Internet of Things Framework for Last Mile Logistics

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Abstract

Technologies often revolutionize the way some industries operate and currently on such technology is the Internet of Things. Some companies have already started using this technology and this forces the rest of the companies on the market to respond by also incorporating IoT in their operations to stay

The world of logistics is consistently growing and improving. With modern technologies like autonomous vehicles, unmanned drones and especially the Internet of Things, the logistics sector is one of the markets that can take advantage from these technologies. Connected devices give logistics organisations the opportunity to greatly increase their efficiency and gain a huge competitive advantage over rival companies. Although IoT has been used in logistics for many years, this technology has improved significantly over the last few years and will continue to improve. This significant improvement will bring a wave of new sophisticated devices that will revolutionize the standards and traditional ways businesses operate, transforming the entire logistics sector.

Last Mile Delivery logistics is the only point of contact that customers have with the entire logistics process. Therefore, it is very important for companies to invest in last mile delivery processes and provide their customers with the best services possible. With the current state of Internet of Things, Last Mile Delivery can become fully automated. This can have massive impact on efficiency by completely removing manual tasks that have to be performed by people and so eliminating human error.

Acknowledgment

I would like to thank my supervisor Dr. Natasha Edwards for working with me on this project and for all the support and supervision she has given me. We have had excellent verbal and written communication which allowed both of us to be flexible and schedule our meetings accordingly. The supervision sessions have been very helpful and have been essential for the successful completion of the project.

1. Introduction

Introduction: This chapter discusses what the project is about and how it was planned to be accomplished through the project's aims and objectives.

1.1 Project Aims and Objectives

1.1.1 Project Aims

The main aim of the project is to provide a framework that companies dealing with logistics can follow in order to incorporate Internet of Things in their operations and make effective use of it. The guide will be created by carrying out a strategic analysis of logistics organisations that use the Internet of Things and analysing the activities and aims these companies have in common and using them to create rules that should be followed to successfully incorporate the Internet of Things. To accomplish this, various smaller objectives should be completed (§1.1.2). Although the focus of the project is on logistics and more specifically "Last Mile Delivery", all companies are different and work with their own procedures, so the guideline will not be personalized for a specific company, but it will be generalized so as much logistic companies as possible can benefit from it. Last Mile Delivery has different meaning according to different people. Some say that the "Last Mile" is the transportation of goods from the warehouse to the final delivery destination. On the other hand, other people say that it is the transportation of goods from the warehouse to the final delivery destination and collecting goods on the return trip. I agree with the first class of people and my opinion is that the Last Mile Delivery does not include the return trip. The models that I have created, and the analyses are based on the definition of Last Mile Delivery that does not include the return trip.

1.1.2 Project Objectives

1. Research
    - Research Internet of Things in Logistics – find out how it is used in the logistics
    - Research organisations that use or are planning to use Internet of Things in logistics – find out what companies use or plan to use Internet of Things in the near future.
    - Collect data and information – find relative sources of information (documents, books, etc.) that will be used as basis for the analysis. A sufficient amount of data and information should be collected before starting the analysis. All the data and information used will be open source or available to me through my university credentials and it will be referenced.
2. Analysis of the findings
    - Choose and justify the methodologies that will be used to analyse data and to carry out the strategic analysis
    - Analyse and understand the impact of Internet of Things in logistics – to produce a strategic analysis, a good understanding of the companies, their goals and how they operate is required. There are some companies that are already using these technologies, so their impact can be analysed.
    - Analyse and understand the advantages of the Internet of Things – this innovative technology can bring many benefits for companies that utilize it. It can bring benefits in terms of improving delivery rate, decreasing costs, minimizing errors in logistics or it can almost, if not fully, eliminate human error.
    - Analyse and understand the disadvantages of the Internet of Things

- Analyse and understand the impact of the Internet of Things on world economy
- Analyse future perspectives for the Internet of Things
- Create models representing IoT in logistics

3. Final report
   - Explanation and justification of what has been done and why certain methodologies and techniques have been used
   - Check if all referenced materials are listed.
   - Review the entire project to check if there is no irrelevant information, missing information or if any corrections are needed.
   - Finalize and submit the project

1.2 Scope

The project focuses on companies that are leaders on the logistics market. In order to have enough and diverse information about logistics, I focused on two major logistics companies: DHL and Amazon. These companies were chosen for the project because both of them are world market leaders in logistics and they already use Internet of Things in some of their operations. Based on their structure and way of doing their business operations, a generalized set of rules, or a framework, can be built and because these companies represent different parts of the logistics sector, the knowledge I gain about these companies will help me build a model that can be used by various logistics companies. Although not all company information is publicly available (§6.1) about processes and use of technology, these two companies have released official reports and with the addition of case studies a sufficient amount of information is available for the purpose of the project.

1.3 Outcome

The outcome of the project is to create a guideline that companies can use to improve their business operations by utilizing Internet of Things. The aim is to help companies improve their operations, which will result in more profit for the companies and possibly more satisfied clients.

Summary: This chapter briefly explained how the project was handled and its main aims and objectives.

2. Work Plan

Introduction: This chapter demonstrates how the project was scheduled. Information about what activities have been carried out and at what point of time can be seen in the Gantt Chart provided. Although there were changes to the project, there was a specified plan that was followed. The Gantt Chart shows only the activities there are a part of the final version of the project.

A Gantt Chart is a method for visializing the activities of a project and how tey are scheduled over time. It is an easy, efficiend and widely used method for developing a work plan. This type of chart can be used in the planning stage of a project of any size as activities can be vizualized over time or as an activity that is done at a specific point of time.

The created chart illustrates the activities that were done for the project, how they were scheduled and at what point of time they were actially done. Every activity is presented with an individual color. The brighter shades indicate the planned duration of activities while the darked shades show the time spent on each activity after the scheduled duration. Milestones are shown in the chart with red star signs (*) and other events that are not spread over a long period of time are shown with hashtag symbols (#).

Work Plan Gantt Chart:

Gantt Chart for Project 88 (Internet of Things Framework for Last Mile Logistics)

					Periods												
Activity	**Plan Start**	**Plan Duration**	**Actual Start**	**Actual Duration**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**	**Easter Recess**	**Week 9**	**Week 10**	**Week 11**	**Week 12**	**VIVA**
Submit initial report	Week 2		Week 2		*												
Collection of data	Week 1	4 weeks	Week 3	6 weeks													
Choose what methodologies and frameworks will be used	Week 3	2 weeks	Week 3	6 weeks + Easter Recess													
Analyse and interpert data (review literature)	Week 3	3 weeks	Week 3	7 weeks + Easter Recess													
Complete selection of methodologies	Week 4							*									
Complete selection of companies that will be analyzed	Week 5							*									
Carry out SSM analyses and create models	Week 7	3 weeks + Easter Recess	Week 7	4 weeks + Easter Recess													
Complete Porter 5 Forces Analysis	Week 10	1 week	Week 10	1 week													
Create Activities Table	Week 11	1 week	Week 11	1 week													
Create framework (Business Process Map)	Week 9	3 weeks	Week 9	4 weeks													
Write findings of the analyses and final report	Week 6	7 weeks	Week 6	7 weeks													
Submit final report	Week 12															*	
Weekly meetings with supervisor	Once a week from Week 3 onwards		Week 3			#		#	#	#	#			#	#		
Project review meetings with supervisor	Week 7 and Week 10									#				#			
Project completion	Week 13-15																*

* - Milestone
- Event

The Gantt Chart of the work plan can be seen in detail and with better quality in Appendix A (§11).

3. Literature Review

Introduction: This chapter reviews what was researched in order to gain a better understanding of the companies and methodologies that are used. It also explains the impact of Internet of Things technology, the Logistics sector and the use of IoT in Logistics. The impact of IoT on economy and IoT in organisations are also reviewed.

3.1 Internet of Things

The Internet of Things is a way of using technologies so that human activity is minimized. Machines communicate with each other and do activities on their own. It is a relatively new approach, but its benefits are well known. It works by tagging every machine and item that needs to communicate with other machines and items. There are multiple methods for tagging. Some of them are attaching a radio frequency identificatory tags (RFID), bar codes, quick read codes (QR) and many others. There also has to be a system (software) that supports the communication between the tags.

The Internet of Things includes all devices from small sensors to smart factories. Every device connected to the internet is a part of the internet of things, but the term Internet of Things is usually used about connected devices that communicate with each other. By connecting all devices, the data can be studied and used to improve operations to create more benefits.

In Logistics, the Internet of Things is used at distinct levels. The three main levels in logistics are Warehouse Operations, Freight Transportation and Last Mile Delivery. IoT is used to connect various assets along the entire supply chain and then the collected data is used to find out what can be improved and how.

Specifically, for the logistics sector, the Internet of Things is not a new insight. It is one of the first industries that started widely using IoT with devices that scanned barcodes on items. Later items condition started being monitored while in transit. Today IoT is much more advanced and brings many benefits to the companies that use it.

3.2 Organisations using the Internet of Things

Organisations in all industries use the Internet of Things in various ways. In 2017, there were about 8.4 billion IoT-capable devices worldwide and the number is rapidly increasing. In just one year, from 2016 to 2017, the number of such devices increased by 31%. Some of the largest companies using Internet of Things are DHL, Amazon, Huawei, Cisco, Samsung, Dell and Bosch, as well as many other large companies. These companies are globally well-known and established organisations with many clients and responsibilities. The Internet of things has played a significant role in the business of these companies and its influence is continually increasing as technologies advance and more and more companies start using IoT.

IoT is not used only by large companies. There are SMEs and even startups that use this kind of technology. It is a technology that can be used by any company, as long as everything is connected and synchronized so that it works as a complete network.

In Logistics, IoT can be used in all three segments – Warehouse Operations, Freight Transportation and Last Mile Delivery. For Warehouse Operations, there are already many things that Internet of Things is helping with and its influence is growing. Such things are security, safety and optimization. Security can include monitoring inventory and warehouse equipment. Alarm sensors and control cameras are used to secure assets in warehouses which decreases the costs for the company by preventing theft or stopping a certain product from being transferred to an incorrect shipment location (truck/ship/lot, etc.). Another implication of IoT in Logistics warehousing is Safety. According to a report by DHL, IoT is used to monitor the condition of equipment and schedule maintenance by predicting failures of equipment. This can reduce costs, save time and even save human lives. Warehouse optimization can also be achieved with Internet of Things. The data collected from tags and sensors can be analyzed and new some parts of the warehouse could be rearranged to optimize routes within the warehouse and save time.

In the delivery process (Freight Transportation and Last Mile Delivery), Internet of Things is used mostly for fleet management. RFID tags have an enormous impact on the tracking of deliveries. Companies like Amazon allow their customers to track the delivery process of their purchase. In the past to know the location of a product, a human member of staff of the delivering company had to manually scan the product. Today, thanks to IoT, RFID tags can be connected to a network and upload data to it. According to Auburn University 96% of retailers are planning to adopt RFID technology. A report by *RFID Journal* suggests that inventory accuracy at the stock-keeping unit (SKU) level is about 65 percent and RFID can get that percentage up to 95 percent.

3.3 Future Perspective for Internet of Things

As already mentioned, Internet of Things is a relatively new method for connecting and using technology. It is continually improving and there are a lot of perspectives for it. Last year there were about eight and a half billion Internet of Things capable devices. According to Gartner, the world's leading research and advisory company, there are going to be about 20 billion IoT devices by 2020. Other estimates point to figures ten times higher. MarketsandMarkets indicate that the IoT market will expand significantly from 170 billion dollars in 2017 to over 500 billion dollars by 2022.

The Internet of Things market is a large one and there are a lot of opportunities in it. Big, as well as small companies can be a part of this market and the numbers show that it is a market that will be highly profitable.

In logistics, there are opportunities for both warehouse operations and delivery. All processes can be automated, and no human interference will be required. Amazon and DHL both have plans for autonomous drones, or Unmanned Aerial Vehicles (UAV), for delivering products. Amazon has their drones ready, but they are still in the testing stage and more tests have to be made before they release their drones to work around the world. There are risks like crashing and damaging someone's private property or hurting someone. There are also issues about congested airspace and public concern. Other future visions for IoT in logistics include self-driving vehicles. According to a report by DHL, sometimes drivers in Last Mile Delivery have to find a parking space and then go the rest of the way to the customer on foot. DHL are planning to automate their vehicles so that they follow the driver when he gets out of the vehicle. This way much time will be saved because once the current parcel has been delivered, the driver will not have to walk all the way back to where he parked the vehicle. It will be also more convenient for the driver. As reported by DHL, autonomous vehicles will help not only with autonomous driving but autonomous loading and unloading. This will improve efficiency as well as safety while in transit and during the loading and unloading processes.

On the client's side, people will receive their orders faster because IoT will optimize the delivery process.

The more IoT develops, the more changes there are going to be in the world. Self-driving vehicles are going to be on the roads in the near future and the logistics industry will have a big role in that.

3.4 Advantages and disadvantages of the Internet of Things

Internet of Things brings many benefits to the companies that use it. It has advantages in various aspects like time saving, cost efficiency, etc. But as with everything, there is a negative side to it.

One of the advantages of Internet of Things is that it uses data. The more data there is, the better IoT will work by taking the right decisions. This data is analyzed and studied, thus improving the quality of the operations being managed by IoT. Another advantage is that machines, products or whatever is tagged can be tracked. Tracking can be both monitoring the location of the tagged things or their condition, like DHL is doing with their equipment. Other benefits of IoT include time saving and money. Sensors and tags can save huge amounts of time because no manual checks have to be done by humans. It is similar with money. A lot of money is saved by companies who use Internet of Things. This technology allows companies to replace staff members who are monitoring and maintaining assets with machines. This will decrease the amount of money being payed to staff members as salary and increase the profit of the company. It is probably the biggest advantage because the aim of every company is to be more profitable.

Although there are great advantages, a few disadvantages exist with Internet of Things. At least for now. As with any other online technology, a security breach is a big concern for IoT. Hacker attacks can cause enormous damage to a company using IoT. Data can be changed or manipulated which can make the processes managed by IoT harmful. Such attack can also break the confidentiality and integrity of data, depending on what type of data the machine under attack is dealing with. To prevent an attack from succeeding, all data can be encrypted but there is always a risk of it being decrypted and used for malicious purposes. Another disadvantage is complexity. The more complex a system is, the more opportunities there are for it to fail. Any bugs in the software or damage to the hardware can cause the system to behave in inappropriate ways which can be a huge setback. Compatibility is also an issue for Internet of Things. Although IoT is a world-wide technology, there is no global standard for tagging IoT devices. Various tags, sensors and devices have to work in harmony to achieve a good IoT network. Because there is no international standard, merging different networks, acquiring new machines or having existing machines work together can be difficult but an international standard should not be difficult to do and probably one will be created within the next few years.

Despite having some disadvantages, the Internet of Things brings such benefits that they should not be overlooked at all. There are efficient measures that can be taken to minimize the risks and consume the benefits. Soon IoT will be an essential part of most successful companies as well as more and more households. It has applications in both industry and homes.

3.5 What impact does Internet of Things have on economy?

With more and more devices being connected via Internet of Things, there is a huge impact on the world's economy because of this technology. It is bringing a revolution in how machines communicate with one another and how humans can interact with them. According to a 2015 report by Machina Research the value of the Internet of Things was around 900 billion dollars in 2014 and it is estimated that by 2024 its value will be around 4.3 trillion dollars (USD), equivalent to about 3.2 trillion British Pounds (GBP). Other analyses indicate a potential value of around 6.2 trillion dollars (about 4.6 trillion GBP) by 2025.

The automation of various processes has the potential to lead to the closing down of job positions but that does not necessarily mean people losing jobs. Most job reductions are in the operations that require manual labor. Usually new job positions have to be opened to deal with the machines themselves and their data and staff members whose job is taken by IoT machines are transferred to the new positions with more complex tasks. Staff members can also be reallocated to new job locations because IoT significantly improves efficiency which can cause a company to expand and create even more job openings. With IoT companies are also taking advantage of reduction in waste and reduction in time lost due to unexpected machine or system failures.

3.6 Common things between organisations using Internet of Things

The Internet of Things can be used to connect all sorts of devices. This is why it is a technology that is used in all fields and sectors by various organisations. The possibilities for Internet of Things are have significantly increased over the last few years and the predictions are that the expansion of IoT will grow even bigger (§3.3). One thing that organisations that have started using Internet of Things have in common is that these organisations are looking for ways to improve their operations by introducing new, innovative technology.

3.7 Logistics

3.7.1 Logistics in general

Logistics include the processes of planning, implementing and controlling the actions needed in order to store, move and deliver products or services. The movement of products can be internal, within company facilities, or external, usually from a warehouse to a client-specified location. The logistics market is huge, and it consists of a lot of organisations from all sizes. The industry is currently going through many changes and this could cause many risks as well as opportunities. New companies regularly enter the logistics market, new technologies occur, customers raise their expectations and business models change.

Logistics are generally divided in three sectors – Warehouse Operations, Freight Transportation and Last Mile Delivery.

3.7.2 Last Mile Delivery Logistics

Last Mile Delivery is a major part of logistics. According to some people and reports, the 'Last Mile' includes the delivery from a warehouse to the client's desired location and the return trip. Other people, including me, think that the return trip is not included in the last mile delivery process.

This part of the logistics process is the only point of direct contact with customers for most logistics companies. This is why it is very important for companies to keep their last mile operations at a high level to improve customer satisfaction

3.8 Internet of Things in Logistics

The impact of this technology in the logistics sector is huge. The uses of IoT are increasing and will soon transform the entire industry.

Summary: This chapter discussed the technology Internet of Things and what impact it has on the world, the companies that use this technology and especially the impact of IoT in Logistics. The data gathered from the literature that was reviewed has been very important for gaining new knowledge and

4. Methodology

Introduction: This chapter reviews the methodologies that were used to analyze data and create a model (framework) for Internet of Things in Logistics. Various methodologies are discussed, with Soft Systems Methodology (SSM) being the main methodology for building the framework. For analyzing DHL and Amazon, other methodologies like Michael Porter's 5 Forces Analysis and others have been used as well as SSM.

4.1 Soft Systems Methodology (SSM)

This method was created from a research at Lancaster University which tried to apply Systems Engineering methods to solve business and management problems. The result was that they tried to apply hard system approach to a soft system. SSM is used to help in solving soft, ill-defined problems. It is used as a framework for dealing with situations where the problem is not defined. A complete conventional SSM model includes seven stages:

- Finding out what the problem is
- Expressing the problem
- Deriving root definitions of relevant systems
- Creating conceptual models
- Comparing the created models with the real world
- Analyzing the wanted change
- Taking action to resolve the problem

The Soft Systems Methodology approach is used to represent actions that a system can be improved. It does not represent an existing system. It is a way of thinking about the real world.

Root definitions (RDs) are part of the Soft Systems Methodology and they are used to precisely define the analysed system. A root definition is usually a single sentence that includes all of the system's key elements. The key elements are also identified in the CATWOE analysis (§4.3). Root Definitions, CATWOE analysis and conceptual models often require a few iterations before a final version is established. SSM model building is the most difficult and time-consuming activity and it is usually done along with CATWOE analysis and root RDs. A root definition can be derived from the CATWOE analysis but is not necessary.

4.1.1 The Enterprise Model

It has been first used as a way of thinking about management processes in an organisation (B.Wilson). Recently, the Enterprise Model has been used as a method to ensure that all required systems within

a Consensus Primary Task Model have been considered and included. This type of model is created from 4 types of systems, represented in the following figure:

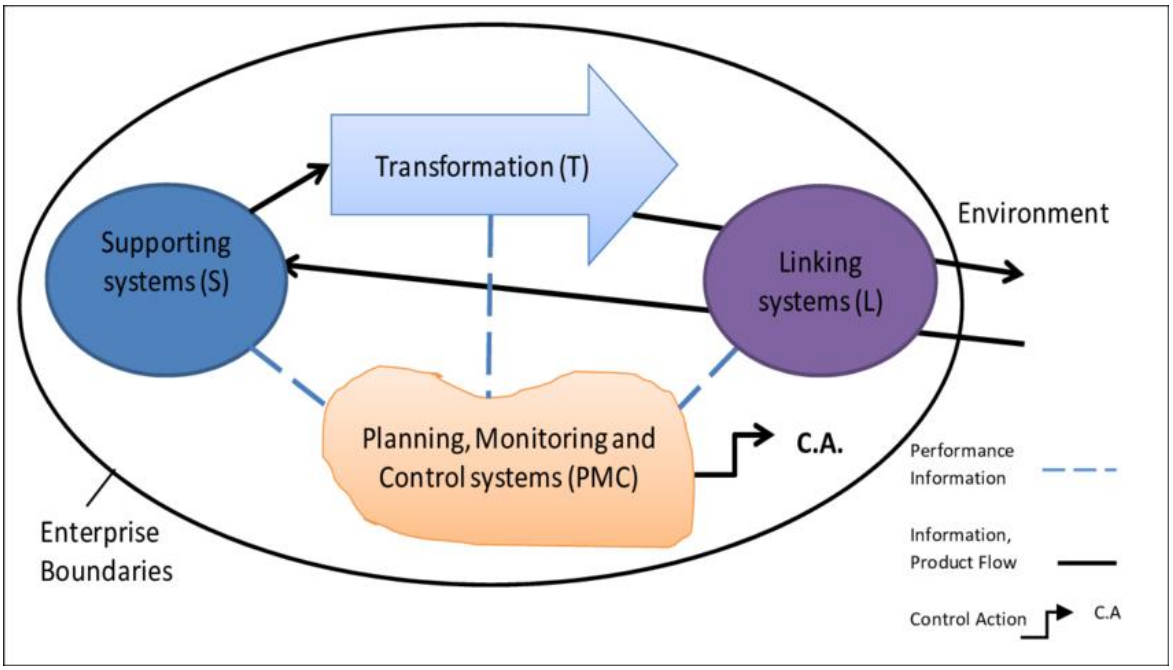


Figure 1 SSM Enterprise Model Diagram

The transformation process (T) represents the core objective of the organisation at hand. Although it is not necessary, the T can be derived from the World View or Weltanschauung (W) from a CATWOE analysis. It is up to the person doing the analysis. Once the core transformation has been established, the other elements from the diagram become clearer and genuine.

Supporting systems (S) represent the systems that assist the progress of the core transformation (T) process. Such systems are the human resources or physical resources required by the T.

Linking systems (L) depict systems that are responsible for providing the necessary interface for the system for the organisations environment.

Planning, Monitoring and Control systems (PMC) represents the systems responsible for planning work processes, monitoring them and taking control actions (C.A.) where necessary. These systems show that an organisation is adaptable and capable of reacting to change. Control actions are reactive measures taken usually to improve a process or make a system behave in a desired way (keep the system on track).

A complete model should represent working concept even if in reality it is not capable of working. To assemble a model, root definitions are used to create subsystems which are later linked to create a complete system. This way the finished model is more detailed and gives a better representation. Root Definitions are created for every subsystem. They give meaning to the systems and help in finding out activities for each system.

4.2 Data Acquisition

A lot of specific data about the analysed companies was needed to carry out all the analyses and create models of the companies and their operations. Two companies were selected for this project based on their logistics operations, strategic objectives and the amount of available relevant

information. The two companies that were selected are Deutsche Post DHL Group and Amazon Inc. A third company would have been very useful for the entire project but a company that complied with all requirements and enough publicly available information was not found.

The reason for choosing these two companies for the project is that they are both some of the world's successful companies. DHL is a courier organisation that is one of the world's market leaders in logistics. They have the capacity to deliver goods to 120 000 locations around the world in about 220 countries.

DHL and Amazon are both huge companies and are some of the market leaders in their fields. Both have a huge customer base and although Amazon is leader in e-commerce, it is very important player on the logistics market

DHL is a German company that has been using Internet of Things technology for quite a long time, considering that it is a relatively new technology. As stated in a report by DHL, IoT is not a new thing for them. They have been scanning parcels with handheld scanning devices, which is also a form of IoT but currently IoT is much more advanced than that and DHL as a logistics company is a company that uses many of the benefits IoT brings. Recently, DHL has been working with tech companies like Cisco to modernize their machine assets. They have been also working with Volvo to improve delivery vehicles. One of the improvements is MoDe – Maintenance on Demand. Thich allows DHL to predict maintenance issues in their delivery vehicles, thus saving time and improving customer satisfaction. The aim of the MoDe project was to create vehicles that can autonomously decide when they need repairs, not relying on human intervention. Another Internet of Things solution that DHL is working on is DHL Paketkasten (or Parcelbox) which are parcel drop-off locations that are connected to a network which can notify a customer if his delivery has been dropped off. Another technology that helps DHL in developing IoT is DHL SmartSensor. It monitors the condition of products that are being delivered to ensure their integrity.

DHL is also working on autonomous vehicles and unmanned aerial vehicles. Autonomous vehicles will bring benefits for DHL in all stages of the delivery process (Warehousing, Freight Transportation and Last Mile Delivery). Both DHL and Amazon are developing IoT unmanned aerial vehicles (UAVs or drones). Both companies have already developed their drones or at least some of them but there are laws and other regulations that prevent the companies from widely using their drones for deliveries. Amazon has been approved to start testing and the first test deliveries were done near Cambridge, UK. Amazon is closer to the wide use of UAVs and Amazon Prime Air is expected to be a regular Amazon service in the next few years.

Some of the mentioned technologies are already used or under deployment in Germany but the projects aim is to investigate logistics as a whole, specifically Last Mile Delivery. DHL's practice is to develop their innovative technologies and test them in Germany. Once they are established and the company has results indicating a technology is effective and profitable, it is introduced in other countries around the world.

All of these technologies as well as others have been taken into consideration when developing the SSM models for the companies.

4.3 CATWOE Analysis

The CATWOE analysis was invented by Peter Checkland as part of his Soft System Methodology. It is a method for thinking who is involved in an organisation or project. The analysis aims to identify the business goals, the problematic areas and the people that are involved. The analysis is made up of six elements: Clients, Actors, Transformation, Weltanschauung, Owner and Environmental Constraints.

- Clients – also called Customers are stakeholders and users of the analysed system/project/organisation. These are the people who usually benefit from the outcome of a system, but they can also suffer damage depending on what the company produces.
- Actors – these are the people who are responsible for the operations of a system/project/organisation. This group of people are also responsible for implementation.
- Transformation – this is what results from the company's processes. It is how the company makes profit.
- Weltanschauung – also called Worldview, it is the strategic belief of the company about how to provide services or products to customers and make profit from that.
- Owner – the owner of a project or company. They are the decision makers and have the power to make changes.
- Environmental Constraints – how the external environment affects the processes and success of a project or company. There could be various constraints like ethical limitations, laws, regulations, resource limitations, financial limitations and others.

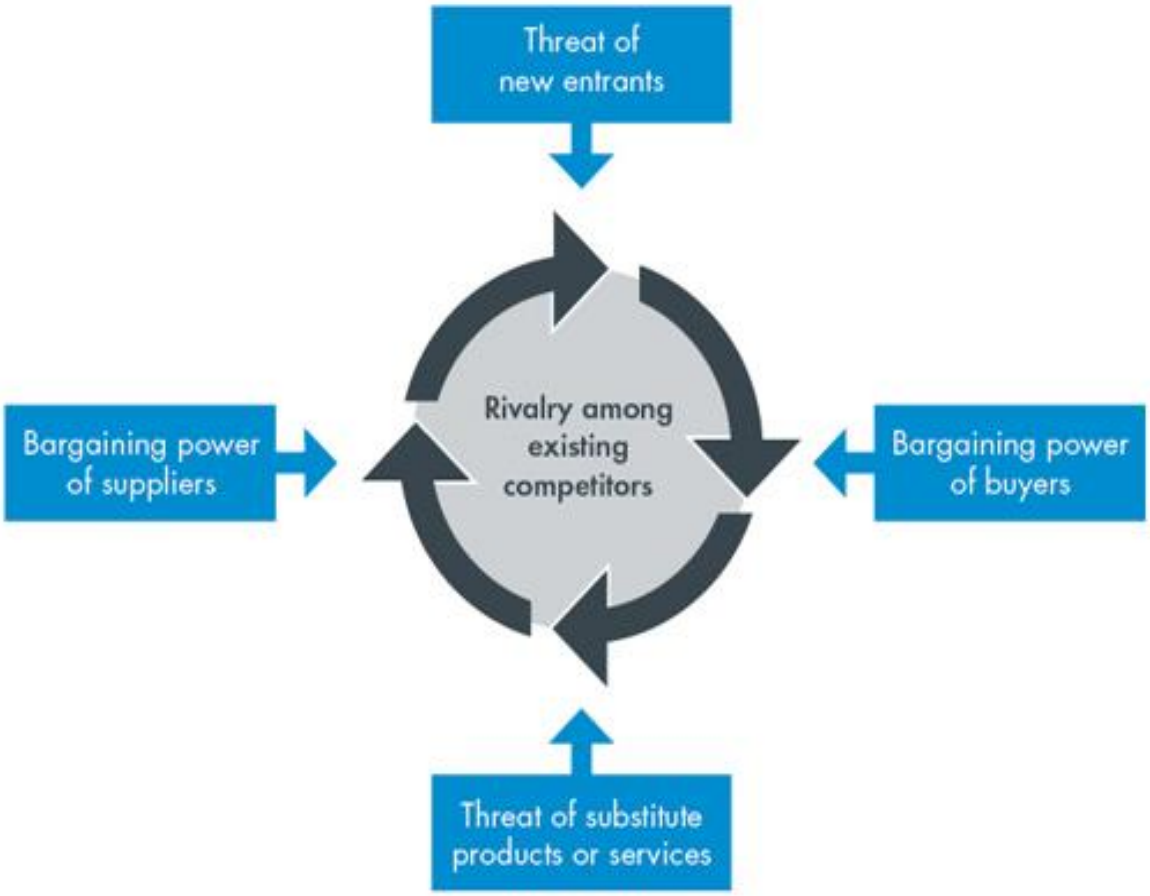
A CATWOE analysis is usually accompanies by a root definition (§4.1) of the analysed system.

4.4 Michael Porter 5 Forces Analysis

Michael Porter's 5 Forces is a powerful tool that is used to help in understanding the business environment of a company. With this tool competitiveness and potential strategies can be identified. Porter's methodology also helps in determining where the power lies in an organisation. The 5 forces that are being analysed are:

- **Rivalry Among Existing Competitors** – this analyzes the competitors. Their number and strength can influence on the organization's profit by decreasing the number of customers there are. The more competitive companies there are and the stronger they are, the chance of suppliers and customers going to a rival company increases. Marketing campaigns and other actions can be taken to minimize such negative effects, but the risk cannot be completely negated while there are rival companies. The more of them there are, the higher the chance of losing customers.
- **Bargaining Power of Suppliers** – this determines how easy suppliers can bargain and determine the price of a product or service, depending on how rare it is or how much it would cost to change suppliers. The less suppliers there are, the more power they have. Moreover, the more a company depends on a supplier, the more power the supplier can have. This can have a significant impact on the organization's profit
- **Bargaining Power of Buyers** - this force analyses the bargaining power of buyers. It is influenced by the strength and number of rival companies. If a customer can easily go to a competitive company, his bargaining power is high. The number of buyers is also important. The smaller and stronger a customer circle is, the more powerful it is.
- **Threat of Substitute Products or Services** – this refers to the chance of customers using a substitute products or services. Where equivalent products or services exist in a market, the chances of customers switching to alternatives increases

- **Threat of New Entrants** – a company's market position is also influenced by the force of new companies entering the same market. The easier it is to enter a market, the more new entrants there are. New entrants can also increase the bargaining powers of buyers and suppliers.



For this project, Porter's 5 Forces analysis helps by analyzing DHL and Amazon and identifying similarities between two different logistics companies. The results from the analyses will help in building a better framework for the outcome of the project.

4.5 Business Process Mapping

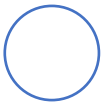
This methodology is used to document an existing process or to model a new one. The purpose of this tool is to gain detailed understanding about the analysed process and everything connected to it – resources, people, inputs, outputs and controls. All of this can then be simplified in order to make the outcome easier to use or to improve the process results. This methodology requires a significant amount of time to gather all of the requirements, but it is has become very common in the business world to standardize procedures, become more efficient, meet requirements and gain competitive advantage.

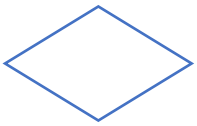
Business Process Mapping (BPM), also referred to as Business Process Diagrams or Business Flow Charts, has been around since the 1920s and it has gone through some changes to become what it is today. Some of its modern uses are to prepare a plan for automation and to help in understanding the impact of changes that are about to be done. This fits the purpose of this project perfectly, which is the reason for choosing to include it as part of the methodologies for creating the logistics Internet of Things framework. Another benefit from using BPM is that by documenting the process in this way, it can be standardized. Once it is standardized, it will be easier to use by companies, which is one of the

goals of this project. Creating a chart provides clear visualization that if done right can be much easier to understand than plain text. The main symbols used in Business Process Mapping are:

Task / Activity: 

Flow:

Event: 

Gateway: 

A task is a specified activity that is performed by a person or system.

Flow indicates the sequence in which activities are performed.

Events actions that trigger the start of a process.

Gateways are decision points that can adjust the next steps of a process based on conditions or events.

4.6 Activities table

To create a generalized framework, different companies were analysed (DHL and Amazon). Because the aim of the project is to create a framework that could be used by many logistics companies, not only a focused group of companies, the key activities from the created SSM models (§5.1, §5.4) of analysed companies were put in an activities table. The purpose of this table is to identify the key activities that could be supported by Internet of Things and provide an explanation. This was done to gain a better understanding of the important activities that are required for the automation of last mile delivery. This understanding was later used to develop the framework.

Summary: This chapter reviewed the methodologies that were used for this project, their purpose and why they were chosen for the project. Based on the analyses and outcome of the used methodologies, the framework and other elements of the project were developed.

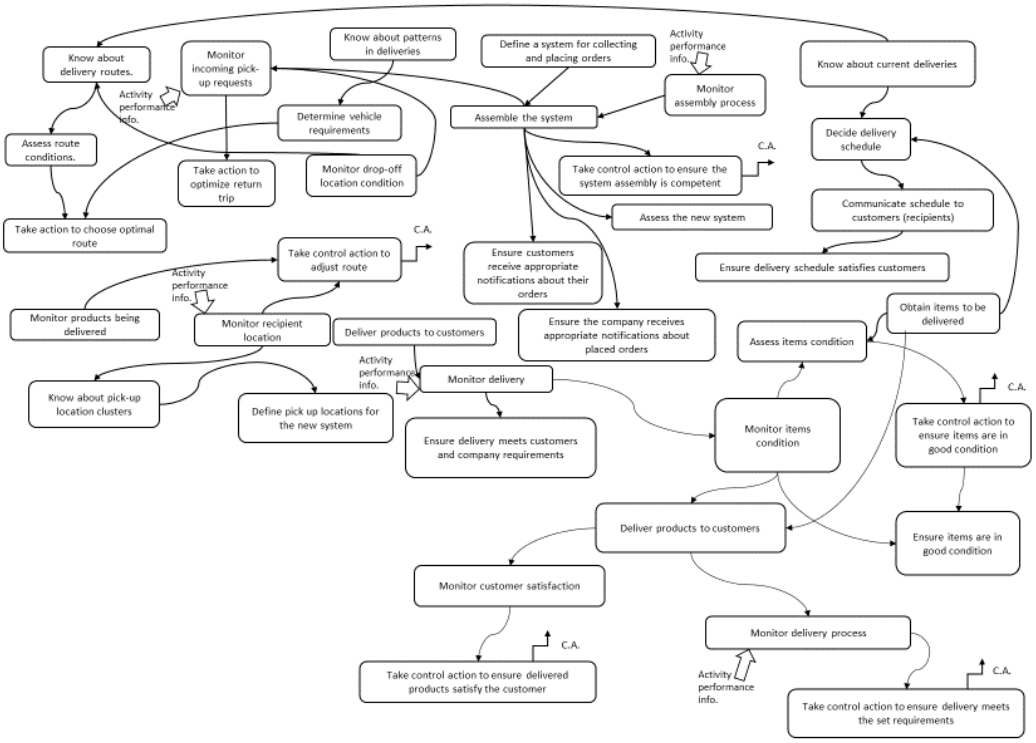
5. Findings (Framework)

Introduction: This chapter consists of all analyses and used methodologies and tools that were used for the project. The framework that is the goal of this project is presented in section 5.7 of this chapter.

5.1 DHL Soft Systems Methodology Enterprise Model

This model was created based on my knowledge on SSM and additional research on that methodology. The data that was used to create the model is based mainly on official reports released on DHL's official website. Case studies and other sources have also been used in addition to the reports. The purpose of this model is to identify the activities that Deutsche Post DHL is doing and planning to do to further extend the current development of Internet of Things in its operation.

The Root Definition of the following model is: A system to connect machines, products and customers by establishing a communication channel for all of them, enabling machines to make decisions and take control actions to deliver customers' orders.



The model can be seen in Appendix B (§12.). The model can also be seen at: LINK where it can be zoomed in. To view the model there, you would have to enter your university credentials.

5.1.1 Activities that can be supported by IoT (DHL Model)

The purpose of this table is to identify the key activities from DHL's model that can be supported by Internet of Things. They can then be analysed and compared to the activities from Amazon's activity table to help in building the logistics IoT framework.

Activity ID	Activity	How it can be supported by Internet of Things
1	Know about delivery routes	Information about delivery routes can be automatically extracted from GPS systems like Google Maps, if there are no restrictions.
2	Assess route conditions	Based on the real time data coming from the GPS system, traffic jams and other obstacles can be assessed by another system.
3	Take control action to choose optimal route	A system receiving data from the previous two activities can be used to calculate the best possible route and set the navigation for the autonomous vehicle or the driver.
4	Take control action to optimize return trip	Vehicles or other devices can be connected to the company's network that is responsible for receiving pick-up requests. The data can then analysed and a pick-up location can be sent to the vehicle's naviagation system, which will adjust the return trip to the warehouse so that the parcel is collected on the way. It is up to the analysis of the data to determine if it would be a good idea to pick-up a given parcel on the return trip or send the information about it to another vehicle.
5	Determine vehicle requirements	Tags or other sensors connected to products can give infromation about the products that are about to be delivered to a system, which will analyse the data coming from the sensors and decide which vehicle would be most appropriate to do the delivery with. The data analysis could be made based on special product necessity (e.g. temperature), size of products or other requirements.
6	Ensure customers receive notifications about their orders	IoT can support this by having a system that depending on product's/vehicle's location can send notifications to recepients about the status of the delivery.
7	Obtain items to be delivered	This can be done by having pick-up requests communicated to vehicles or drivers and sending out a vehicle to pick up the order autonomously or manualy via the driver. The route is defined following activites number 1,2,3 and 5 or activity number 4
8	Monitor and assess items condition	Items condition can be assessed by having cameras or other types of sensors that monitor the items. This data from the sensors can be automatically analysed and reactive measures can be taken if needed.

9	Deliver products to customers	This activity can be supported by IoT by fully or partially automating delivery vehicles. UAVs (drones) and autonomous vehicles can do deliveries without any human interference by using data and guidaing systems. Vehicles can be partially automated to follow the driver while he is on foot, handing parcels to customers.
10	Monitor delivery process	Sensors or tags placed on items or delivery vehicles can be used to send data to a network on which customers can see the status of their delivery.

5.2 DHL Michael Porter 5 Forces Analysis

- **Threat of New Entrants** – for DHL the threat of new entrants on the logistics market is high. The logistics market is large and attractive. DHL is one of the world's leading logistics company, providing its services in about 220 countries, delivering shipments by road, air, sea and rail. The various methods for delivering shipments means that if a company using any of these means of transport for logistics enters the market, it has the chance to impact DHL's customers and market share. This means that the threat of new entrants is high for DHL. The logistics market is large, and it is expected to grow even more. It is easy to enter and there are no barriers to it. Especially in most of Europe because of the European Union it is easy to establish an international logistics company. DHL's advantage is that it was established in 1969, which gives it a lot of experience and appearance on the market. Another benefit is that it is a large, well-established companies like DHL have contracts and partnerships with some buyers and suppliers. Despite the scale and history of DHL, the risk of new companies entering the logistics market is high.
- **Bargaining Power of Buyers** – there are many companies on the logistics market that offer similar services. Buyers have the power to choose a cheaper or more expensive company. Buyers also have the power to become clients of a rival company. As stated in the previous bullet point, the logistics market is large and there are many companies on it, giving buyers a wide variety of options to choose from. DHL's advantage is that it has established partners and contracts with buyers and suppliers but that does not prevent buyers and suppliers from going to another company once a contract expires. Because of the number companies on the logistics market that offer similar to DHL's services, the bargaining power of buyers is high.
- **Threat of Substitute Products or Services** – the price of DHL's services depends on similar services offered by other companies on the market. If there is an equivalent service on a lower price offered by another company, it is very likely that clients will choose to go to the other company. The power of substitute products or services depends on marketing and advertising. The more a company promotes itself to the public, the higher chance it has of attracting more customers to its client base. Marketing can be essential to attract customers. DHL should rely on marketing as well as it's well-known name to expand its customer base. Researches and analyses can be carried out to identify customer need or other factors.
- **Bargaining Power of Suppliers** – there are many suppliers for DHL's need. This project focuses on Last Mile Delivery, so this part of Porter's 5 Forces analysis will focus on suppliers for operational purposes. DHL is expanding the use of Internet of Things in its delivery operations. The suppliers which can answer DHL's need are not many, so there is a dependency on

suppliers. IoT technology is complex and expensive. Therefore, suppliers like Cisco hold great power over their clients. The bargaining Power of Suppliers is high.

- **Rivalry Among Existing Competitors** – on the logistics market there are small, medium and big companies. DHL is one of the top big companies but the competition among this type of companies is very big. One way DHL is trying to gain advantage over rival companies is the use of innovative technology. This helps the company in gaining a competitive edge but there are other risks as well. DHL operates in more than 220 countries and most of the competitors are other big companies that operate internationally. There are also the small and medium logistics companies that pose threat to DHL on local level. A company that works within a single country or area could be chosen by clients over DHL. There are risks on both local and international level from all kinds of logistics companies so the rivalry among existing competitors is high.

5.3 DHL CATWOE Analysis

Customers: People awaiting deliveries from DHL

Actors: Warehouse and Delivery Staff

Transformation: Deliver products

Weltanschauung: Connect people and organisations by making deliveries and generating profit from that.

Ownerc: Deutsche Post DHL Group

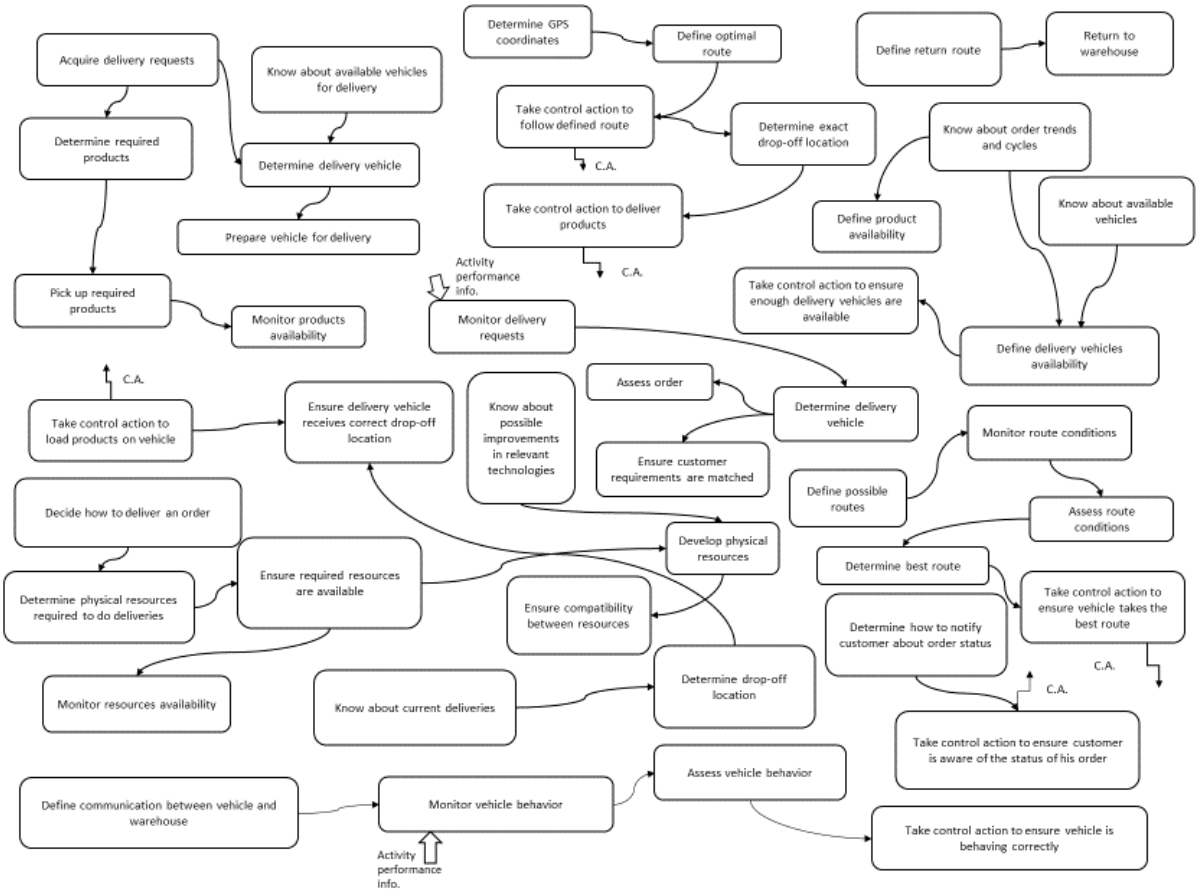
Environmental Constraints: Local and international law and regulations

Because the enterprise model (§5.1) of the company aims to identify the key activities, customers and actors are mostly ignored in the model. Moreover, the model and framework (§5.7) focus on IoT and automation of activities, the purpose of the project is to minimize actors in the system.

5.4 Amazon Soft Systems Methodology Enterprise Model

The following model has been created using Soft Systems Methodology. The model does not represent the current state of Amazon's operations, but it represents the innovations and changes that are under development or testing. This model, along with the created SSM model for Deutsche Post DHL are created in order to analyse them and help in the creation of the framework for logistics companies that want to incorporate Internet of Things in their operations.

The Root Definition of the following model is: A system to provide communication between assets, clients and products by enabling company-owned vehicles and other apparatus to analyse and calculate variables, make decisions and take actions to do deliveries and allowing customers to monitor that process.



The model can be seen in Appendix B (§13.). The model can also be seen at: LINK where it can be zoomed in. To view the model there, you would have to enter your university credentials.

5.4.1 Activities that can be supported by Internet of Things (Amazon model)

The following table provides information about activities from Amazon's SSM Enterprise Model and how these activities can be supported by Internet of Things. The aim of this table and the one for the activities from DHL's model is to identify activities that can be used to create the IoT Framework.

Activity ID	Activity	How it can be supported by Internet of Things
1	Pick up required products	This can be done by having pick-up requests communicated to vehicles or drivers and sending out a vehicle to pick up the order autonomously or manualy via the driver.
2	Monitor products availability	When everything in the warehouse is tagged, the tags can easily send data to a network, which can follow their availability and notify staff if necessary.

3	Take control action to load products on vehiccle	The loading process can be automated by having autonomous forklifts or other machines taking products from the warehouse and navigating their way to the delivery vehicle by sensors placed on the forklifts, delivery vehicles and all around the warehouse. The delivery vehicle should also communicate with the forklift to ensure that the forklift receiver the correct drop-off location
4	Decide how to deliver an order	An IoT network can be used to decide how to deliver an order by analysing customer requirements, possible ways to deliver, available delivery vehicles, possible routes and their conditions. Based on the analysis a delivery can be automatically scheduled and the information can be passed on to warehouse machines (forklifts) and the selected delivery vehicle.
5	Define optimal route	To define the optimal route, a few systems are required to communicate to each other. There should be a system that has GPS data, so that the possible routes are known. Another system should analyse the possible routes that the GPS system has for traffic jams, obstacles and delays. A third system should analyse which route would be optimal and pass the information to the delivery vehicle. IoT can be used to connect these systems and automate the entire process.
6	Take control action to deliver procuts	This activity can be supported by IoT by fully or partially automating delivery vehicles. UAVs (drones) and autonomous vehicles can do deliveries without any human interference by using data and guidaing systems. Vehicles can be partially automated to follow the driver while he is on foot, handing parcels to customers.
7	Monitor vehicle behaviour	Sensors placed on the delivery vehicles can be used to gather data from them and send it to a network where the data is analysed for irregularities. Based on that data delivery maintenance can be automatically scheduled (MoDe §4,2).
8	Take control action to ensure customer is aware of the status of his order	IoT can support this by having a system that depending on product's/vehicle's location can send notifications to recepients about the status of the delivery. The status is defined based on data that is extracted from tags and sensors connected to a product.

5.5 Amazon Porter 5 Forces Analysis

Amazon's business is online retail. Only part of the company is dealing with logistics. The logistics of the company depend on the online retail, so despite the focus of this project being on Logistics, both e-commerce and logistics markets are considered. Amazon Web Services (AWS) are not analysed as they provide online services and do not impact the logistics of the company.

- **Threat of New Entrants** – Online retail or logistics, both markets are profitable, growing, attractive and easy to enter. This allows many new companies to enter the same market as Amazon, becoming a threat to Amazon by reducing Amazon's market share and possibly attracting some of their customers to go to a new company. Another threat is physical stores that are strategically distributed to attract customers. People might choose to go into a physical store instead of ordering online. The threat of new entrants is high. Amazon's advantage is that it is one of the top online retailers and their logistics largely depends on their e-commerce. Another competitive advantage that Amazon has is that new entrants on the market are not likely to be even close to the international level of Amazon but on the other hand, new entrants might be more dangerous in single countries or other smaller areas.
- **Bargaining Power of Buyers** – Amazon gives a lot of attention to customer satisfaction. Services like Amazon's One-Day Delivery are very important for the organisation and buyers can easily go to a competitive company if they are not satisfied. With the number of online retailers growing, customers have a variety of companies to choose from, which gives them a lot of power. The bargaining power of buyers is high.
- **Threat of Substitute Products or Services** – There are both online and physical stores and services that can attract Amazon's customers. There are some customers that prefer to purchase products from physical stores, which Amazon does not have, except for Amazon Go but it is not widely available. Moreover, the amount of similar services available to customers is huge, so even existing customers can go to a rival company. Amazon does not provide anything that is unique so there is a high threat of substitute products or services but there is a lot of variety that is offered, which is the competitive advantage of Amazon.
- **Bargaining Power of Suppliers** – Amazon has a huge advantage over its suppliers. Due to the number of items sold on the platform, suppliers are eager to work with Amazon. But not all suppliers can work with Amazon. There are ethical principles that companies must have in their workplace if they want to supply for Amazon. Because of the scale of Amazon and its position as one of the market leaders, many supplying companies want to be suppliers for Amazon and there is a lot of competition among suppliers. The price for Amazon to change suppliers is low which additionally increases the rivalry and competitiveness among suppliers, thus decreasing their power against Amazon. The bargaining power of suppliers is low.
- **Rivalry Among Existing Competitors** – Amazon's main rival organisations are other online retailers like eBay, Alibaba, Wal-Mart (in United States of America), Tesco (in United Kingdom) and other e-retailers. Smaller companies are also fighting for their position on the market which can have impact on Amazon. Some people might want to buy from a specialized store like PC World instead of a store that has everything like Amazon. Such companies are also rivals to Amazon because they provide similar products. The online retail market is a large and competitive one. Because of all of the intense competition, the rivalry among existing competitors is high.

5.6 Amazon CATWOE Analysis

Customer: Amazon customers who have placed orders on the company's website

Actors: Warehouse and Delivery staff

Transformation: Deliver customer's parcels

Weltanschauung: Make profit by selling products online and delivering them to customers

Owners: Amazon Inc.

Environmental Constraints: Local and international laws

Because the enterprise model (§5.4) of the company aims to identify the key activities, customers and actors are mostly ignored in the model. Moreover, the model and framework (§5.7) focus on IoT and automation of activities, the purpose of the project is to minimize actors in the system.

5.7 Internet of Things Framework

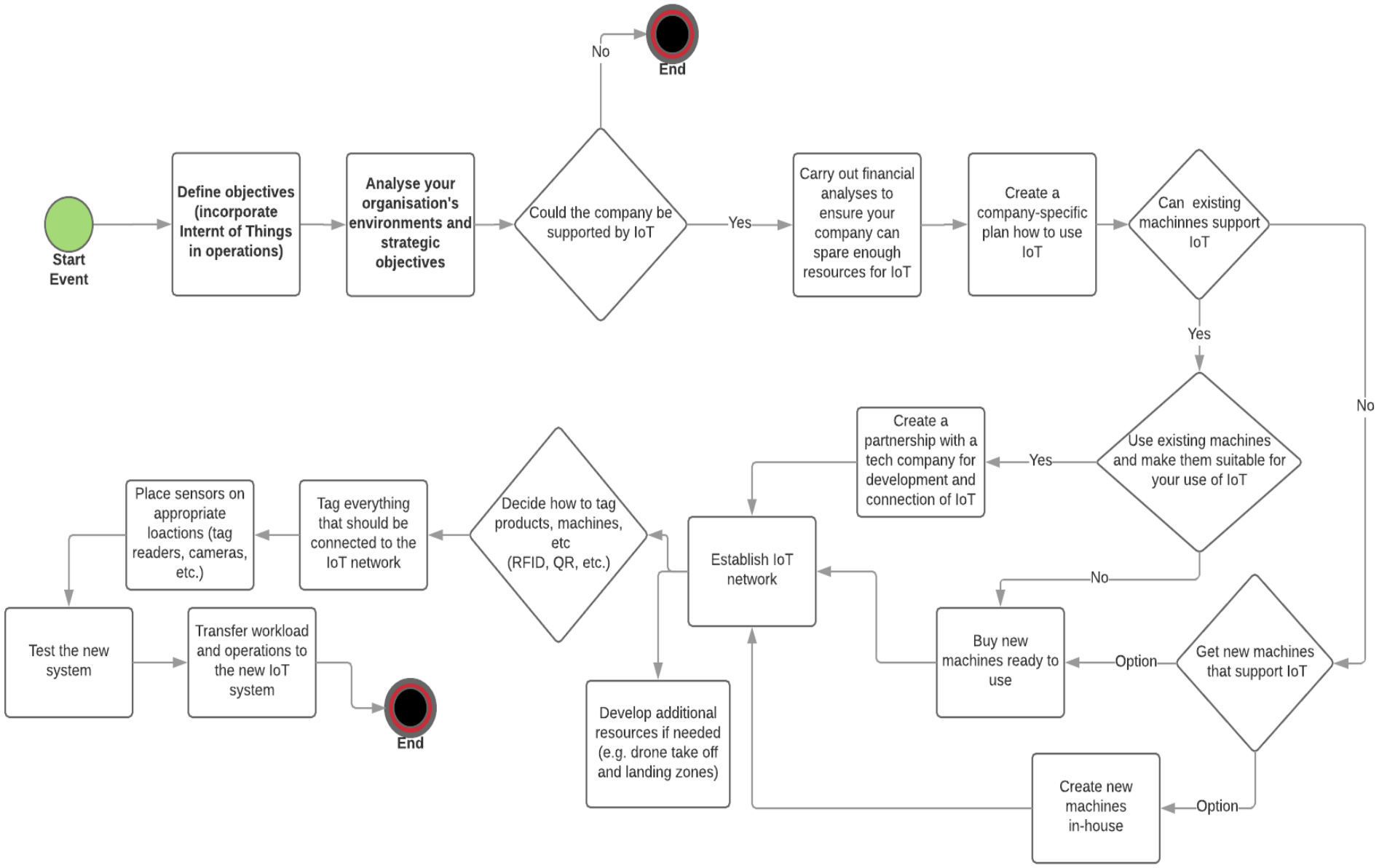
This framework aims to help logistics companies by creating a guideline on what should be done in order to add Internet of Things to a logistics company's operations. The project targets last mile delivery, so a significant amount of the framework is about the vehicles that are used to do a delivery. In the Business Process Map vehicles are names as 'machines' because there could be different types of vehicles and the word machines is used to summarise them. The model has been designed based on all used methodologies (§4) and aims to automate processes by replacing traditional operations in last mile delivery with IoT processes.

This is a generalized framework and it should not be used exactly as it is presented. Every company is different and should carry out various analyses before implementing the IoT framework to make it suitable. Financial and environmental analyses, both internal and external, are probably going to be essential for the successful implementation of the IoT framework. The framework is generalized because this way it could be useful to a large number of organisation. Every company is individual. A more concentrated framework might bring slightly more value but the number of companies that could benefit from it would be significantly smaller.

Internet of Things is a technology that is changing how many organisations operate. Especially in logistics, IoT is on the verge of revolutionizing a large portion of the field. This is why this framework could be very useful for logistics companies that want to start using Internet of Things for their Last Mile Delivery.

Every companies that uses the framework should adapt it to its own requirements and strategies. Physical resources like DHL's Paketkasten (§4.2) might be required on the client's side but this is specific for DHL. Every company is specific and should use the framework according to its own vision and methods.

The framework can be seen on the next page.


Start Event
Define objectives (incorporate Internt of Things in operations)
Analyse your organisation's environments and strategic objectives
Could the company be supported by IoT
No
End
Yes
Carry out financial analyses to ensure your company can spare enough resources for IoT
Create a company-specific plan how to use IoT
Can existing machinnes support IoT
Yes
No
Use existing machines and make them suitable for your use of IoT
Yes
Create a partnership with a tech company for development and connection of IoT
No
Establish IoT network
Buy new machines ready to use
Option
Get new machines that support IoT
Option
Create new machines in-house
Develop additional resources if needed (e.g. drone take off and landing zones)
Decide how to tag products, machines, etc (RFID, QR, etc.)
Tag everything that should be connected to the IoT network
Place sensors on appropriate loactions (tag readers, cameras, etc.)
Test the new system
Transfer workload and operations to the new IoT system
End

Summary: This chapter presented all analyses and models that were used and created in order to create the logistics IoT framework.

6. Limitations

Introduction: This chapter reviews the limitations that have impacted the project in any way. Possible solutions have been provided for most of the limitations.

6.1 Available Information

Due to the nature of the project, there are some limitations to it. As mentioned, Internet of Things is a relatively recent technology and companies are not freely giving away all the information on how they use this technology. The models and analyses done have been based on available reports and case studies which may not include all the information about the use of IoT in the analyzed organisations. The best way to overcome this limitation would be to interview relevant people from the analysed companies. They should have the most accurate information but since this is a university project, no people from the companies have been interviewed. For this project, a sufficient amount of information has been found, mainly from case studies and reports but if more information was available, it would have been better.

6.2 Technology Under Development

Although the project is investigating the use of IoT in Amazon and DHL, some IoT technologies are still under development in these companies and there is no information released about the use of them and how exactly they operate. This limitation can be overcome with future work when more documents and studies are available to the public. This limitation is hard to overcome because companies usually do not reveal information about their projects that are still under development. Information about such technology can be obtained only if the owner company releases documents and statements about it.

6.3 Number of Companies

Another limitation connected to the lack of available information is the number and variety of companies. The initial plan was to have 3 different types of logistics companies, so that there is a variety of analysed companies to base my models on. There are a lot of logistics companies using reported to be using Internet of Things in some way but there is too little or no information at all about how these companies are using this technology. This is the main reason why there are only two companies used to create models on and draw conclusions from them. DHL and Amazon are both successful and established companies on the global scale and there is a lot of information available about them. This limitation can also be overcome with future work improvements when move information is available to be analyzed. Although a third company would have been better, the two used companies provide a good level of variety and are organisations that can be seen as leaders on the logistics market. Currently this limitation can be overcome if the scope of the project is expanded. If the focus is not only on Last Mile Delivery, more companies could be analysed because more there will be a lot more information to be used.

6.4 Cost-Benefit Analysis

One of the methodologies that were planned to be used to analyse the use of IoT is a cost-benefit analysis but there is no information available about how much the analysed companies have invested or plan to invest in Internet of Things. The purpose of this analysis was to help companies that use my framework in their decision whether to take actions towards IoT but in order to carry out the analysis costs are required, and they are not stated by the companies. Even if the cost of a sample vehicle, sensor or something else is taken from the internet, there are still a lot of unknown costs like

implementation cost, required additional resources and others. This could be overcome only if all costs are known.

6.5 Bias

The created models might be biased towards my own perception of the analysed companies or something else. Soft Systems Methodology models represent a way of thinking about the real world and these models are highly susceptible to bias. The final framework is based on the SSM models, so there is a possibility of it being biased. It is a very hard limitation to overcome, especially by people with little experience in creating such models.

Summary: This chapter reviewed the limitations that affected the project. Solutions were also proposed.

7. Future Work

Introduction: This chapter discusses the possible improvements if the project is to be continued in future. There are many improvements that can be done but the time limit did not allow them to appear in this version of the project.

7.1 Quantity

Because of the timeframe of the project, its focus is solely on Last Mile Delivery. A major improvement that can be done in future work is expanding the scope to the entire logistics field. This includes Warehouse Operations and Freight Transportation as well as Last Mile Delivery. Some models have been created for parts of this piece of work, but I chose to focus on Last Mile Delivery only because the outcome is preferred to have more quality instead of quantity.

7.2 Variety of frameworks

Another improvement that could be made is to create a framework on how to use different types of IoT in logistics. For example, a framework for IoT Unmanned Aerial Vehicles (drones), another framework for Autonomous Vehicles and so on. The more granularity there is, the more adaptable the project would be for companies that want to use the frameworks. Organisations could choose which frameworks would suit their need the best and focus on them, instead on a single model.

7.3 Research

Because the logistics sector is constantly improving and getting bigger and bigger, additional research will have to be done for all future implementations of this project. The changing environment and improvements in technology makes it difficult to make predictions for the future, so more research will be necessary for any future improvements.

7.4 Testing

This was planned for the current version of the project, but no suitable people were found to do a user evaluation. Because the goal of the project is to create a framework for logistics companies, an evaluator would have to be some kind of manager in a logistics company. Although effort was put towards finding such people, no suitable evaluators were found.

If a test user is found for a future implementation of the project, he would have to evaluate the created framework and give his opinion on it. Depending of the state of the project, the ideal number of evaluators may vary.

Summary: This chapter reviewed the improvements that can be done if the project is continued.

8. Conclusion

In conclusion, the logistics market is huge, and it is one of the markets that can benefit from Internet of Things in various ways. Although IoT is a relatively new technology, some logistics companies have been using versions of IoT for years. In recent years, Internet of Things has been significantly improved and it is expected to grow even bigger (§3.3). Internet of Things in logistics brings benefits across the entire logistics value chain. Warehouse Operations, Freight Transportation and mostly Last Mile Delivery. Some of the impacts that Internet of Things makes in the logistics industry are time-efficiency, security and cost-effectiveness.

The final process of a logistics delivery is the so called Last Mile Delivery. This sector of logistics is currently highly dependent on manual human labor and Internet of Things has reached its level of development so that it can significantly reduce manual operations. Automation of vehicles can have a huge positive impact on logistics organisations and some companies have already incorporated IoT in their Last Mile Delivery operations.

Various methodologies were used to analyse the operations of Amazon Inc. and Deutsche Post DHL Group. Soft Systems Methodology (SSM) models of the two companies were created in order to visualize their IoT development plans and identify the key activities that are required to incorporate IoT in their Last Mile Delivery. Based on the created models, a table with the key activities that could be supported by IoT was created for each company. These tables provide explanations about how the identified activities can be supported by IoT. Another tool that was used is Michael Porter's 5 Forces Analysis. Both organisations were analysed using this tool and the results show that the competition in the logistics market and its last mile delivery sector is very high. Rival companies exist on multiple levels and the threat of new rival companies emerging on the market is also very high. This is why for companies to gain a competitive advantage, innovations and improvements have to be highly desired. Internet of Things is a very powerful technology that has the ability to revolutionize a logistics company, which will help it in the battle against competitors. The created framework will bring a lot of value to the companies that use it because it has the aim to help companies in incorporating IoT in their last mile delivery operations. The framework guides users through the processes that would be required to automate processes. It is a general model and it is not focused on a specific company or activity. Every company handles its operations differently, so it would be up to the companies that use this framework to adapt it to their style and operations.

9. Reflection

To reflect on the work I have done on the project over the last semester, I believe that the goal of the project has been accomplished. The desired framework was created and I believe that it could be used by logistics companies that want to incorporate IoT in their operations. It would have been much better if the framework consisted not only from Last mile Delivery, but Warehouse Operations and Freight Transportation models as well but because of the time limit and the changes of the topic in the beginning stage, the project could not be completed with the initially planned scale. Initially, the project had a different topic but following discussions with my supervisor, we decided that it would be best to change the topic to logistics.

Working on this project increased my knowledge in areas like Soft Systems Methodologies and all other methodologies and tools that were used. My data acquisition, analysis and modelling skills have also been massively improved. Before starting the project, I have had some experience with SSM and Porter's 5 Forces analysis on other university tasks but now my knowledge and experience

have significantly improved. Having done this project, my management and communication skills have also improved. Scheduling tasks and arranging supervisor meetings are some important activities that I have done and this experience will definitely be useful for future projects in and out of university.

Looking back at the work I have done for the project, I realize that I did not schedule my workload correctly and this can be clearly seen in the Gantt chart. It was definitely a challenge to work on this project and although there are things that could have been done differently, I am happy with the final outcome. The framework has potential to really be used by logistics companies and it will bring value to them if used properly.

The most difficult part of the project was creating the SSM models (§5.1, §5.4). They required the biggest amount of time and a few iterations before they became what they are now. The rest of the analyses are mostly based on the SSM models and were not as hard to create but some of them also had to be done a few times to get them right.

Throughout the project, there have been many changes, but I successfully adapted to them and was able to carry on working and complete the project before the deadline. If there is something that I would change if I had more time, it would be the scale of the project. If I have to do this project again I would set my objectives as early as possible, but I would still choose to do the activities that I have done.

10. Abbreviations

IoT – Internet of Things

BPM – Business Process Mapping

SSM – Soft Systems Methodology

RFID – Radio-Frequency Identification

QR – Quick Read

MoDe – Maintenance on Demand

CATWOE – Customers, Actors, Transformation, Weltanschauung, Owner, Environmental constraints

UAV – Unmanned Aerial Vehicle

RD – Root Definition

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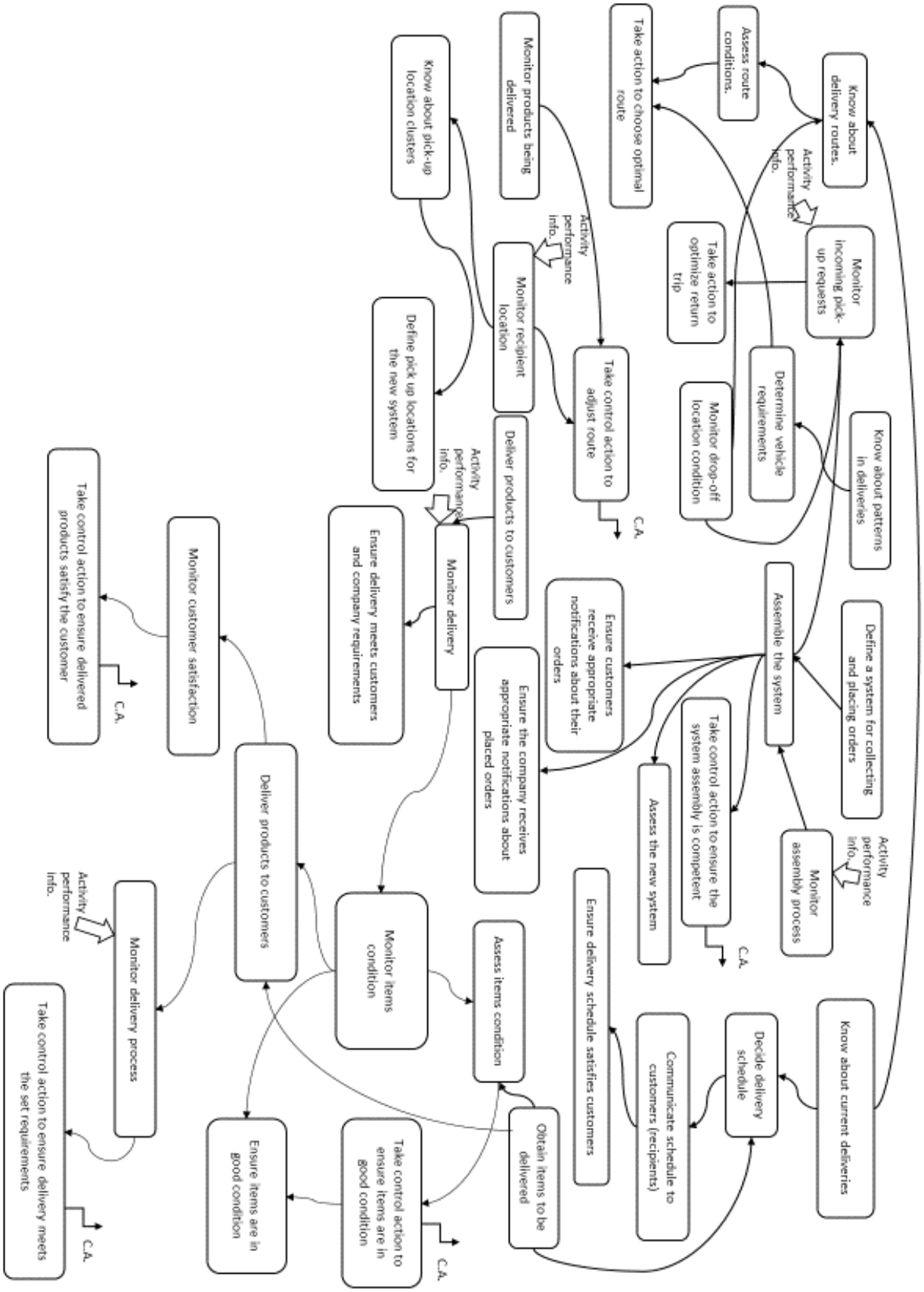
12. Appendix A – Work Plan

Gantt Chart for Project 88 (Internet of Things Framework for Last Mile Logistics)

Activity	Plan Start	Plan Duration	Actual Start	Actual Duration	Periods: Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Easter Recess	Week 9	Week 10	Week 11	Week 12	VIVA
Submit initial report	Week 2		Week 2		*												
Collection of data	Week 1	4 weeks	Week 3	6 weeks													
Choose what methodologies and frameworks will be used	Week 3	2 weeks	Week 3	6 weeks + Easter Recess													
Analyse and interpert data (review literature)	Week 3	3 weeks	Week 3	7 weeks + Easter Recess													
Complete selection of methodologies	Week 4							*									
Complete selection of companies that will be analyzed	Week 5							*									
Carry out SSM analyses and create models	Week 7	3 weeks + Easter Recess	Week 7	4 weeks + Easter Recess													
Complete Porter 5 Forces Analysis	Week 10	1 week	Week 10	1 week													
Create Activities Table	Week 11	1 week	Week 11	1 week													
Create framework (Business Process Map)	Week 9	3 weeks	Week 9	4 weeks													
Write findings of the analyses and final report	Week 6	7 weeks	Week 6	7 weeks													
Submit final report	Week 12															*	
Weekly meetings with supervisor	Once a week from Week 3 onwards		Week 3			#		#	#	#	#			#	#		
Project review meetings with supervisor	Week 7 and Week 10									#				#			
Project completion	Week 13-15																*

* - Milestone
\# - Event

13. Appendix B – DHL SSM Enterprise Model



14. Appendix C – Amazon SSM Enterprise Model