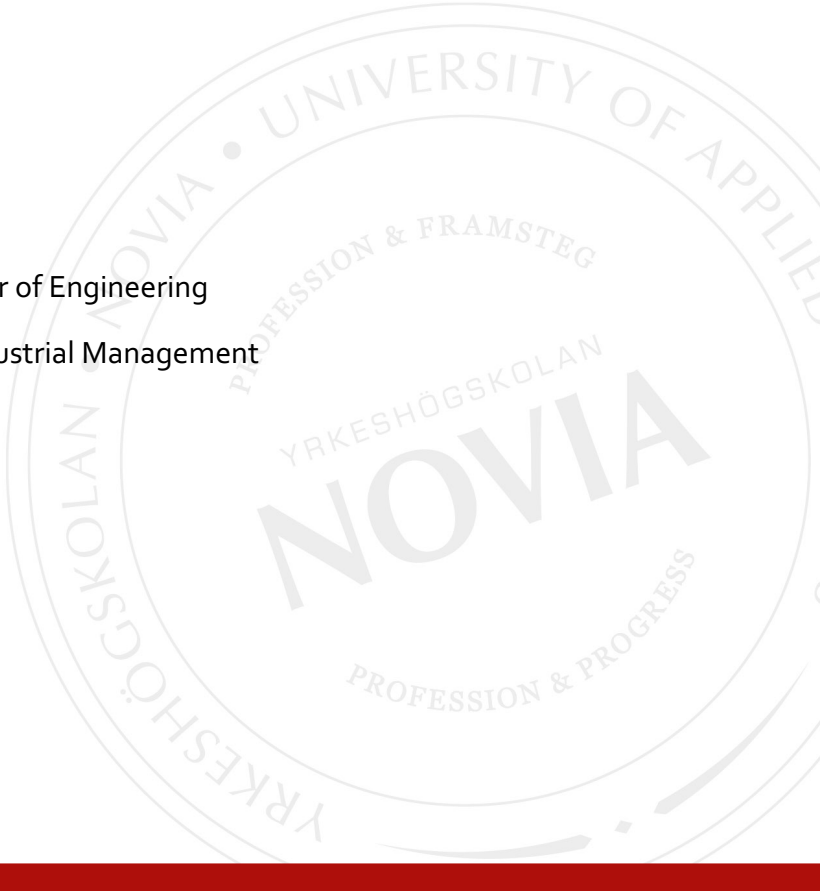

BACHELOR'S THESIS

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Abstract

This Bachelor´s thesis is made on behalf of Wärtsilä Energy Solutions, Project Logistics & Transport Management department whose main task is to coordinate and ensure that materials and products are transported to the right place and on time in Project Logistics.

This thesis examines how you could improve Wärtsilä´s Project Logistics by using Internet of Things. By developing IoT, there has been an increased chance to get more information about transports than before and Wärtsilä is currently looking for new solutions to use that could improve their current logistics system. The **purpose** of this thesis is to review new, and used, solutions on the market, and then see what could work in practice at Wärtsilä.

Material to this thesis are gathered from books, web pages and articles that reviewed interesting IoT solutions and which also gave examples on different solutions that are used by other companies in the same business.

The **Result** is two different methods that could improve Wärtsilä´s Project Logistics in different occasions. These results are intended to give tips on how IoT could improve the department´s ways of coordinating and check transports and logistics within a project.

Language: English Key words: Wärtsilä, IoT, Project Logistics

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EXAMENSARBETE

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Abstrakt

Detta examensarbete är gjort i uppdrag av Wärtsilä Energy Solutions, Project logistics & Transport Management avdelningen vars huvuduppgift är att koordinera och se till att material och produkter transporteras till rätt plats i rätt tid inom projekt logistiken.

Examensarbetet behandlar hur man kunde förbättra Wärtsiläs projekt logistik genom att använda Internet of Things. Genom att IoT har utvecklats har det uppstått möjligheter att få fram mer information om transporter än tidigare och Wärtsilä söker för tillfället nya lösningar som kunde användas för att förbättra deras nuvarande logistiksystem. **Syftet** med arbetet är att gå igenom nya, men även redan befintliga, lösningar som används på dagens marknad - för att sedan se vad som kunde fungera i praktiken hos Wärtsilä.

Material till arbetet är samlat från böcker, webbsidor och artiklar som gick igenom intressanta IoT lösningar och som också gav exempel på hur olika system fungerar och används av andra företag inom samma bransch.

Slutresultatet blev två olika metoder som kunde förbättra Wärtsiläs projekt logistik vid olika tillfällen. Dessa resultat är tänkta för att ge tips på hur IoT kunde förbättra avdelningens sätt hur man koordinerar och granskar transporter och logistiken inom ett projekt.

Språk: Engelska Nyckelord: Wärtsilä, IoT, Projekt Logistik

CONTENT

Table of Figures

ABBREVIATIONS

IoT - Internet of Things

EPC - Engineering, Procurement & Construction

AEO - Authorized Economic Operator

OT – Operational Technology

IT – Information Technology

RFID – Radio Frequency Identification

M2M – Machine to Machine

WSN – Wireless Sensor Networks

SCADA – Supervisory Control and Data Acquisition

WMS – Warehouse Management System

ERP – Enterprise Resource Planning

COMSAT – Communication Satellite

GPS – Global Positioning System

KPI – Key Performance Indicator

1 INTRODUCTION

The first chapter will briefly take you through this thesis background and problem areas, as well as the purpose and delimitation will be discussed. Before presenting the company, disposition will be discussed so you can get a small understanding of this thesis.

1.1 Background

This thesis is made for Wärtsilä Finland, Energy Solutions Project Logistics and Transport Management Department. The task was to search for new IoT solutions which could be implemented and used at Wärtsilä in Project Logistics. I was given this task to answer the question; how could this be efficient and is this possible to implement in Wärtsilä's logistics systems.

Logistics and transportation information goes today through an own developed system. In the system, you can see information from ordering a product to be shipping and delivering the finished product. The information is often manually printed in the system and may sometimes take a while before they will be updated. Products are ordered from subcontractors and the order will be available in the system from the beginning. Subcontractors have often availability to fill in information straight to the system so Wärtsilä can follow their order situation, and when it will be ready for pickup. My task will be to see how IoT could be changed and how the information flow could be upgraded.

IoT have been taking over the information and data transfers the past ten years. This is a system that uses computing devices, digital and mechanical machines to transfer data over the network without human requirements. A thing in the internet can be everything from a sensor on a product to a monitor showing you heart rate. This have opened opportunities to communicate and send data easily around the world (Internet of things agenda, 2016).

"If you think that the internet has changed your life, think again. The IoT is about to change it all over again!" (Ariasystems. 2015)

- Brendan O'Brien, Chief Architect & Co-Founder, Aria Systems

1.2 Problem Area

As mentioned in the background chapter the problem with Wärtsilä´s Logistics information today is that it is in many scenarios, manually printed in their logistics system. I was questioned that **is it possible to arrange so information somehow could automatically go to this system in an easy way, that every customer and subcontractors could use**. When sending a product over the world it is very important that information is updated, so customers and Wärtsilä can see when the product will arrive, and if there are any problems that should be corrected.

1.3 Purpose

My main purpose of this thesis is to **give Wärtsilä new information in IoT** and help them in looking for new Project Logistic solutions. I will focus on information flow when sending a product to a project and go through how this could be upgraded. The secondary purpose is to find a IoT solutions that will suite Wärtsilä and see how efficient this could be if it would be implemented in their logistic system.

1.4 Disposition

The setup of this thesis is divided in 6 chapters, these are:

The first chapter introduction, has the reader got a small overview in what this thesis will contain. Background of this thesis were discussed as well as the main problems and purposes.

Second chapter will briefly take you through Wärtsilä corporation and their different businesses. At last, the department this thesis is made for is presented.

The third chapter will introduce the reader to the theory for this thesis. Basic information about IoT and different case solutions and research will be discussed.

The fourth chapter in this thesis is Methods. The chapter will discuss, how did I reach my results and where did I get the needed material and answers from.

The fifth chapter will present the reader to the Result this thesis have. Results will be presented in figures and words.

The last chapter will take the reader through the thesis and a final conclusion will be made.

2 WÄRTSILÄ

Wärtsilä is a multi-international global leading company in complete lifecycle solutions for the energy- and marine markets with their advanced technologies. The company was founded 1834 and operates today in more than 70 countries over the world with around 18 000 employees. (Wärtsilä, 2017)

One of the biggest key words that is important to Wärtsilä is sustainability. By emphasizing sustainable technologies, they can maximize customer's vessels and power plants environmental and economic performances. (Wärtsilä, 2017)

Wärtsilä's strategies are to be a business partner which have the most value on the market, to change the need of energy and increase environmental awareness. To follow these strategies Wärtsilä must provide energy solutions with new innovations that affects the way customer operates. This is made by constantly looking for new ways to maintain high quality and efficiency. To reach their strategies they also put big effort on their values. In figure 1. you can see that value is divided in three sections; Energy, Excellence and Excitement. This means that they must be better than the competitors and be open minded to test new solutions and innovations. (Wärtsilä, 2017)

Figure 1. Wärtsilä's values. (Annual report. 2011)

Wärtsilä is divided in three different departments; Energy solutions, Marine Solutions and Services. In chapter 2.1, 2.2 and 2.3 you can read more about these businesses.

2.1 Energy Solutions

Energy solutions at Wärtsilä is a department which concentrates on designing and building modern power plants. They offer power plants able to run on any liquid or gas fuels including biofuels. Power plants developed by energy solutions have a high value and are guaranteed to be a good investment for buying customers. By offering support in project development, financing and project services, Energy solutions is a leading Engineering, Procurement & Constructor (EPC) on the market.

You find today their solutions delivered in 176 different countries worldwide, with a capacity range from 10 to 600 MW big power plants at 4700 different projects. (Wärtsilä, 2017)

2.2 Marine Solutions

Wärtsilä have been for a long time a leading provider in ship machinery, propulsion and maneuvering solutions. Wärtsilä states, that every 3rd ship in the world is maneuvered by a Wärtsilä Marine Solution, which is explained in the info video at their website. That means that with experience back from year 1843 they offer products that is designed to be both operationally and environmentally efficient. Marine solutions can provide service from the very early stages of the project throughout the entire project. (Wärtsilä, 2017)

Today the market is changing due to the greenness and environmental friendly solutions and Wärtsilä have been open for new innovations to hold the leading position on the market. Their newest engine is W31 which also is the world´s most efficient 4 stroke diesel engine. (Wärtsilä, 2017)

2.3 Services

When Wärtsilä gets a project, they also offer lifecycle solutions. Services supports customers with expertise in environmental solutions and a portfolio consisting spare parts, maintenance and optimization services. (Wärtsilä, 2017)

Wärtsilä Services have a global availability with highly trained personnel of 4500, stationed in 70 countries worldwide. They are able to handle all types of maintenance, modifications and repair work. Their strategies are to be so close to customers as possible when needed and deliver a professional service. (Wärtsilä, 2017)

2.4 Project Logistics & Transport Management

This thesis will be written for Energy Solutions Project Logistics & Transport Management. They provide Transport & Logistics services in Project Logistics. This department have experience and knowledge in executing heavyweight transports, safely and on time as agreed. As mentioned in the introduction, logistics information is managed through an own developed information system. The department have Authorized Economic Operator (AEO) certification and offers customer communication and progress reports. (Wärtsilä internal, 2017)

Logistics management is a part of supply chain management department at Wärtsilä. Their task is to plan transportations so it´s transported safely and on time from several locations to different projects. This thesis is mainly written to Project Logistics Management and not to regular warehouse logistics. Differences between these two are that in regular warehouse logistics you follow a path. In Project Logistics, Logistic Management varies between projects in how to plan and coordinate transports. (Wärtsilä internal, 2017)

3 THEORY BUILDING

This chapter will be the foundation of this thesis. First I will discuss about IoT in general followed by different IoT cases and researches in companies. Facts is studied in journals, at websites and in books.

3.1 Internet of Things in General

Internet has developed numerous times the last 10 years and was mainly made for connecting computers to each other's. Today we are in a unique period of internet´s lifetime evolving in smartphones, tablets and more. From here we find the foundation to IoT starting early 2000´s connecting physical things by the network. (Macaulay, J. Buckalew, L. Chung, G., 2015)

We find IoT in several places today when we see around us. A forklift was before only used to lift pallets and street lights to only light the sidewalk. Today they are connected to internet resulting in new information and new insights in business values. A connected forklift can for example provide information to the customer when service is needed and intelligent tell locations in the warehouse. A streetlight can sense when light is needed by measure the traffic flow and darkness. To get these kinds of information from physical objects, connections must have diverse array of different technologies as Bluetooth, RFID, WI-FI and ZigBee called operational technology (OT). (Macaulay, J. Buckalew, L. Chung, G., 2015)

Figure 2: IoE, the Networked Connection of People, Process, Data, and Things[5]

Despite that the internet have developed numerous times we are only in the beginning of IoT´s revolution. We are only using one percent of today's potential objects we could connect internet to of 15 trillion IP-addresses. Cisco have estimated that by year 2020 there will be about 50 billion devices connected to the internet, instead of 15 billion that we had in year 2015. These connections have changed internet and will be the future in information flow between human and physical objects. (Macaulay, J. Buckalew, L. Chung, G., 2015)

3.2 Operational and Information Technologies

To control and monitor physical devices you need a software and hardware categorized as an Operational Technology. In the past, there were big differences between Operational Technology (OT) and Information Technology (IT). OT was made as an industrial control system that wasn´t connected to any network as IT was. But today OT and IT have been developed so they can work together as a "smart" hardware system. From that we have new internet-capable technologies that have taken over the industrial control systems. (Techtarget, 2016)

In the next chapters, you can read more about different types of Operational and Information Technologies.

3.2.1 M2M

Machine to Machine (M2M), is a system that sends data without manual assistance by using technology devices that have a network connection. The system was most known from the M2M communication system Telemetry, that is a wireless transmission and automatic measurement data receiver. M2M have been built in many products. These products with built in M2M is referred as a "smart" device platform. (Internet of things agenda, 2010),

M2M is a basic concept in IoT and is used in for example Logistics Services, Supply Chain Management, Traffic Control and Warehouse Management. Components that M2M includes is any types of sensors, RFID-tags and Wireless network that can be cellular or hybrid. To get collected data from these components they must be attached to a central server (Software program) that can convert the data to needed information. Any standardized M2M systems are currently not found. Instead the systems are built specific for different tasks and situations. (Internet of things agenda, 2010), (Zhou, Honbo, 2013, p.63)

3.2.2 Bluetooth

Bluetooth is a system that can wirelessly exchange data to another device at a short distance. The name Bluetooth reflects the origin of Scandinavian technologies. You can find Bluetooth in many devices today as smartphones, computers, cameras and in every device that have an inbuilt chip. To transmit data through Bluetooth, it creates a short range of network where it can securely transfer radio frequencies. (BBC, 2012)

Bluetooth have a big role in many IoT solutions and can be in the future connected with 30 billion devices in the next five years. In logistics, it is often used to transfer information from products that are delivered or will be shipped. The consumer only need a sensor, tag or a chip on the product to integrate with the Bluetooth sensor to get data. After new features updates for IoT solutions, Bluetooth have a four-time longer network range than another OT. Other specifications Bluetooth have compared to the competitors in IoT is that it is a much smaller hardware device to operate and have a small battery that can operate for months or years. (Readwrite, 2016)

3.2.3 RFID

RFID stands for Radio Frequency Identification and is an operating technology since year 1970, that uses radio waves to automatically send and identify data. This system uses a RFID tag that is a chip that can be passive or active, attached to an antenna to send identified information. The received data can be converted to digital information, which can easily be send to a connected computer. (RFID Journal, 2017)

RFID got its big boost in early 2000´s when Supply Chains in companies saw the opportunities with this system, tracking pallets and cartons. Michael Fein who is Senior Product Manager for RFID at Zebra Technologies said that "*people had unfair expectations that it could change the world in a couple of years. But if you look at the technology adoption curve, RFID is not at all behind. I´d say the technology is doing well"*. RFID was a concept years before IoT was introduced and is today almost 20 years later a IoT system that companies prefer to use. (Logistics Management, 2013)

3.2.4 WSN

Wireless Sensor Networks (WSN) is the transducers of internet. It consists of different sensors that can collect data in environmental conditions, for example the products temperature, pressure and motion. Collected data from sensors is converted often through a short-range wireless network. (Zhou, Honbo, 2013, p.80-87)

The recent technology development has led to that sensors can make own decisions based on observations and processed data. WSN was developed for military in battlefield surveillance but is also implemented in buildings, home automations and different environmental monitors, where it can detect chemical, nuclear and biological attacks. (Zhou, Honbo, 2013, p.80-87)

WSN market is growing fast on the market and according to IDTechEx it will grow from 0.45 billion US dollars in 2011 to 2 billion US dollars in 2012. The United States stands for 72% of the WSN development worldwide. The U.S military have invested and created new solutions in this IoT solution in many years and thanks to international corporations as IBM and Microsoft, WSN is expected to be the next model of computing. (Zhou, Honbo, 2013, p.80-87)

3.2.5 SCADA

Supervisory Control and Data Acquisition (SCADA), is a system for the controllers of the internet meaning it uses computer systems to monitor and control different types of industrial and infrastructure processes at locally and remote locations. Companies uses this for processing real-time data that helps in taking smarter decisions and analyzing. SCADA can be compared to other systems as Warehouse Management System (WMS) and Enterprise Resource Planning (ERP). (Zhou, Honbo, 2013, p.88-94), (Inductive Automation)

A typical SCADA system consist of a device where the human can monitor and control processes through different sensors and PLC devices. In IoT, SCADA is a more extended scope compared to M2M and WSN. (Zhou, Honbo, 2013, p.88-94)

3.3 IoT sensors

Sensors are used to gather information from several physical objects connected to an Operational Technology. In IoT these are often combined with many other solutions to get a more desirable result.

Organisations have a wide option of sensors to choose depending on what information they need. For example, a sensor can detect speed, size, temperature or location and more, which will be explained more detailed in this section. (Helgar, Peter, 1998, p.1-2)

- **Measurement of Motion** can be measured in linear, angular and proximity. Sensors are detecting any small displacements by putting in the right information when programming. An Optical Sensor is one that can detect a motion by using diodes light reflected on a sensor. When light doesn´t reach the sensor, it will alert the motion.

- **Size Measurement** sensors are used to detect volume, height and level. They can be floating devices when needed information about liquid or devices that sends electrical reflections to the sensor to get size data.

- **Temperature Measurement** sensors measures the temperature around and in the object. This is important when some objects are very sensitive and need the right temperature. Some examples of temperature sensors are liquid, electrical and metal sensors.

- **Display and Recording** sensors give an additional information that can be analysed to needed data. These sensors can be combined with other sensors to get a more specific result and record more data.

Sensors aren´t today so expensive and according to The Globe & Mail, sensor price will sink from today's average cost on a sensor of 0,50 cents to 0,38 cents by 2020. (Cio, 2015)

In the marine business, sensors are used on containers and large products. A company called Tote Maritime have developed and invested the last year in 350 new high-tech containers that can be monitored. They use a system called VesselConnect by Orbcomm. This system uses sensors to detect location, temperature and shipping status that can be monitored from land. If a sensor detects any failures it will alert the monitors so an engineer can promptly check it out. (Twentyman, 2017)

3.4 Satellite IoT

Satellites in IoT are used for receiving data from one location through radio waves, and sends it to another location, also called *bent pipe*. Hundreds of Communication Satellites, COMSAT, are operated in space specialized on wireless data manoeuvring. These are used for network communication in wider areas, for example; planes, ships and Global System Positioning, GPS, which are important to transport and maritime business. (Zhou, Honbo, 2013, p.119-121)

"*For vehicles that moves in urban areas or on major highways, cellular coverage is usually good enough, but what about construction equipment at remote locations, agricultural equipment or ships? That´s where satellite communications comes into play*". (Zhou, Honbo, 2013, p.119-121)

A major issue about satellite communication can be the cost. High cost depends on that IoT data are received through a two-way transmission to a smaller satellite rather than a one-way transmission satellite used for example TV´s. Therefore, the cost per gigabyte is higher. This could be lowered by using a dual-mode device meaning that it combines cellular and satellite data sending. Information are received through cellular network when it is available, but in need of information in a hurry, data can be send through the satellite connection. A company who have this solution is ORBCOMM, that have designed a device specialized on dual-mode data sending. The company also offer a security and alert application. Their products are used by customers such as Volvo Trucking and Caterpillar where they can manage and track their equipment over the world. (Zhou, Honbo, 2013, p.119-121)

ORBCOMM have a product called *The GT 1100* that can be attached on many products. It is self-powered and charging by solar panels meaning that it has a low maintenance and service requirements. (Orbcomm)

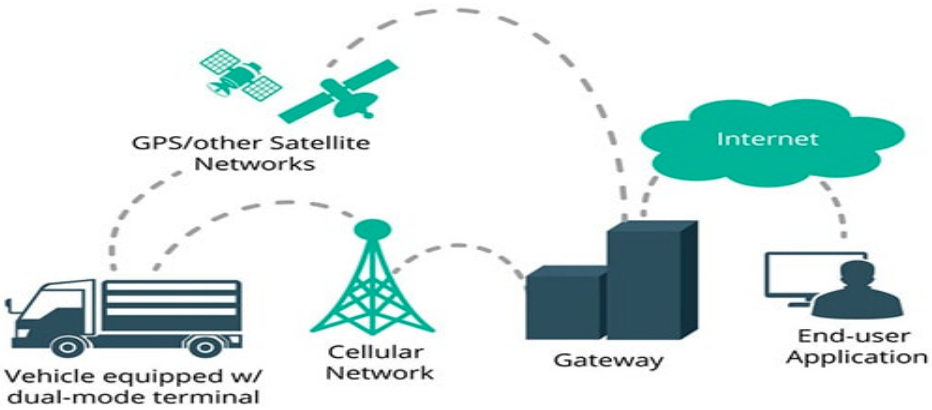


Figure 3. Model of dual-mode connection. (Orbcomm)

3.5 IoT Security

Sometimes companies have a hurry to implement their IoT solutions in their business, that they forget to overlook the importance of the security features. By storing all data and information in the cloud it can easily be visible and exposed for attackers and unauthorized parties with a weak security. (IoT Analytics, 2016)

Example of a solutions with poor security can be that devices password are included in the source code and visible for attackers. Another problem can be that the whole company network is easily hacked and information can be gathered and destroyed. To prevent security flaws like this IoT systems should have a program that covers devices, cloud and everything between it. This can be done by combining a hardware and software solution in the IoT concept. (IoT Analytics, 2016)

Vendors are frequently pushing the customer to be aware of these security challenges. The customer must know the possible cyber threats and think through the security from end to end. This means that all the possible attacks are blocked and thought through, and unauthorized devices are access restricted by the security program. To get a good end to end solution the company can create a security-by-design. A security-by-design are made of security experts, engineers and people involved in the IoT team. Security staff are also involved from the beginning and across the whole product lifecycle, which leads to a more modern and safe solution. (IoT Analytics, 2016)

A good security solution could include the following practices:

- Employing a hardware-based security.
- Use a unique identity key to the devices.
- Protect the devices behind a security firewall.
- Use a device that verifies user ID´s.
- Choose a based security approach that is easy to use.
- Enable security monitoring meaning that the company employs a security analytic.

A IoT solution should have a software and hardware that are non-vulnerable and trustworthy in security aspects. (IoT Analytics, 2016)

3.6 How to implement IoT

When a company choose to get involved in IoT the first criteria is to think through, what are our visions, what data do we want to collect, how will this data be collected and how would this be efficient. They have to sit down with their engineers and involved teams and discuss the problems an IoT solution could fix. As mentioned in the security chapter 3.5 companies are going too quickly forward with their IoT solutions and underestimate the timeline of the implementation project. A successful IoT solution could take approximately 18-24 months to get on the market from when the project started. (IoT Analytics, 2016)

"When we started our IoT implementation effort we had no clue what we needed and who to approach – to be honest, we didn't even know what we were looking for."

IoT Project Manager at a Machinery OEM. (IoT Analytics, 2016)

3.6.1 Build Vs. Buy

When the criteria's are thought through, the company have to choose if they want to buy the solution of a third-party, that have good expertise in IoT solutions or if they want to develop a solution from scratch. Today it has become more normal to choose an out-of-the-box solution by a third-party than before, because this is a faster concept to choose and they will get access to good expertise and skills within IoT.

Benefits:	Reasoning:
a. Quicker Time To Market	Critical infrastructure in place by default
b. Access to crucial skills	Readily available partner network with expertise across domains
c. Secure by design	Secure development lifecycle builds in security from outset
d. Optimized to work with wider ecosystem	Aligned with industry standards across partner ecosystems e.g., IIC[§]
e. Scale with ease	Modularized and optimized for large scale deployments
f. Enable a more end-to-end offering	Multiple parts work together from one vendor e.g., OS[§], Cloud, Analytics

Figure 4. Why companies go with out-of-the-box solutions. (IOT Analytics, 2016)

When choosing to develop a solution from scratch companies often doesn´t understand that they doesn´t have the expertise and skills in security design, software programming and

cloud architecture that are needed in implementing IoT systems. But if they still choose to develop it they need to involve experts to get a deep knowledge in different fields.

When deciding to develop this solution with a third-party they should choose a partner that have the same visions in this project. In the long term being locked with a vendor that doesn´t fit the company can lead to a failure in implementing the solution and unwanted costs. Vendors often offers free trial sessions to interested companies where they can test the solution and see how it works. But even though it is free to test the solution, it will cost to get the free trial solution up running. By choosing a partnership with a company that have good expertise in IoT solutions the company also get access to a wide partnership network. This means that the cloud vendor and software company can have built their devices with the same setup and may also have worked together in previously projects, which can be a key to an easier implementation of the solution for both the vendor and the customer. (IoT Analytics, 2016)

Partner Type:	Partner strength:
Device hardware vendors	Enable quick start prototyping
Original design manufacturers	Offer reference PCBs for “white label” solutions
Silicon / chip vendors	Customize specific designs for embedded systems
Gateway partners	Deliver security-enhanced data flows
Communication partners	Support connectivity across multiple networks
Cloud platform providers	Offer a cloud computing backend and supporting infrastructure
Independent software vendors	Bring holistic solution development expertise
Analytics professional service providers	Offer unique expertise in big data analytics and data science services
System integrators	Play a central role in stitching solutions together

Figure 5. IoT Partner Network. (IoT Analytics, 2016)

3.6.2 Organizational and Cultural changes

When implementing an IoT solution it is more successful if many departments within the company could take advantage of it and develop it together. The solution would be standardised in the company’s management and tested in many scenarios. By standardising, employees will mentally embrace the situation and learn by doing and interact with the project. (IoT Analytics, 2016)

3.7 Measure IoT

When a company have implemented and are using a IoT solution it is important to measure your success and see if it´s giving something back. To measure these kind of systems, companies use different kinds of KPI´s (Key Performance Indicators) that are specialized on measure performance. It´s important to put up goals for your IoT system before measuring it, so it can later measure if individual goals are achieved. (Heflo, 2017)

Example of some KPI´s to measure your IoT success are:

- **Efficient Indicator** measure your achieved result in relation to recourses used. The goal here are to get the best result with least amount of resources. Focusing on measuring this KPI, the company can reduce unnecessary costs with the IoT system.

- **Effectiveness Indicator** measure your received result in relation to your expected result. Considering and measuring your received result can bring benefits, as for example, higher profits.

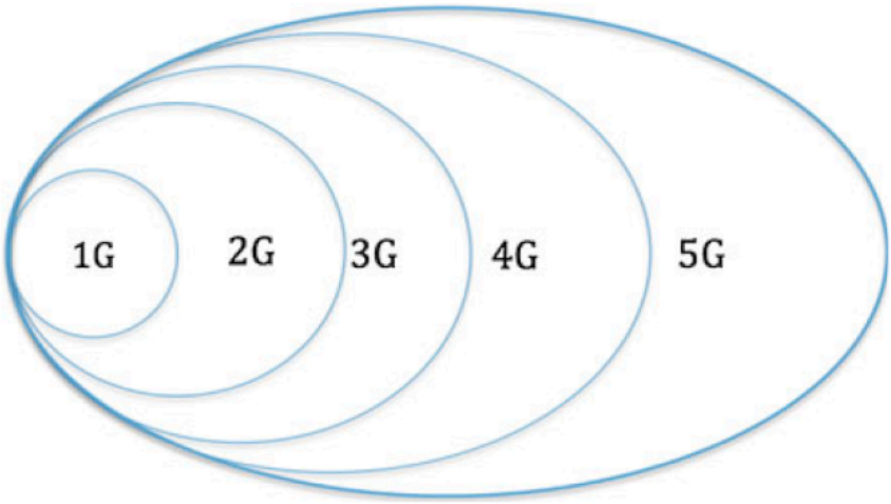
- **Quality Indicator** measuring company´s service quality. Gather information from every collected data and calculate the quality from total output and products with week quality and faults.

- **Value Indicator** measuring the value you get from using the implemented IoT system. Collecting data from the customers product.

So why use KPI´s to measure your IoT solution? By measuring IoT´s success, the company will have information that can be needed for different situations. It will track and follow your business and convert it to analyses that are available to managers at the company. These are used so the right decisions are made in the situation. Efficiency and effectiveness measurement will bring positive results and will be important for the management. It will also improve the speed and understanding of results. If the achieved goal is not what you aimed for, it will analyse what the problems are. (Heflo, 2017)

3.8 The Future in Tracking Management

IoT are in a phase when it is undergoing a transformation in the next years and industries will change with it. Automations will develop further and human interaction will decrease, when communication are expected in year 2020 go through machine technologies. By the development, machines need a more advanced wireless connection to operate. Our future in Wireless connectivity are 5G that are expected to future voice and data, that 1G to 4G do compared. It will provide 1000 times higher wireless area capacity. The energy consumption will decrease with 90 % and are made to treat over 7 billion people. (Mavromoustakis, C. Mastorakis, G. Mongay Batall, J, 2016, p.55-60)



Figur 6. 5G is expected to feature voice, data, always on connectivity – everything that 1G to 4G offered (Mavromoustakis, C. Mastorakis, G. Mongay Batall, J, 2016, p.56)

By year 2020 it´s expected that 5G will be on the market and technologies will change according to it. Companies as Nokia and Ericsson have made services to test 5G capability. IoT solutions with a large number of meters and sensors have been tested so 5G could develop around these requests. It is expected that 5G wireless network will be a standard for IoT solutions in the future. (Mavromoustakis, C. Mastorakis, G. Mongay Batall, J, 2016, p55-60)

GPS are also developing and popping up in many technologies. Today we use GPS in industries for vehicle tracking and monitoring. GPS are expected to become more powerful and decrease in size. This will lead to GPS will be more used in IoT in different scenarios. (Tracking the World, 2017)

4 METHODOLOGY

This chapter will introduce to the reader, how and with which method I gathered information for my empirical part, to get my final result for my Bachelor´s thesis. I will first discuss my method of argument and how this thesis started, followed by validity and reliability of material in this thesis.

4.1 Choice of Method with Arguments

This thesis took start from when I contacted my supervisor Mikael Lindberg at Wärtsilä. I was interested in writing my Bachelor´s thesis about Transport and Logistics. We had a meeting where we sat down and discussed possible topics I could write about. After several discussions, we decided that IoT could be interesting to write about, because Wärtsilä are at the moment studying and searching for new solutions to implement in Project Logistics. I got several questions from my supervisor I could research in, which also this thesis will answer on, from my point of view.

At the moment, when I got my topic for my Bachelor´s thesis I was working at Wärtsilä Energy Solutions, Project Logistics and Transport Management department. I had some knowledge about IoT and I used their software they are using daily, so I could recognise the flaws with the system if there were any. I wrote down some problems I had when using the software, that I could later study about and see if there are any solutions that could fix it.

After a meeting with my supervisor at Novia I got some examples where I could find material for my thesis. I chose to read a book called *The Internet of Things in the Cloud* authored by Honbo Zhou. This book had a lot of interesting new studies about IoT in several, and I got new knowledge about different solutions I could use for this thesis. For more specific material needed, I decided to search on the internet for published articles and company websites. These internet websites and articles were easy to find and reliable to pick.

Material for the topic IoT are very wide and a lot to pick from. I chose to write about those solutions I think would serve Wärtsilä like they wanted. These solutions were also used by several companies in the same business, which also made it easier for me when I could see case examples of IoT solutions how they could work in general in a big company. By searching material from internet articles and internet websites I got the latest information about IoT, that also was important for this research, because they wanted new solutions to work with.

4.2 Validity and Reliability

The material of this thesis has in my opinion a good validity, because I have researched in the newest material you can find in books and on the internet. The material is based on used solutions by other companies that are updated and analysed well. The validity of this material is very important, so the result can be a solution that could serve Wärtsilä well.

Solutions Wärtsilä wanted from this thesis, should be a working concept and the information I have picked are reliable. Reliability of the material are as I mentioned earlier very good, because there were used IoT solutions that I could find in articles and on websites that other companies use.

5 RESULT

In this chapter I will present the result of my study. From reading books and studies about the topic, I have found more than one IoT solution that could be implemented at Wärtsilä in different cases. These solutions will be discussed and shown in figures to get a better picture how they could work at Wärtsilä if they were implemented. In the end of this chapter there will be a chart where IoT solutions in this result will be compared.

Each solution can be found in the theoretical part of this thesis where you can read more detailed how they work and case examples in other companies.

5.1 Dual-mode

The first IoT solution that I have chosen to present, that would work in several cases at Wärtsilä Energy Solutions, Project Logistics, are a satellite system with a Dual-mode solution. As mentioned in chapter 3.4, sending data through satellites are in the long turn more expensive than other systems. But it would be important to have GPS connection if you want to know live updates where your products are, and if there aren´t any cellular connection available around. That´s why dual-mode would be useful in many scenarios which I will explain more detailed about.

Dual-mode would be useful in Project Logistics when Wärtsilä are sending engines, generators and larger products that can´t fit a container. A small box containing chips and GPS senders would be attached on the transport equipment's that could be re-used. Dual-mode could also be attached on containers but are more difficult due to the many subcontractors Wärtsilä have where containers will be loaded and packed. When implementing a dual-mode I would prefer that Wärtsilä would choose a company that have a complete solution, because this system requires a lot of knowledge to get it work like you want it to do. This would save time and the company would have a partner that have done this before.

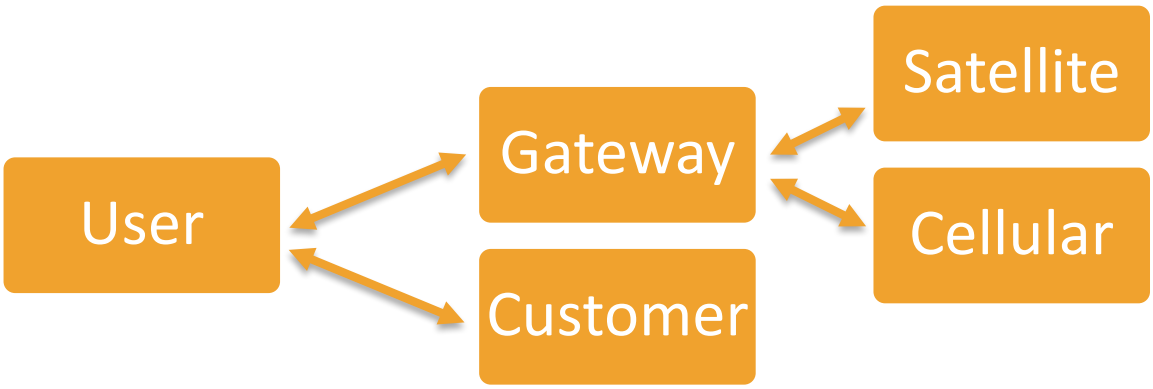


Figure 7. How Dual-mode solution works.

A company that I mentioned in chapter 3.4 which have worked with other big companies are Orbcomm, who are specialized on these dual-mode solutions. They have a dual-mode chip *The GT 1100* (figure 8.) that can be attached on many products. It is self-powered and charging by solar panels, meaning that it has a low maintenance and service requirements. They also offer a security and alert application in this system that Wärtsilä could have use of when equipment's often are unguarded.

Figure 8. Orbcomm Dual-mode The GT 1100. (Source, Orbcomm)

5.2 Passive RFID with Sensors

My second IoT I have chosen are a solution with passive RFID-tags, combined with smart sensors. This solution would serve Wärtsilä in Project Logistics, when smaller equipment and products are transported. Wärtsilä wanted to have a solution where you could check for example the temperature around the cargo, security alerts and automated checkpoints. In those examples would passive RFID-tags and sensors work.

As I mentioned in chapter 3.3, sensors are decreasing in price and becomes more and more a popular IoT solution for companies. This solution would be the most reasonable because of the lack of batteries.

A passive RFID-tag would be placed like a sticker on equipment and products where it is easy to recognise. Due to the many subcontractors Wärtsilä have, where containers are loaded, it would be up to these to handle and attach these RFID-tags before delivery. When cargo have arrived at the destination, employers have a scanning device that are connected to Wärtsilä´s logistics system, which will updated the information where the cargo is. A passive RFID-tag have no batteries which radically lower the cost of the IoT operation. This solution would develop Wärtsilä´s logistic system to a more automated solution and employees would have more control over their cargo than it is done today.

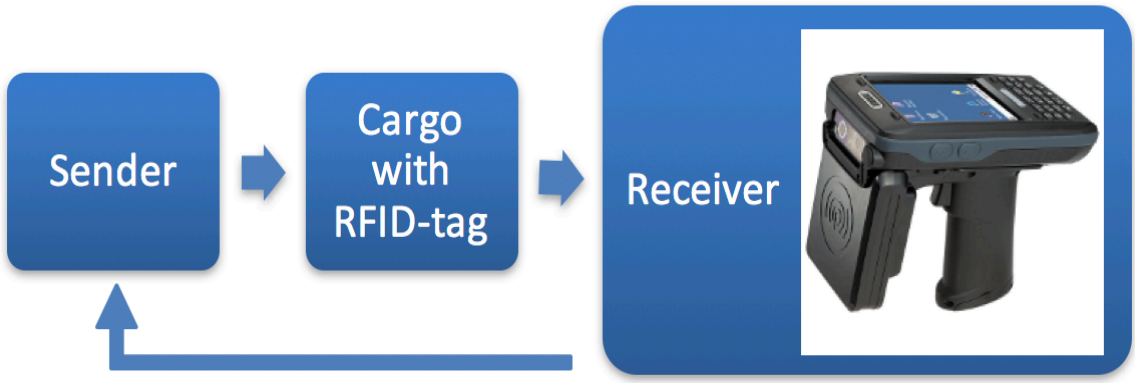


Figure 9. Example of how a solution with passive RFID-tag would work.

To get temperature and security data, you need sensors around or on your cargo. Products that are sensitive and have high requirements on temperature would be equipped with temperature smart sensors. Sensors would be handed out to those subcontractors who pack these products so it is placed on the product before delivery. These sensors could also contain a GPS sender if there are important to know the location of it. To receive data from these sensors, container´s should be equipped with a data transmitter that can receive and transmit data to users. A downside with sensors are battery time. It requires some maintenance and have a life span until the battery dies, compared with a dual-mode with solar power that charge itself.

5.3 Comparison between solutions

These solutions I have chosen works different and are designed for different cases. But they have also some features that are the same, and those will be compared in this section.

Dual-mode have an advantage when you can monitor your cargo live through GPS or cellular connection whenever you want. By also having solar power batteries, it has a longer life span in relation to sensors that have a life span as long as the battery hold. A Sensor battery time are between 3-5 years, depending on work task.

If temperature and security alert are important, Wärtsilä should choose smart sensors that can alert suspicious actions. Also temperature alerts from sensitive cargo are operated by Smart sensors. By combining Smart sensors with Passive RFID-tag, Wärtsilä could have more updated information about their Project Logistics cargo, which would save time and customers will have access to important information when needed.

	Dual-mode	Smart sensor	Passive RFID
Price	High	Low	Low
Operating costs	Medium	Low	Low
Size of object	High	Low	Low
Battery time	High	Medium	-
Data range	High	Low	Medium
Data type	Satellite, Cellular	Bluetooth	Radio waves
Life span	High	Medium	High
Live monitoring	Yes	No	No
Temperature alert	No	Yes	No
Security alert	Yes	Yes	No

Figure 10. Comparison between IoT solutions.

6 CONCLUSION

In this chapter I will present my conclusion from this thesis. First there will be a short section with the problems I had with this thesis. I will also discuss about what Wärtsilä could study more about, which you can find in my proposal for further research. At last you can read a short summary, where I will discuss how I think this thesis have gone and what I have contributed to Wärtsilä.

6.1 Problems

Problems with thesis was to find a solution that could work at Wärtsilä and have the features that was requested from the department. As I mentioned Wärtsilä don´t have their own containers they use and that was a big problem for me. Many IoT solutions requires for example built in Bluetooth or WI-FI connections in containers. This couldn´t I require that Wärtsilä should have because of the big investing costs it would have been if they needed such containers.

Another problem was that most IoT solutions are custom made for companies and are hard to copy because of the different types of how they manage their logistics.

6.2 Proposal for Further Research

When you are writing about IoT you find a lot of information and new solutions that are made for the business market. This thesis was only a short example of what I think could work at Wärtsilä today. It is important that Wärtsilä follow what the IoT market are offering and implement solutions that can be developed according to requests. Many blogs and articles that I read mentioned that IoT will changes the way we do things in the future and this are important that Wärtsilä will follow and study more about.

My proposal for Further Research would be that you could study more about the future and see if there are any IoT solutions that will change the way we today see on logistic monitoring. Then they could implement a solution with space for further developments and solutions.

6.3 Summary

The topic IoT was very interesting to write and study about. Information was never a problem to find and it was almost difficult to choose which information I should choose to write about. The theoretical part was very time consuming but interesting. After writing this thesis I have learned a lot about how Logistics Management can be done in so many way´s with different types of IoT solutions.

The goal was to find a solution that could work at Wärtsilä´s Project Logistics and see how this could work.

I think that my contribution to Wärtsilä with this thesis are important in how they will look at their Logistic Management. They will have a good theoretical chapter where they can read about different IoT solutions followed by recommended IoT solutions that could work at Wärtsilä Project Logistics from my point of view. They will also have a co-worker with a good knowledge about IoT.

At last I want to thank my supervisor at Wärtsilä, Mikael Lindberg that I got this opportunity to write my Bachelor´s thesis for Wärtsilä Energy Solutions.

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