IOT SYSTEM FOR TRACKING PRODUCTION AT

NOVEFA

5TH SEMESTER PROJECT, INFORMATION TECHNOLOGY

GROUP 8

EMIL RAVN, LASSE JAKOBSEN, LASSE REHDER SØRENSEN, SIMON ELIASEN, THOMAS VINTHER

AALBORG UNIVERSITY
STUDENT REPORT

Information Technology
Aalborg Universitet
5th semester

Title:
IoT system for tracking production at Novefa

Theme:
Integrated Distribution Systems

Project Period:
September, 2020 - December, 2020

ECTS:
15 ECTS

Group:
Group 8

Participants:
Emil Ravn
Lasse Jakobsen
Lasse Rehder Sørensen
Simon Eliasen
Thomas Vinther

Supervisor:
Chen Li

Characters: 96.219
Pages: 51
Appendix: 2

Abstract:

The purpose of this paper has been to identify and analyze the processes of a business with the intent of optimizing them. Furthermore, the integration between IT and the processes of the business has been the end-goal.
In this project, a collaboration with Novefa, an agricultural company utilizing vertical farming, has been established. Their processes have been identified and analyzed thoroughly through the use of interviews. In conjunction with the data, the paper suggests that the tracking of the growing process could be optimized by utilizing an IoT system.
The paper follows the principles of Business Process Management, specifically the BPM lifecycle, to analyze and investigate the processes of the company. This includes the use of an as-is and to-be process models. Furthermore, an analysis of the redesign has been done by the use of the Devil's Quadrangle. This has been done in order to evaluate the optimal solution that would best fit their needs. Finally, an implementation and an evaluation of the actual IoT system is found in the end of the paper.

Preface

This project is written by 5^{th} semester students studying Information Technology at Aalborg University. The goal of this project is to bridge IT and business by obtaining knowledge on business processes, understand how these processes work and impact the business, design a system to improve said processes, and implement the system into the business. The acquisition of this knowledge is gained through project work with a private business.

Acknowledgment

We would like to thank our supervisor, Chen Li, for providing us with feedback and supervision throughout this project. Furthermore, a special thanks to our project collaborators from Novefa, Matias Holch Christensen and András Kiss, who have been willing to work with us for this project and allowed us to visit their facility for our data gathering efforts.

Emil Ravn
eravn18@student.aau.dk

Lasse Jakobsen
ljako13@student.aau.dk

Lasse Rehder Sørensen
lsaren18@student.aau.dk

Simon Eliasen
selias18@student.aau.dk

Thomas Vinther
tvinth18@student.aau.dk

Report Structure

The report is based on the Business Process Management (BPM) lifecycle, which will be defined later in the report. Furthermore, in this report the lifecycle is defined as six individual phases, and each phase will be explained in their respective chapter.

The citation and reference style used in the report is according to the American Psychological Association (APA). Figures and tables will be numerated according to their Chapter, for example *Figure 4.1.* If a previous section is referred to it is explicitly written which section it is. A list of figures, appendixes and references is found at the end of this report.

Contents

1 | Introduction

This paper focuses on showcasing how the implementation of an IoT system can benefit a company called Novefa which uses vertical farming. This chapter introduces the relevant terms that are needed in order to understand the problem statement.

1.1 Internet of Things

Internet of Things, or more commonly known as IoT, is a term first introduced in 1999 by Kevin Ashton. The term references a network of physical objects (things) embedded with technologies such as sensors and software. IoT aims to streamline processes whether it be a business process or a daily process at home, and is used in areas such as defense, healthcare, industry, and agriculture (IoT Analytics, 2020).

1.2 Vertical Farming

Vertical farming are closed systems where crops are farmed indoors using LED lights as the light source instead of the sun. The crops are stacked vertically in shelves which means that multiple crops can be on top of each other. The main benefits of vertical farming is that it takes up less space and that pesticides can be avoided, which enhances the quality of the produce. The fact that it is in closed systems entails that all factors can be controlled. For this reason, vertical farming is independent of the seasons and can therefore be grown all year as well as being resistant to other weather changes. Vertical farming also requires less water (Nielsen, 2020).

1.3 Novefa

In an effort to show the applicational value of IoT, a cooperation with Novefa, a small start-up company based in Aalborg, has been established. Novefa's main goal is utilizing the benefits of vertical farming, and bringing high quality produce to local restaurants and retail businesses. Novefa was founded on the values of responsibility, quality, being open-minded, open-hearted, and decency (Novefa, 2020).

Novefa is trying to modernize agriculture and seeks to fulfill their vision of, "inspiring

innovation and sustainability in tomorrow's food production" (Novefa, 2020), by utilizing new technologies for a fresh take on farming in modern societies. The modernization comes from a focus on vertical farming and the associated benefits this method brings. Furthermore, this modernization is in line with Novefa's own values. The primary focus of Novefa is to provide produce to the customer without compromising the quality of the produce itself. This is done by providing the best conditions for growth by monitoring, and by fulfilling every need of the plant. The needs are covered by using hydroponics. This means that the water used is recirculated and is distributed directly to the plants. This makes for healthier produce by neutralizing the need for pesticides which in turn also heightens the quality of the produce (Novefa, 2020).

Denmark has regulations regarding food and agricultural products. A business selling food and/or agricultural products needs to be able to document who the suppliers are and to whom the products are sold (Fødevarestyrelsen, 2017, p. 8). This is in place to ease the problem of recalling a product if needed. Therefore, Novefa need a system that is able to support the primary focus by tracking the produce from when their seeds are sown to the shipping of the end-product.

As previously mentioned, one of the main benefits of vertical farming is that all factors can be controlled for example the light, the water, the temperature, the humidity, the seed, the seed density, the seed bed, and the hydroponics. The production tracking system should therefore also provide data that Novefa can analyze in order to optimize these factors, as well as optimize the economic aspect of the business.

1.4 Research Question

Based on the previous section, the following research question is found relevant to explore:

How can an IoT system improve the tracking of the production at Novefa?

2 | Methodology

2.1 Business Process Management

The term *Business Process Management*, which is abbreviated BPM, is defined as "[...] the art and science of overseeing how work is performed in an organization to ensure consistent outcome and to take advantage of improvement opportunities." (Dumas et al., 2018, p. 1). Basically, the goal of BPM is to manage entire chains of events, activities, and decisions that add value to both the organization and its customers. Finally, BPM is also seen as a collection of tools, techniques, methods, and entire methodologies that support all the stages of a *business process*, which is defined as "a collection of related, structured activities or tasks that produce a specific service or product for a particular customer or customers [...]" (Dumas et al., 2018, p. 1). The broad spectrum of BPM can be captured in the *BPM Lifecycle* as seen in Figure 2.1.

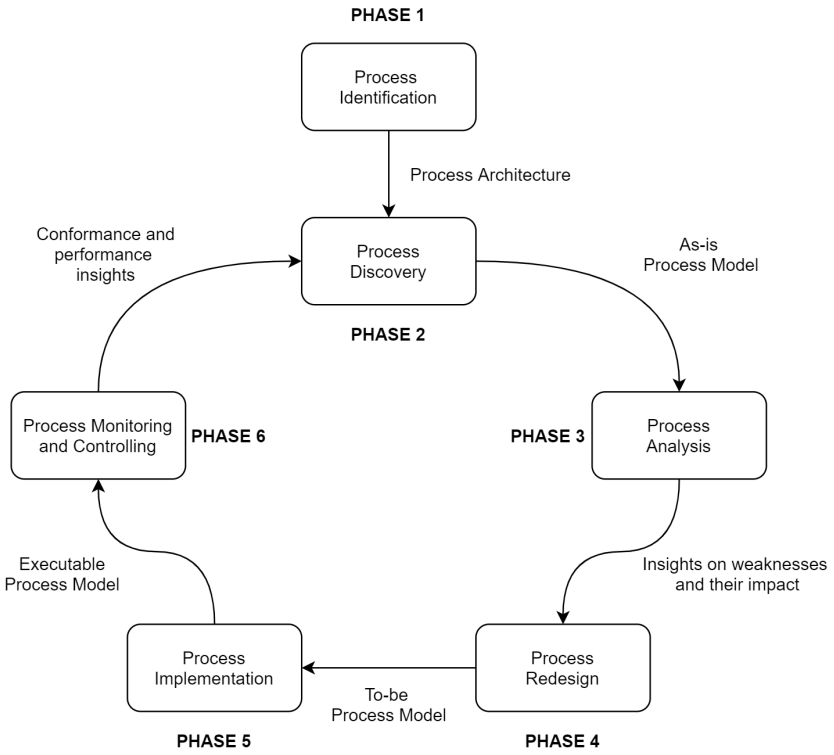

Figure 2.1: BPM Lifecycle (Dumas et al., 2018, p. 23)

The BPM lifecycle consists of six phases, with each phase having a distinct purpose. As

mentioned in the structure for this report, each phase will be given an explanation at its respective chapter. Starting off by identifying the relevant processes of the organization, one will be selected for further analysis. After the analysis has been conducted, a redesign will be proposed for the selected business process on behalf of the requirements given by Novefa. Finally, an implementation on the redesign proposal will be presented. The report will exclude phase six due to the nature of the project's deadline and the fact that resources will not be allocated for further monitoring and control of the system after the implementation. This responsibility befalls Novefa and their employees.

2.2 Business Process Model Notation

To model the business processes in terms of an as-is process model, an explanation of the modeling language is required. The use of *Business Process Model Notation* is used to structure a model that can depict all the possible scenarios a given business process can be exposed to (Dumas et al., 2018, p. 75 - 76). The four main modeling elements are activities, events, gateways, and sequence flows, as shown in Figure 2.2.

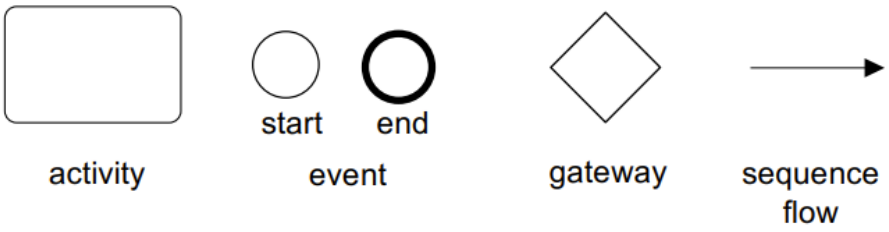

Figure 2.2: BPMN Core Elements

An event can either define the beginning or the end of a process and signifies an action that happens instantaneously. An activity defines tasks in the process and has a fixed or varied duration. A sequence flow depicts the route of the activities in the process model. An activity may also repeat, denoted by an activity with a sequence flow going back to a prior activity before it. Finally, a gateway defines the path in which an activity must follow based on what happens during the execution of it. Gateways comes in three forms; exclusive gateways (XOR), parallel gateway (AND), and inclusive gateways (OR), as seen in Figure 2.3.

(a) XOR (b) AND (c) OR

Figure 2.3: BPMN Gateways

The XOR gateway as seen in Figure 2.3a is illustrated as a diamond marked with an "X". The

XOR gateway allow activities to take a split decision, which means taking one sequence flow entirely excludes the other. The sequence flow proceeds when one of the incoming branches of the XOR gateway has completed. The parallel gateway as seen in Figure 2.3b is illustrated as a diamond marked with a plus sign. The parallel gateway needs two activities to execute in order for the sequence flow to proceed to the next activity. The OR gateway as seen in Figure 2.3c is illustrated as a diamond marked with a circle. In this scenario, one or more activities may occur at the same time for the sequence flow to proceed (Dumas et al., 2018, p. 80-86).

Data objects will also be depicted on the as-is process model. They capture a physical or an electronic object which is a necessary object needed to trigger an activity and/or proceed in the sequence flow. Finally, the model depicts what is known as pools and lanes. A pool captures a resource class and in this case models the separate entities: the customer, the company, and the supplier. A lane indicate a class inside the pool, in this case employees working at Novefa (Dumas et al., 2018, p. 93-96).

2.3 Gathering Information from Novefa

To work out a possible solution for Novefa, it is important to gather reliable data since this data is used to both analyze the current situation but is also used to give a qualified assumption on improvements on the analyzed situation. The situation at hand will affect the chosen method but it is important to distinguish whether the objective is to obtain qualitative or quantitative data To gather information for this project. (Dumas et al., 2018) lists the following data collection methods: Evidence-Based Discovery, Interview-Based Discovery, and Workshop-Based Discovery (Dumas et al., 2018, p. 165-175).

There are multiple submethods for the three mentioned methods. Document analysis, observation, and automated process discovery is linked to performing evidence-based discovery, whereas interview-based discovery primarily concerns itself with interview with domain experts. This is to uncover and get an understanding of the different processes. Lastly, workshop-based helps to create a rich understanding of the business processes. This method has an advantage over the interview-based discovery because it uses the process participants (Dumas et al., 2018, p. 172), but the advantage is negated since Novefa is a startup company and therefore the employees can be considered the process participants.

For this project, an interview-based discovery method is used. There are different kinds of interview structures: structured interviews, semi-structured interviews, and free-form interviews. These three structures shares the importance of validating assumptions made from the previous interviews. This implies that the interview-based discovery is an iterative process (Dumas et al., 2018, p. 168-172).

Structured interviews, as the name implies, are preplanned and are constructed with specific topics and questions. It aims to execute the interview with few to none deviations from the interview guide (Kvale and Brinkmann, 2015).

Semi-structured interviews is the same as structured interviews in regards to it following an interview guide, but the difference is that semi-structured interviews have space for deviations in the interview guide allowing the interviewer to follow up on respondents' answers (Kvale and Brinkmann, 2015).

Lastly, free-form interviews have no predefined interview guide. There is a set of topics that the interviewer wants covered, but the interview itself can be seen as a conversation between the respondents and the interviewer. The free-form interview allows the respondent to discuss the processes at a level they find appropriate which might uncover aspects of the process previously disregarded (Kvale and Brinkmann, 2015).

For the acquisition of information from Novefa, a semi-structured interview was conducted with the CEO and CTO.

2.4 Interview Summary

An interview was done with Novefa's owners at their facility in Støvring. The interview introduced Novefa, the owners, their prior experience in the field of vertical farming, as well as their intentions for Novefa's future endeavors. In addition, it revealed several key aspects related to their internal processes, and their thoughts on a potential system integration. Two main topics were discussed during the interview, namely their current workflow, and system requirements they wanted to see in a potential system integration. Information extracted from the interview in the form of a transcription, gave great insight into the workflow of employees, and allowed for the project group to gain a baseline of knowledge to help model the processes of Novefa. In addition, a system suggestion was discussed, which resulted in feedback on proposed functions, and provided the project group with an opportunity to adapt the system to fit the needs of Novefa in their current situation.

3 | Process Identification

To get an understanding of what part of Novefa an IoT system could provide the most value, an understanding of the processes within Novefa was needed. However, in order to understand these processes, it is imperative to identify them. Novefa already had other students working with them that both sought to analyze their business and implement IT-systems, where information between students also helped give a broader understanding of their business processes. The first phase in the BPM lifecycle, *process identification*, concerns itself with identifying processes which exist within an organization (Dumas et al., 2018, p. 35). For this phase, to not exclude any processes, it will broadly identify as many processes as possible. When the broader processes have been identified, the identification of subprocesses will begin. These subprocesses are what constitutes each of the broad processes. An evaluation of the processes will proceed the identification process once these have been identified and will be evaluated on certain criteria. The end goal of process identification is a *process architecture* which will be introduced in the following section. The initial architecture will allow us to get a deeper insight into the structure of Novefa at its current state (Dumas et al., 2018).

Dumas et al., 2018 suggests that it is important to focus on the processes that are central to the area of concern for the business or organization. In cooperation with Novefa, the processes of the business have been mapped. These major processes are seen as impactful to the startup business. The following is a list of the major processes within Novefa:

- **Strategic Management:** Refers to the top management process. It sets the objectives and vision of Novefa based on the founders wishes. Furthermore, it assesses the resources and logistics whether it be internal or external and provides direction for the rest of the processes.
- **Inventory Management:** This process concerns itself with the regulation of the warehouse. It administers purchased material/produce and the distribution of said produce.
- **Logistic Management:** This process overlooks most of the other processes and has an impact on the other processes' planning and execution.
- **Purchase Management:** This process concerns itself with analysis of the market with the goal of producing the correct produce. With the analysis of the demands of the market, the management purchase and produce accordingly. This is also known as forecasting.
- **Purchasing:** Refers to the acquisition of material/seeds for the warehouse.
- **Sales:** Refers to the process of selling Novefa's produce.

- **Service:** Refers to the process regarding customer and customer service. It therefore handles the problems in the procurement-to-customer flow.
- **Distribution:** The process of shipping the products to the customers.
- **Finance:** Refers to the process that handles all cost, fees, and profit within Novefa.
- **IT:** Refers to the process which covers and supports Novefa's digital processes.

3.1 Process Architecture

Process architecture is an illustration of the discovered processes from the process identification and is meant to give an overview for both the business and those who performs the process identification. This is achieved by displaying the processes and their relation to each other as well as how they behave in the business. Process architecture comes in three abstraction levels: *Process Landscape*, *Business Processes*, and *Sub-processes and Tasks* (Dumas et al., 2018).

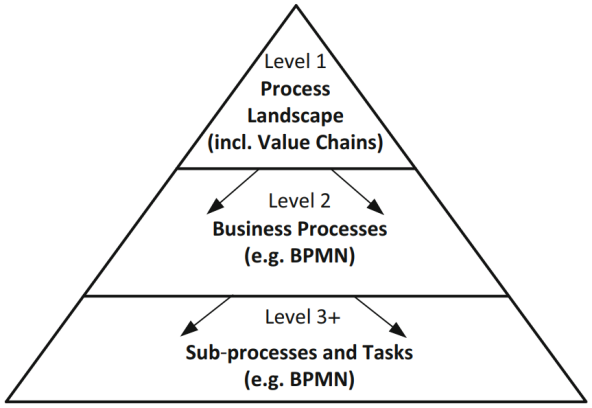

Figure 3.1: Process Architecture Levels (Dumas et al., 2018, p. 44)

The first level seen in Figure 3.1 is very abstract in its description of processes and only illustrates different processes. This allows businesses to relate and confirm the processes (Dumas et al., 2018). The second level uses models, which shows the relation between processes and the part of the business they serve. The third level gives a deeper insight of specific processes. The insight could come in the form of control flows, in- and outputs, participants, etc. (Dumas et al., 2018).

The processes will be categorized using *Porter's Value Chain*, which is meant to focus on system, and how inputs are altered into the outputs purchased by the consumer. Originally, it only consisted of core processes (primary activities) and support processes (support activities), but later had management processes added as a third category (Dumas et al., 2018, p. 41).

- **Core Processes** relates to the essential value creation within a business or organization. These processes can include manufacturing, marketing and sales, delivery, after-sales, etc.
- **Support Processes** are what enables said core processes. These include IT management, accounting, financial management, legal services, etc.

- **Management Processes** are what provides directions, rules, and practices for the core and support processes (Dumas et al., 2018, p. 41).

The processes discovered in the identification phase will be split into the aforementioned categories. Furthermore, *processes* are defined as what companies do whenever they deliver a service or a product to customers (Dumas et al., 2018). An example is the order-to-cash process, which handles all the activities that are related to purchase order verification, shipment, delivery, invoicing, payment receipt, and finally acknowledgment.

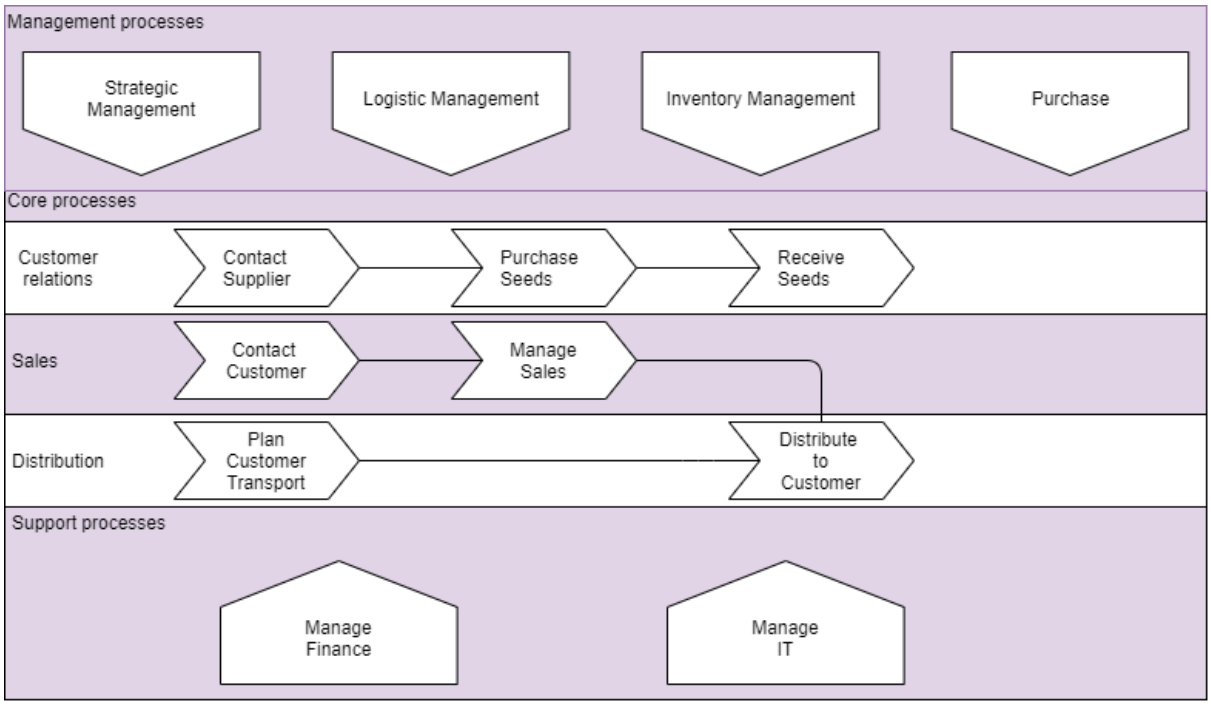

Figure 3.2: Process Landscape for Novefa modelled after (Dumas et al., 2018, p. 42)

The processes of strategic, logistic, purchase, and inventory management is inherently management processes and is therefore placed within the management category regardless of business structure.

The procure-to-pay process is the overall process and the supply chain revolves around this process. The processes linked to procure-to-pay will therefore also be labeled as core processes. These are purchasing, sales, distribution, and service.

Lastly, the support processes are what allows the core and management processes to function. Looking at Novefa's processes, all require financing to function and therefore the finance process will be placed as a supporting process. IT is another process that allows the other processes to function smoothly, and IT is becoming a requirement for most processes to function properly, which is why it has been set as a support process.

3.2 Process Evaluation

As previously stated after mapping the processes, an evaluation of said processes will occur. However, before the evaluation can proceed, the criteria for the evaluation will be described. These criteria are defined by Dumas et al., 2018, p. 56:

Importance

Dumas et al., 2018 explains that a process is defined as being important, the more impact it has on the business. Therefore, this criterion is used to assess the importance of a process in accordance with its impact on the business.

Health

This criterion determines how likely problems related to a process. According to Dumas et al., 2018 the processes in deepest trouble are the ones that will profit the most from BPM initiatives.

Feasibility

The criterion determines the likelihood of which a process is carried out by the process management initiatives. It is likely that there are obstacles for a process, whether it be organizational or political. Therefore, it is important to consider the obstacles before subjecting a process to design.

Now that the criteria have been defined the core processes can be evaluated using these:

Purchasing

As stated previously the purchasing process is related to the acquisition of materials and/or seeds for the warehouse. This process is ranked high on the importance criterion since without seeds, Novefa can not plant and sell produce. Since this is an important process for securing revenue the health of this process is high. The feasibility is low to medium because the employees might have some concerns regarding new initiatives.

Sales

This process starts when a customer has placed an order at Novefa and ends when the customer receives said order. This process is ranked high on importance since this is Novefa's main source of income.

This process is ranked high on the health criterion. Problems with this process will result in profit loss, making it worthwhile to continuously monitor this process. The feasibility of this process is ranked low high the employees of Novefa might be dissatisfied with any changes to this process.

Distribution

This process concerns itself with the distribution of Novefa's produce and is ranked as low on the importance criterion but will be moved up to important when Novefa upscales their business. It is important to Novefa that they get a new distribution system, which includes a tracking system regarding the regulations set by the Danish government (Fødevarestyrelsen, 2017, p. 8). The health criterion is evaluated to be low. This is due to the problems with keeping up with manually typing in shipping information and tracking the produce. An improvement in this process can help smoothe Novefa's upscaling. The feasibility criterion is set as high in this process since a new system could make it easier for the employees at Novefa. They seek to automate this instead of typing everything manually.

Service

This service process concerns itself with customer service. It is related to the sales process and starts when a customer requests for a product. The process is ranked high in regard to the importance criterion since it is closely related to sales, the main income of Novefa. This is also a process worth monitoring making it less likely to relate to problems. Therefore it can be evaluated as high on the health criterion. The feasibility for this process is relatively high since a great customer service is important for any business; especially a smaller one, that heavily relies on customer satisfaction while building up a customer base.

By mapping and evaluating the core processes the second level in Figure 3.1 has been completed. The more detailed description of the processes and their sub-processes will be described and explained in the following chapter, being showcased in an as-is model.

4 | Process Discovery

This chapter explores how to gather and organize information to create a representative abstraction of Novefa's business processes based on the processes that are relevant to explore for this project. These efforts were carried out in an iterative process together with Novefa to increase the validity of the findings. The final result of this phase will be in the form of an *as-is process model* that presents an overview of the processes at Novefa, which helps and enables the analysis and improvement upon the current business processes (Dumas et al., 2018, p. 159).

Upon data collection of information for analyzing business processes, it is important to ensure that the information gathered to form models are not only syntactically correct, but they should also reflect the actual business process that is being modelled. In this instance, process analysts require information from the domain experts at Novefa, where the representatives from Novefa both function as actively working in the factory, and managing the business. This is given by the company's limited size, thus giving a full picture of the active business processes taking place and steering away from a fragmented process knowledge.

4.1 As-is Process Model

In light of the already established focus on improving upon the internal tracking of produce and the stages of development. The resulting as-is process model, as shown in Figure 4.1, will include a broad overview of all core processes at Novefa in order to identify the most critical process in which a process redesign can bring the most benefit in regards to Novefa's goals. The as-is model serves as a foundation of which the to-be model will be built upon, which will be presented in Chapter 6, in order to shed light on a process redesign.

The following model uses all of the elements presented in section 2.2 about business process model notation. Furthermore, the use of *start timer event* and *intermediate time event*, which respectively are used to indicate whenever a process instance is started on cyclic timer events, i.e points in time, and the other indicates whenever the execution of a process is delayed until a certain point in time is reached or a particular duration is over (Signavio, 2020). Finally, the model identifies three pools. These are the customer, Novefa, and the supplier. It also identifies three core processes at Novefa with two of them being subprocesses. The model can be seen in Figure 4.1

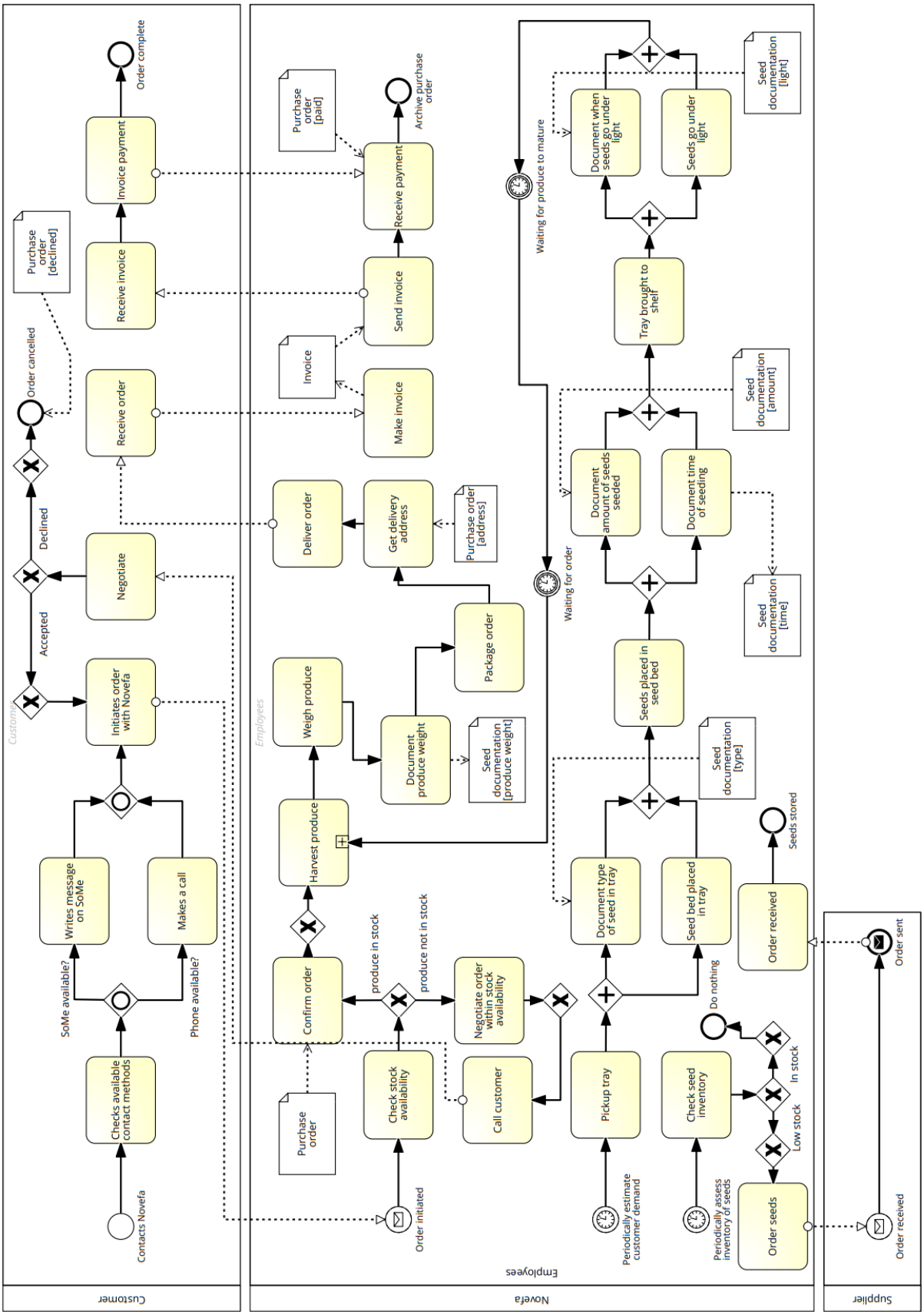

Figure 4.1: As-is Process Model

Summary of As-is Process Model

The customer pool is initiated by a decision to contact Novefa. This is either done through a message on social media or a phone call. Once both parties are in contact, a message start event is initiated and ends in the Novefa pool, beginning the core process at Novefa. The employees at Novefa starts by checking their stock availability in regards to the customer's demand. This also creates a document containing the purchase order. The XOR gate shows two possible sequences; the produce is either in stock or it is not in stock. Based on the outcome of the sequence flow, Novefa either tries to negotiate with the customer, starting the order cycle all over again, which can either result in the customer declining the negotiation or the negotiation gets accepted and the order is committed again.

If the produce in question is in stock, Novefa confirms the order which then initiates a subprocess, which is to grow the produce. Grow produce begins by a start timer event that is based on a periodic estimation of customer demand. The first activity, pickup tray, creates a new data object called seed documentation, which is needed to store information about the seed. Along this process, with every activity comes some form of information regarding the seeds which needs to be documented. This documentation needs to happen at every activity before moving on to the next one. Once the seeds go under light it is just a matter of waiting for the produce to mature, as shown on the intermediate time event, in order for the produce to be ready for harvesting. Finally, the waiting for order timer begins, awaiting a customer order.

Once the harvesting is done, Novefa will both weigh the produce in regards to the customer's demand, and document details about the produce. The next step is to package the order and prepare it for delivery. This process is another subprocess within Novefa's core processes, namely shipping and invoicing. In this subprocess, Novefa delivers the order before invoicing the customer. The invoice document is then created and sent to the customer. Once the payment is received from the customer, the document containing the purchase order can be marked as paid and the purchase order can be archived, ending the process.

Finally, Novefa has one more core process that is initiated periodically when inventory of seeds are checked. Novefa will manually check their inventory to see if they are short on supply. Based on this check, they will either order seeds from their supplier, and in return receive the seeds and store them at the facility, or they will simply do nothing in the case that the seeds are in stock.

It should be noted that the system which Novefa seeks to implement will alter the core process by simplifying the documentation. This will be done so an overview of each crops placement in the production process can be monitored from a single computer, thus creating a greater insight into the traceability internally at Novefa. This will be explored further in the next chapter.

5 | Process Analysis

In this chapter, the subprocess that is identified in chapter 4 is highlighted. The subprocess, which will be referred to as the *growing process* throughout the report, is the one linked to the 'harvest produce' activity. To analyze the internal processes discovered at Novefa, the *Value-Added Analysis* is used (Dumas et al., 2018, p. 213). The purpose of this analysis is to increase the understanding of the current growing process by identifying the values associated with the activities in the process.

5.1 Value-Added Analysis

Decomposing in the Process

The first aspect of the analysis is to decompose and break down the overall process into simple steps, which can also be described as tasks of the process. This makes it possible to gain an overview of each individual step, and analyze the value it brings to the process (Dumas et al., 2018, p. 214).

Identifying the Customer

The second aspect of the analysis is to identify the customer. Recognizing the customers of the process makes it possible to get a clear insight into what value the specific process brings to them, and what the desired outcome they want to see is (Dumas et al., 2018, p. 214).

Analyzing the Value of Each Step

The final aspect of the analysis revolves around the potential value each step brings. The steps of the process can be categorized into three different categories, depending on the value they add and the importance of them for the process as a whole (Dumas et al., 2018, p. 214). The categories are:

- Value Adding (VA): It provides value for the customer of the process.
- Business Value Adding (BVA): It is required for the business to function as intended, or if it is required by law.
- Non Value Adding (NVA): It does not fit in the other categories and does not provide value in some form for the customer or the business.

5.2 Analysis of the Activities at Novefa

As the previous chapter describes, Novefa's current process were discovered from data gathered from meetings with the owners. In this section, the steps showcased in the as-is process model will be analyzed on the basis of the value adding categories, and presented in chronological order. The growing process has been reformatted into a condensed format for clarity and readability, which is shown in Figure 5.1.

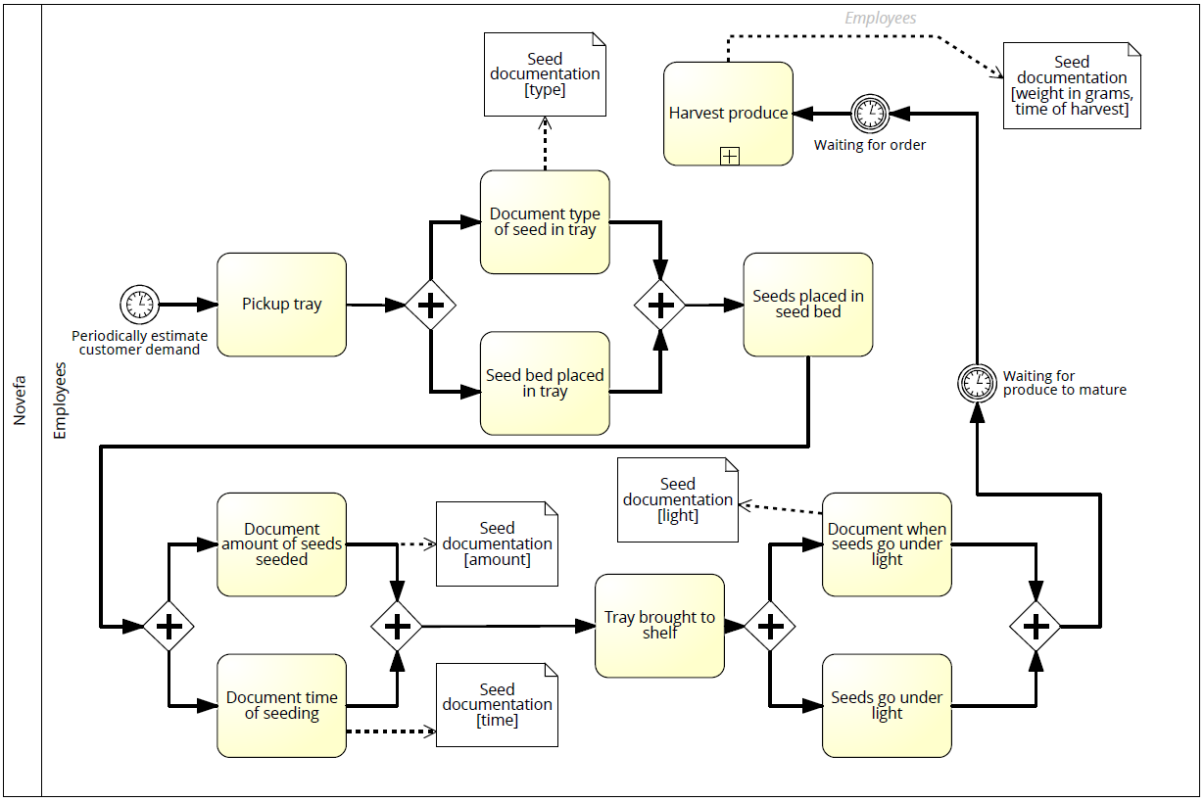

Figure 5.1: Subprocess - Harvest Produce

In the model, the event that starts the process is identified as *periodically estimate customer demand*. It is derived from a subjective opinion from the employees at Novefa, based on their forecast of customer demand. This step is evaluated as BVA, as it is needed for the business to run optimally. The step allows the company and its employees to have produce in stock when it is requested in an order, therefore enabling them to harvest produce, ship faster and produce more.

The first activity in the process model is identified to be *pickup tray*. It occurs after the estimation of customer demand has been made. A tray is picked up by an employee and is bringed to the seeding table. This step is categorized as NVA, because it does not add any real value to the business or customer. It is simply a transportation step.

The next activities, which run in a parallel gateway sequence flow, is identified as *document type of produce in container* and *seed bed placed in tray*. The first activity is conducted when

a specific type of produce is designated to a certain container for planting purposes, and is documented in a set of control sheets. This step is evaluated as BVA, as the control sheets are used as a managing tool to keep track of which plants are placed in which container, and helps the employees to keep track of the produce. However, because the control sheets are in the form of manual data entry, they will have to manually enter data every time a step in the process requires something to be documented. The second activity is performed when the seed beds are cut up and prepared for the seeds to be placed in them later on. Afterwards, they are placed in a tray. This activity is evaluated as BVA, as it is essential for the quality of the produce, namely that the right environment is set up for seeds to allow for the best growing conditions from the beginning. the containers also allow for the company to keep a more structured overview of the collective crops being produced.

The next activity is identified as *seeds placed in seed bed*. It occurs when the containers have been prepared and are ready. It is evaluated as BVA, as it is essential for the business to run as intended. This is one of the most vital steps as the process cannot produce a result without it. For this reason, it could also be evaluated as a VA.

In the lower half of the model, the next activities also run in a parallel gateway sequence flow. These activities are identified as *document amount of seeds seeded* and *document time of seeding*. The first activity happens in correlation with the seeds being planted in the seed beds. This is BVA, as it is used for keeping track of the amounts of seeds planted in each container, and comparing them to previously sown batches. It produces value because it is possible for Novefa to analyze the yield and growth potential and better themselves in this prospect. The second activity happens sequentially with the step before, and is used for the same purposes as well as helping with determining when the produce is ready for harvest. As both activities still are manual data entries, they will have to manually enter data every time a step in the process requires something to be documented.

The next activity is identified as *tray is brought to shelf*. It happens right after the aforementioned step is completed. This step is evaluated as BVA in that it brings management advantages to the process. By placing the containers in organized shelves, it makes it possible for the employees to place containers as needed while keeping an overview of their placement for quick access. However, it could also be categorized as a VA, because the lights is placed on the shelves, so the growing process is dependent on the trays being moved to the shelf.

The next activities runs in a parallel gateway sequence flow. These activities are identified as *document when seeds go under light* and *seeds go under light*. The first activity happens after the containers have been placed in the shelves, and the light has been turned on. This step is, together with some of the aforementioned steps, used for the purpose of monitoring the growing process, and is evaluated as BVA. This step is used for monitoring how far along in the individual growing process the plants are, and is crucial for estimating approximately when the produce is ready for harvest. Furthermore, this activity needs to be documented manually.

The second activity happens when the growing process is about to begin. This step is evaluated as BVA, because it adds a significant amount of value to the produce when they finish their growing process, and it is needed for the process to continue. The customer is willing to pay for the value that is adding which is why it could also be identified as a VA.

The process then comes to a halt when there is a time gated event. The produce need to mature before it is ready for harvesting. This is indicated by the event *produce matures*. This is evaluated as BVA, as the produce needs to mature before something of value is gained from the entire process before it. For this reason it could also have been identified as a value activity. This event is followed by another time gated event, *waiting for order*. Novefa will not harvest the produce until a customer has made an order, but the wait time is not directly adding value to the business, nor the customer, which is why it is a non value adding event.

The final activity is identified as *harvest produce*. When the produce is matured and have reached their desired yield, this activity is carried out. It is evaluated as BVA, as it is important that the produce is harvested at the right time to retain the optimal quality of the produce. This greatly benefits both Novefa, and their customers, as a high quality product is desired by both parties. However, this activity could also be a value adding activity because the customer is willing to pay for it.

Summary of Process Analysis

BPMN Type	**Description**	**Value**
Start Timer Event	Periodically estimate customer demand	BVA
Activity	Pickup tray	NVA
Activity	Document type of seed in tray	BVA
Activity	Seed bed placed in tray	BVA
Activity	Seeds placed in seed bed	BVA
Activity	Document amount of seeds seeded	BVA
Activity	Document time of seeding	BVA
Activity	Tray brought to shelf	BVA
Activity	Document when seeds go under light	BVA
Activity	Seeds go under light	BVA
Intermediate Time Event	Produce matures	BVA
Intermediate Time Event	Waiting for order	NVA
Activity	Harvest produce	BVA

Table 5.1: Identified Elements of Process Analysis

Figure 5.1 visualizes the collection of BPMN elements in the process which has been analyzed, and how these add value to the process as a whole. A number of activities included in this section holds potential for improvement, which will be the focus point in the following chapters.

6 | Process Redesign

This chapter seeks to expand upon the previous phases of the BPM lifecycle in order to identify and improve upon existing business processes at Novefa. A short explanation of the concepts and method along with the results from the redesign will be presented in the following chapter.

Process Redesign is defined as a change to an existing process (Dumas et al., 2018, p. 300). In order to do this, the subprocess that was presented in chapter 5 is explored further. Furthermore, the use of the *The Devil's Quadrangle* by Dumas et al., 2018, p. 304 will be used to establish what the end-result should be when a process is selected for process redesign. The outcome of this phase will be a to-be process model.

6.1 The Devil's Quadrangle

The Devil's Quadrangle, shown in Figure 6.1, is a model showing four diagonals representing four performance dimensions. These are flexibility, time, cost and quality.

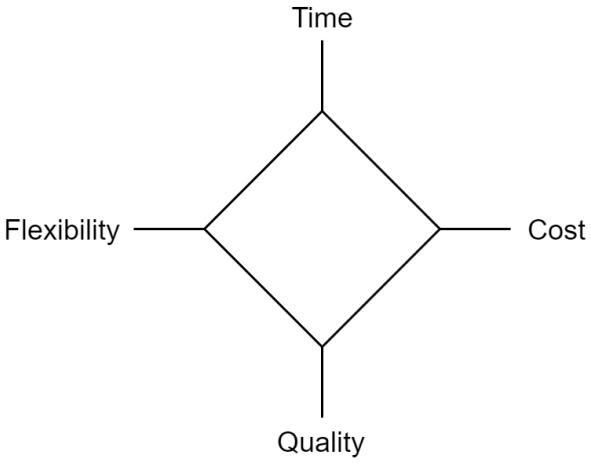

Figure 6.1: The Devil's Quadrangle (Dumas et al., 2018, p. 304)

The four dimensions entails that pulling one metric on a diagonal may affect the opposite metric on the same diagonal. These four dimensions are important to consider before progressing with a redesign choice.

Time

The time dimension describes time in relation to cases - a case being an order for example. It can be viewed from two perspectives: processing time and waiting time. Processing time deals with the time a process participant uses to handle a case throughout a process. Waiting time deals with the time a case spends in a state of no progression (Dumas et al., 2018, p. 59).

As mentioned in chapter 5, there are multiple steps in the process that could be optimized, specifically in the time dimension. These are all the steps containing documentation.

"*[...] and then we have documented how many grams we have seeded, when they were seeded, when they were put under light, like right now, these are not put under light, when they are put under light, when they are harvested.*" (Appendix A, column 33).

As seen in the quote, the owners describe how a large amount of information needs to be documented multiple times throughout the process. This activity takes some time in the long term, as the employee in question will have to go and retrieve the 'control sheets' at each of these points in the process, where details need to be documented.

"*And then we'll know that when we have scanned this tray once, then it's because it's under cover, and then when we scan it the second time, that's when we are putting it under light*" (Appendix A, column 163).

A potential solution to managing the process data is to implement a digital solution which will take advantage of a barcode scanner to manage the different states of the process that the produce will undergo. This could greatly improve the time dimension of the Devil's Quadrangle, in that it would be possible for the employee to use the scanner every time a container needs to change states, and scan it to progress it in the system replacing the control sheets. The data would then automatically be saved and organized in the system, so that the employee at any time could retrieve it. By redesigning the process this way it would also add some quality benefits, which will be explained in greater details in the quality dimension.

Quality

The quality dimension of the Devil's Quadrangle can be divided into two aspects: external and internal quality. The external perspective deals with the contentment of the customer in regards to the product of the process itself. The internal perspective deals with how the process participants experience the process (Dumas et al., 2018, p. 60).

As mentioned previously, Novefa is documenting all relevant steps manually which consequently can be an inconvenience for the employees at times.

"*when we are doing the partial harvesting, then we are just guessing, okay this is maybe 2 fifth, or 3 seventh of the whole tray, and then we are writing it two places that yeah first it was 100 grams, and when we finalized the harvest some days after, then its additional 120 grams, so we are writing that down manually [...]*" (Appendix A, column 165).

As the statement suggests, during the harvesting step, the manual handling of data sometimes causes a hassle. When Novefa harvests produce for a particular order, they primarily perform partial harvests of a tray, as the trays typically contain a significant amount of produce. Therefore, multiple orders could contain a certain type of produce from the same tray. In accordance with the as-is process model, Novefa manually writes down the specific weight of the partial harvest and the date in the control sheets. Novefa would like to digitize the data entering and potentially use the data to analyze and gradually improve the growing process.

"*[...] it would be nice if the system could like say okay this tray is the same as the other partial harvest so then we multiple those two, and also having the date of when the first partial harvest was and then when the full harvest was.*" (Appendix A, column 165).

As seen in the statement, Novefa's owners have a proposal of how this could be optimized by integrating these steps with the aforementioned digital solution. The system could include a section of the system where the employee in question would be able to enter the weight of a harvest done on a particular tray, and automatically calculate the total weight when the tray is fully harvested, which should enable Novefa the ability to optimize the yield potential of future trays.

Another obstacle Novefa has encountered is the legal requirement to keep relevant order information in the case that consumption of a specific produce causes health issues for a customer.

"*[...] we need to track it for some time the lot number, because if someone get sick of this exact tray, we need to call back all the deliveries that we have had with this one tray.*" (Appendix A, column 217).

The system would already contain data about every stage throughout the process in which a tray moves through, therefore the data storage is already implemented as a byproduct of the digital solution suggested. The only added attribute needed in the system to accommodate Novefa's request is that the partial harvest of an order needs to be connected to the customer to allow the tracking of the entire order throughout, making it retraceable in case of a needed callback of certain produce. By accommodating these optimizations of certain process steps it is possible to increase the quality of the overall process in Novefa. Both to the advantage of the customer, who receives better quality produce throughout their business with Novefa, but

also for the company and their employees, as the quality of the workflow is increased by making documentation steps more efficient and by centralizing the process data.

Cost

The cost dimension encapsulates and describes the financial side of a process. In general, a business would like to minimize costs but attain high profit. In redesign, the focus is on reducing operation cost (Dumas et al., 2018, p. 60).

The cost perspective of the process can be expected to receive an improvement as well. Assuming the suggestion for a digital solution is implemented and used, it can be assumed an increase in produce quality would have a positive effect on the revenue of Novefa in the long term. Secondly, in the future as Novefa's potentially expands their production, the system could decrease the cost of labor as it automates the manual entering and management of data, freeing up employees for other tasks, saving both time and money. These changes would also be apparent at time of implementation, but would have a impact correlated to the facility's size.

As of now they write everything down manually as mentioned in the quality section, as a result of this potential errors could happen upon loosing or misreading manually typed out data, which would result in a loss of money.

Flexibility

The flexibility dimension of the quadrangle is described as the ability to adapt to changes (Dumas et al., 2018, p. 61). If Novefa in the near future considers upscaling their production facility, the newly implemented system would increase flexibility as they would already be equipped to react to the changes. New workforce in the business would be able quickly adapt to the increasing workloads with each expansion in their production facility. The IoT implementation is therefore more scalable in the new business process than in the old business process, where a expansion would require a great deal of managing manual data entries. The manual tracking imposes an greater risk in relation to making errors upon manually creating documentation in the system. the issues of manual data entry is potentially exponentially correlated to the scale of Novefa. This would be avoided by using an IoT system.

Redesign Impact on The Devil's Quadrangle

In the process analysis, it was discovered that the growing process contained a great amount of documentation steps throughout the process, which was an inconvenience at times, and is time consuming in the long run. The redesign of the growing process is therefore mainly focused on shortening the time dimension, bettering the quality by enabling the employees to monitor and improve the growing process, and thereby improving the remaining two dimensions as a byproduct of this.

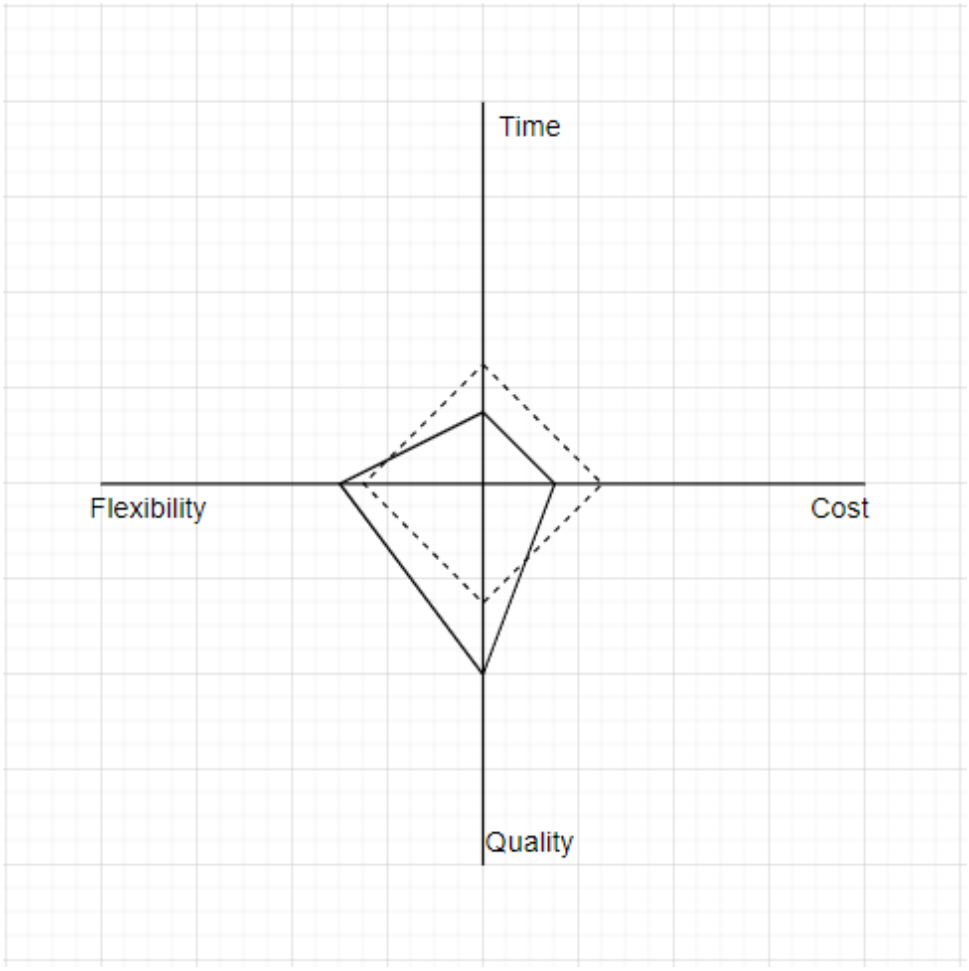

Figure 6.2: The Devil's Quadrangle Post Redesign

The model, shown in Figure 6.2, is a representation of the impact the redesign of the process, is expected to have on the four dimensions of the devils quadrangle after the aforementioned digital solution suggestion has been implemented. The stippled line depicts the baseline of the four dimensions, whereas the other line depicts the change in the dimension as a result of the redesign. Though it should be noted that this representation is only an estimation, given that it is not based on concrete data, because the theory does not contain a way of doing so, but rather on the estimates made by the process analysts.

Heuristics

To explain how the redesign improvements, introduced in the previous section, will be implemented, heuristics are used. Heuristics focuses on a systematic contemplation on a number of different redesign heuristics (Dumas et al., 2018, p. 315). Based on the dimensions seeking improvement in the Devil's Quadrangle, a set of heuristics have been chosen based on their relevance. These are:

- **Parallelism:** Is about executing activities simultaneously to decrease the time spent on

these activities as a whole.

- **Activity automation:** Is about automating a process activity to decrease the time spend as well as producing higher quality results at a lower cost.
- **Integral technology:** Is about eliminating constraints by implementing technology that introduces positive effects on a process.

Redesign of Container Preparation

In the beginning of the process, the employees prepare a tray for production by preparing the seed beds and documenting information about the produce as mentioned in the previous section. This section of the process will be redesigned so that the workflow will be as follows.

The employee will retrieve a tray and bring it to the seeding table. Each tray and seed storage container will be pre-labeled with a unique barcode. Afterwards, the employee will grab the wireless barcode scanner, which as mentioned in section 6.1, will be implemented as part of the system. First they scan the tray where the seeds will be planted in, followed by a scan of the seed container. The system then, based on the barcode of the seed container and the production tray, create a unique lot number that will register the connection between the seeds and the tray in the system. In addition, the system will set the tray to be in the seeding stage, whereafter a timer will be toggled on in the system enabling the employees to know how long it has been since the seeds were planted. After the redesign, the steps will look like this:

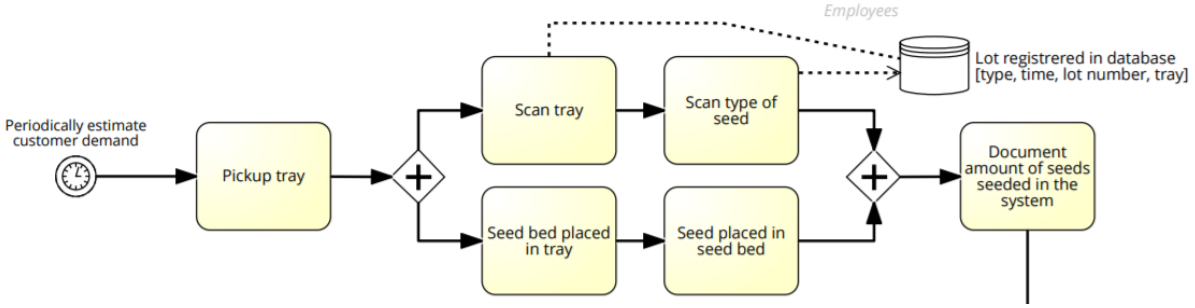

Figure 6.3: Prepare Tray Redesign

The redesign of this section has been based on the heuristics parallelism and activity automation. Instead of registering all the data manually it has been transferred to a system, thereby eliminating the act of manual data entry and reducing the time consumption as explained later in chapter 8. By automating the activity, the section also fits the parallelism heuristic as the system causes the documentation steps and the physical steps to be carried out together simultaneously by the use of the barcode scanner.

Redesign of Growing Process

The growing process will also receive a redesign. As mentioned in Chapter 4, the employees move the tray to the designated shelf when it is ready to start the growing process. Here,

they note the date and time in the control sheets of when the tray goes under light. After the redesign has been implemented, the workflow will look as follows.

When the seeds are ready to start the growing process, the employee will move the tray from the seeding table and place it in its designated spot in one of the shelves. The employee then uses the barcode scanner to (1) scan the barcode of the tray followed by a scan of the shelve, (2) to connect the two in the system which (3) enables the employees to look up its location in the system. After some time spent, a double scan will be done on the tray. This act will change the state of the tray in the system from "seeding" to "under light". In addition, a timer connected to the lot number will automatically start, allowing the employees to know exactly how long the produce in question has been under light. After the redesign, the steps will look like this:

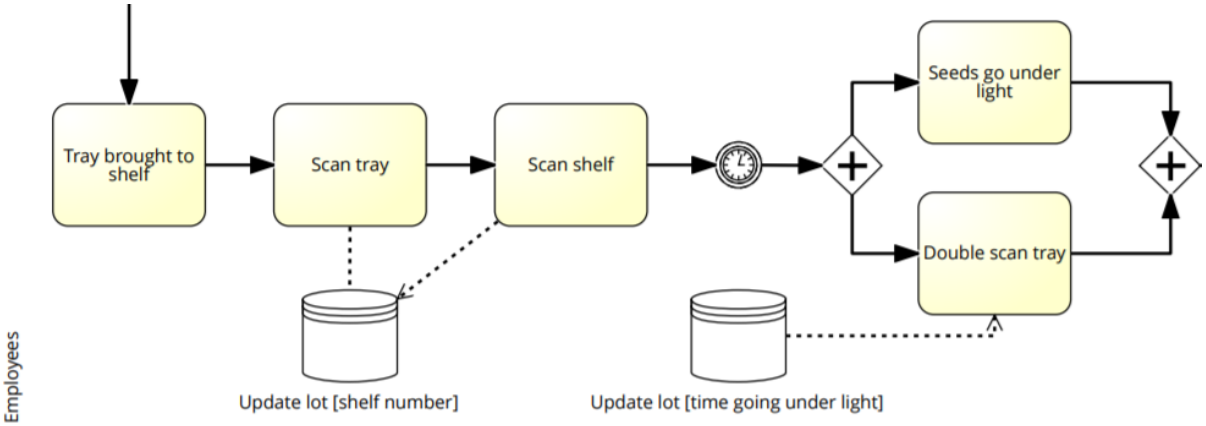

Figure 6.4: Move Tray Redesign

The redesign of this activity has been based on the heuristics parallelism, activity automation and integral technology. As the aforementioned redesigns, the manual documentation step is eliminated in favor of using the barcode scanner together with the system, thereby automating the process. The system is also utilizing the integral technology heuristic, allowing the employee to have continuous access to all information about the growing process as well as information about earlier steps the particular produce has been involved in, eliminating the need for the employees to manually keep track of the time the produce has been under light.

Redesign of Produce Harvest

The last redesign of the process revolves around the harvesting of the produce. As described in the Devil's Quadrangle, the employees experience some inconveniences in regards to the partial harvests of a tray and the related data handling steps. To accommodate these inconveniences, the redesign will be as follows.

After the produce has been harvested and weighed out based on an order, the employee will go to a PC with access to the system. Here, they will be able to select the tray in question and enter the weight of the harvest as well as the customer it will be sent to. This integrates

the documentation step with the system in continuation of the previous steps, and allows the employee to get a centralized overview of the data. In the case of a full harvest, the employee will grab the barcode scanner and perform a double scan of the tray barcode, which in return resets the tray, making it available for use for future batches as well as changes the state of the lot number to harvested in the system, thereby finalizing the process. After the redesign, the steps will look like this:

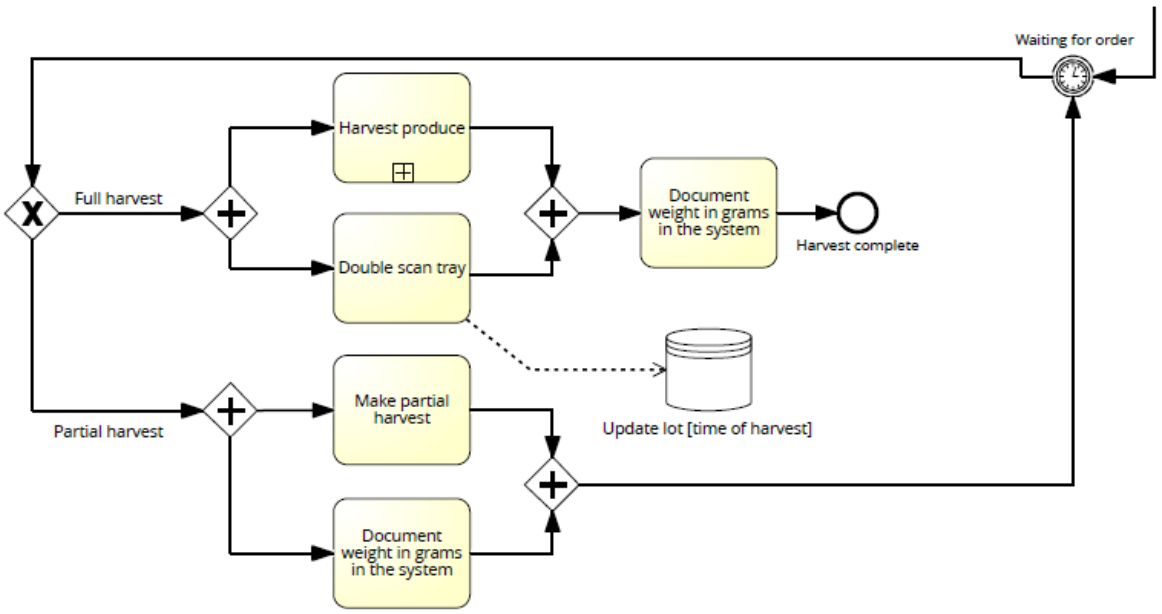

Figure 6.5: Harvest Tray Redesign

This redesign is based on the heuristics Integral technology and Activity automation. After the redesign, instead of the physical step of documenting the process, it has been integrated as a function in the system. In addition, the documentation of a full harvest has been improved by the use of the barcode scanner, whereby the previous manual step is eliminated.

6.2 To-be Process Model

In chapter 4 the as-is was presented which illustrates the internal processes of Novefa. In this section, the to-be model will be presented. A to-be model represents the end result of the redesign phase, and contains the suggested restructuring of the process model. It is possible for a redesign phase to result in multiple redesign suggestions in which case each suggestion needs to be analyzed so the best candidate can be identified.

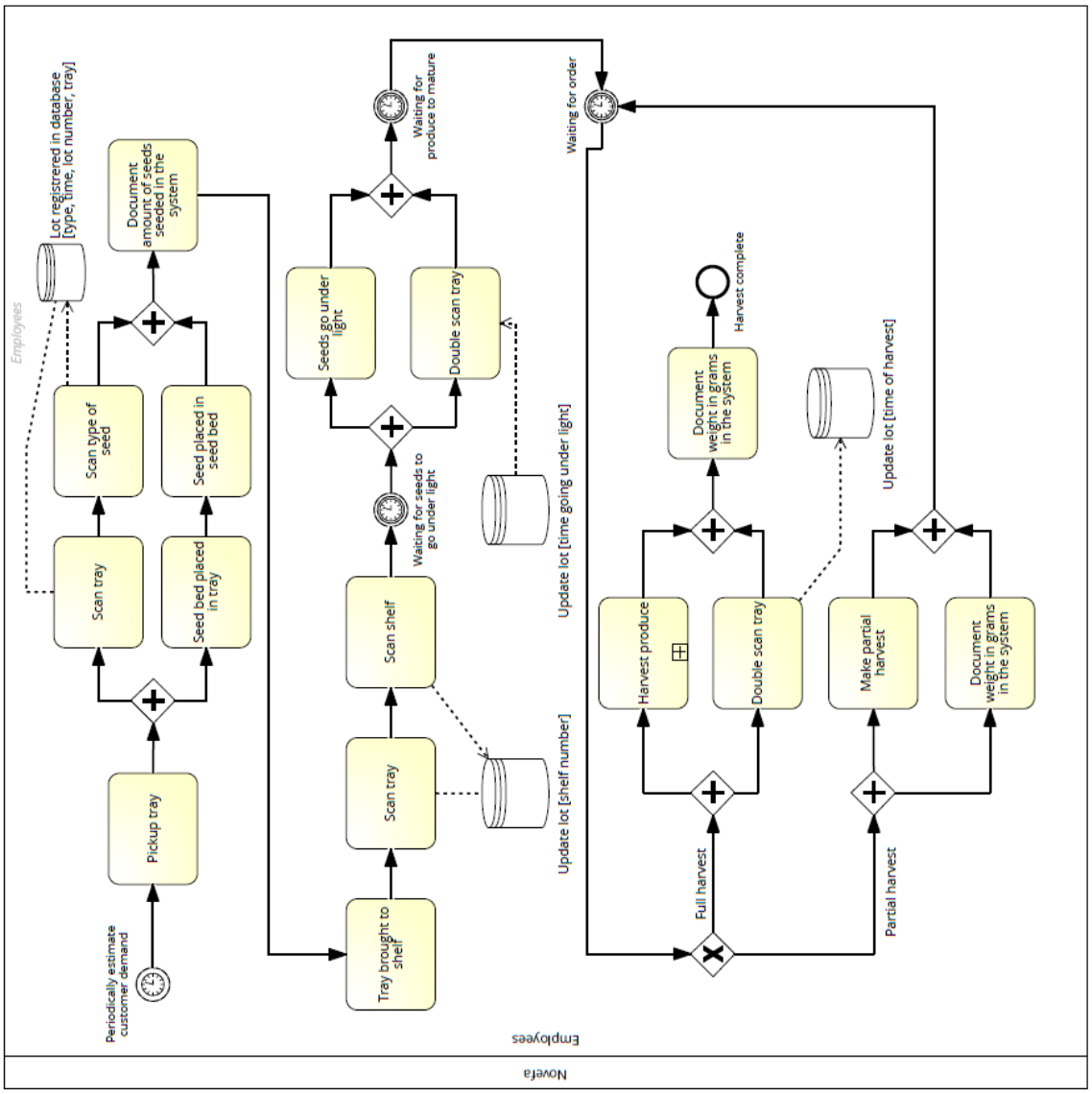

Figure 6.6: To-be Process Model

Figure 6.6 illustrates the to-be model which is showcasing the growing process after the implementation of the discussed system has been implemented as a part of the workflow. As seen in the model, the scanning sequences discussed in the heuristics have been implemented with the purpose of automating steps, and simplify activities such as: time of seeding, time of light. In addition, the barcodes on the production trays serve as a tracker throughout the process, allowing the employees to monitor the movement of the trays, as well as change its current state by the act of scanning. Documentation activities such as documenting time of seeding and documenting amount of seeds seeded has been moved into one activity named, 'document amount of seeds sown in the system', to follow the pattern of digitizing the process, and providing the employees with a centralized overview of the process data.

To ensure that the redesign is implemented correctly and to ensure equal expectations of the systems features among the project group and Novefa's owners, a system definition was formed

together with a MoSCoW ranking of the requirements based on interview data, which will be explained in depth in the following section.

6.3 System Definition

To get a clearer vision of what the system is supposed to do, a system definition is defined. The system is developed with the purpose of tracking produce in Novefa's production facility. The system should be able to register new produce, the state of the produce, and store data which can be viewed on a display. The system should allow edits to the produce. The system should be able to run regardless of a specific operating system.

6.3.1 Requirements

Based on interviews with the owners of Novefa and an on-site tour at their facility, requirement specifications has been developed for the system, which branches out from the system definition. A requirement can be defined as *something the product must do or a quality that the product must have* (Benyon, 2014, p. 139). The process of defining requirements for a system is very iterative which is why the first iteration of requirements will likely not be the only requirements. A requirement specification should be easy to read and understand in order to ensure that all important stakeholders have understood them (Benyon, 2014, p. 140).

The MoSCoW model classifies requirements into four different categories:

- **Must have:** Requirements which must be in place, for a given system to function properly.
- **Should have:** Requirements which are important for the system, but can be left out due to time restraints.
- **Could have:** Requirements that would be nice to implement, but are not vital for the system.
- **Would have but won't have at this time around:** Requirements that will not be implemented at this stage.

It might seem illogical to include requirements that will not be implemented in the system. However, this does allow for some benefits. First, it makes it easier to align the expectations of the system. Secondly, it ensures that these requirements will not be reintroduced later on in this stage.

Table 6.1 shows the requirements that is laid out for the system. Each requirement is assigned a number to easily identify a specific requirement alongside a category and a description of the requirement in accordance with the MoSCoW model. The requirements highlighted in bold are planned for development.

Number	Category	Requirement
1	M	**Scan and assign types of crops by associating the crop with a printed label**
2	M	**Identify when a crop was planted**
3	M	**Identify when a crop went under light**
4	M	**Identify when a crop was harvested**
5	M	**Display data in a simple layout like Microsoft Excel**
6	S	**Keep track of how long each individual crop has grown**
7	S	**Access the data via a website**
8	S	**Send information about each lot to a co-operating system**
9	S	**Export data in .CSV file format**
10	C	The ability to recognize the QR-code from the bag containing the seeds to register them in the system
11	C	Keep track of the seed density for each lot
12	C	Keep track of when a product was shipped
13	W	The ability to have external tracking in their supply chain
14	W	Identify the height of the lot
15	W	Track the light levels
16	W	Track water levels
17	W	Track the weight of a lot

Table 6.1: System Requirements

The implementation of the digital solution included in the redesign discussed in this chapter, will be showcased from a practical standpoint in the following chapter, where a walkthrough of each implemented feature in the system will be made.

7 | System Implementation

This chapter will rely upon the results from the BPM methodology which have been used to seek out to map the work performed in Novefa with a standardized approach that has helped in regards to highlighting improvement opportunities. An abstraction of the daily workflow undergone at Novefa is now established, which can be seen pictured in the as-is model and further expanded upon in the analysis and redesign efforts. The result of these efforts is ultimately pictured in the to-be process model which sets the foundation of what activities and events the system will be built to support.

In regards to the system implementation, the focus will stray away from the BPM methodology in exchange for a more hands on approach where the focus will be on the choice of hardware, the architecture containing them, the fulfillment of the initial system requirements extracted from the MoSCoW analysis from chapter 6 along with the resulting development that occurred, based on the requirements laid out.

They system is made in an effort to support Novefa's initial request of increased traceability and internal tracking of their produce. This is done to verify their produces history and location and furthermore gain a higher insight into their supply chain. This will make it possible to recall produce sown together or just gain real time insight into their crop performance for optimized forecasting or tweaking variables that can secure a higher yield in their facility.

In an effort to create a system that correlates to the aforementioned paragraph and the MoSCoW system requirements, the power of IoT is utilized. IoT enables the utilization of smaller hardware devices to strategically track the produce from sown to harvested, via precise location monitoring of lots in the manufacturing as well as a history of each produce that can help out optimization efforts. Another benefit of using IoT for the system development is that in a larger manufacturing environment it is possible to distribute devices throughout the facility, instead of an employee having to return to a single location in a 3000 m^2 warehouse and instead distribute the IoT devices throughout the facility, thus increasing the scalability of the system and limiting the cost in regards of time used by employees to use such a system.

7.1 Hardware

To successfully create a system that tracks the produce throughout the facility in real time, static elements in the process is utilized by giving them unique identifiers, so it is known where anything is at any time and have elements to link to each unique lot.

Lot: Unique identifier for each lot

- **Shelves:** The placement of the lot in the facility
- **Trays:** What tray is the lot placed in
- **Seeds:** What seeds are in the lot

Barcode Scanner

To communicate with the system, an input device is needed that translates the placement and stages of each lot in the system as an IoT system is being build with emphasis on tracking and scalability. The input should not be gathered at a central location as this would increase the time spent using the system greatly in larger manufacturing environments. To increase the flexibility, a barcode system can be utilized where a barcode scanner is used to scan barcodes that are translated into commands that the system can understand in order to create or update lot data. A barcode system was chosen in favor of a system relying on RFID tags, as it is associated with lower cost, reduced complexity, and easier maintainable for casual users, where a new barcode can simply be printed if an identifier (a barcode) is deemed as faulty thus making troubleshooting easier.

Label Printer

In extension of the chosen barcode system, a label printer is used to print barcodes that are used to translate barcode scanner input into commands in the system. These barcodes are then physically placed on the different seed containers, shelves and trays who then can be scanned to execute different commands. This will be explained in more detail at a later stage.

Raspberry Pi

A Raspberry Pi is used to collect the data gathered from the barcode scanner and translate the barcodes given into meaningful information in the system. The Raspberry Pi is mounted near the roof of the facility in order to give a greater range of the barcode scanner, whose Bluetooth range is 30 meters. Furthermore, by placing it near the roof it eliminates the chance of bad signaling on the ground, where metal shelves in the facility might have a chance to disturb the signal. The Raspberry Pi was used in favor of devices such as Arduinos as the complexity is greatly reduced. The Arduino microcontroller does not operate on a operating system which is the standard way of communication with the barcode scanner set by the factory. This would create issues in regards of having to write custom code to translate barcode input to the Arduino. The case of using Arduinos could possibly change in the future as the cost is lower and it has

the benefit of running software at launch, instead of having to navigate to the application on launch from the OS. A further benefit of the Raspberry Pi is that the system can be created as a web application ensuring cross-platform accessibility, and remote access for Novefa into the system.

Raspberry Pis as Nodes

The idea of using Raspberry Pis or microcontrollers extends further than having it implemented in Novefa's current facilities. In principle, this setup can further be expanded up by utilizing the Raspberry Pis as nodes in a network, which extends the range of the use enabling it to scale up indefinitely in theory and being utilized in vertical farming or just factory sizes of a larger scale. This can also be seen pictured in Figure 7.1.

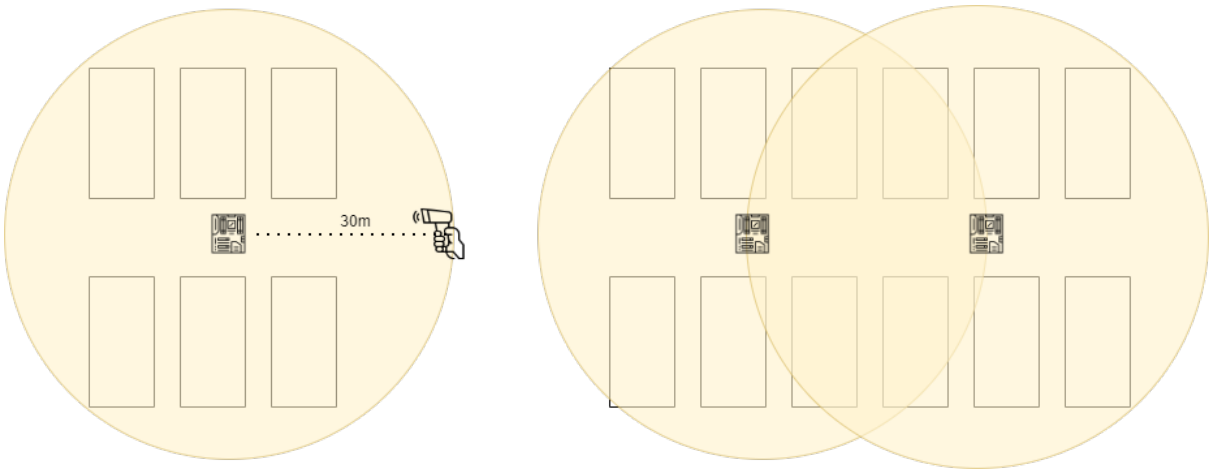

Figure 7.1: Raspberry Pis used as Nodes

7.2 Hardware Architecture

Following the choice of hardware in the previous section, the infrastructure needs to be defined to let each device communicate successfully in order to create an abstraction of the facility in the system. The use of Raspberry Pis as nodes or hotspots have already been discussed for the application to gather input, but the following section will now seek to expand further upon the use of the system.

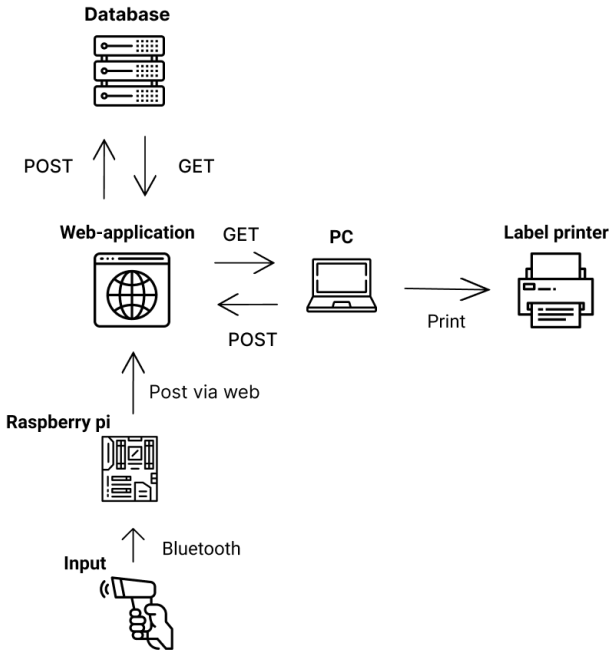

Figure 7.2: Hardware Structure

As seen in the picture above, the central point of the system is a web application. This application gets and posts input as well as acting as an intermediary making it accessible across devices, a web application was chosen for this reason because of Raspberry Pis running the operating system Ubuntu, which is based on Linux, that posed issues in relation to making an application that both performed well with all of the hardware on both Windows, Mac, and Linux. The web application further fulfill the requirement of it being accessible anywhere by Novefa.

Connected to the web application in the diagram there is both the PC and the Raspberry Pi. These two devices both interact with the web application, but in different ways. The Raspberry Pi is using the scan application of the web application that handles user input from the barcode scanner by scanning barcodes throughout the facility via a Bluetooth connection. The PC on the other hand functions as an admin panel, which lets the user perform CRUD operations, as well as control the print functionality and exporting the data as a .csv file. The input gotten through either the scan or the admin page is then stored or retrieved from the database, dependent on the action performed.

7.3 Technologies Utilized

To create an application that can uphold the previously described functionality from a web application as described in the previous section. It will now be looked into what languages, tools and technologies that are used to create a system that is accessible remotely and can be used across multiple devices and operating systems.

The front end of the application where the user input is gotten and the data is displayed uses HTML to mark up the elements that is showcased to the user. These elements are then styled using CSS which is commonly used by most web applications.

To add increased functionality vanilla Javascript is used as the programming language of choice. The language makes changing elements of the HTML available and furthermore acts as an intermediate between the front end of the application and the server side handling the requests and responses to the database.

On the server side spectrum Node.js is used, which enables writing back end code with JavaScript and handle requests and responses to the database. Additionally Express.JS is utilized, as a web application framework to add further functionality and structure to the system, when utilizing JavaScript on the back end.

The Barcode.JS Javascript library is utilized to generate barcodes, and the MySQL library is used for setting up a connection to the database, this will be further expanded upon in the next section.

7.4 Database Model

The database follows a relatively simple design containing four tables: lots, counter, seeds and users which can be seen pictured in Figure 7.3.

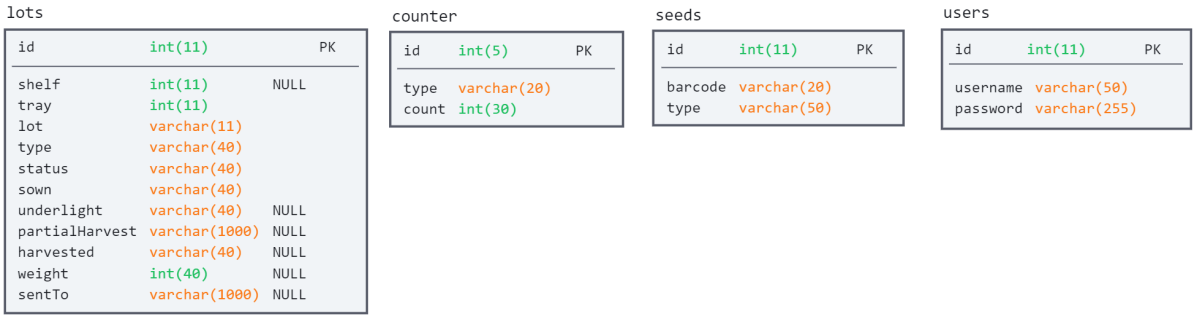

Figure 7.3: Tables in the Database

The lots table contains all data related to a single lot, moving through the facility from sown to harvested. This table holds the shelf where the lot is placed, the tray that the seeds sit in, the lot number, the seed weight and the type of seed that is in the tray. The status variable describes the state of the produce; if it has either just been sown, if the lot is placed under light or the lot has been harvested. Furthermore, the time of when each state was activated is recorded in the sown, under light and harvested column so it is recorded how long the lot is in each state. At last there is the partial harvest column which records each time some produce is taken from each lot eg. 300 grams. This also correlates to the SentTo column where the customer receiving the partial harvest is stored. In addition to the weight of each partial harvest, the time of harvest is also recorded. This is stored in a .json format in the table to

store more data in a single column. In the end, the weight of each partial harvest is summed up by the user and inserted in the weight column, for a total weight of the produce made in the specified lot.

The counter table keeps track of how many different lots, shelves, trays and seeds that have been created. This is used for the generation of new barcodes, where one number is simply added to the existing number upon the printing of a new label.

The seeds table keeps track of each seed type and the corresponding barcode for each seed, for easily registering new seeds and retrieving previously used barcodes for seeds.

The users table simply stores the username and password for logging in to the web application.

7.5 Revisiting MoSCoW

Having established the foundation of the developed system the MoSCoW requirements will now be revisited as listed in Figure 6.1 and further be elaborated upon in regards to which features successfully were made and how they were developed. Related items will be grouped together to limit the amount of repetition of similar features. The requirements which have successfully been implemented is marked in bold text.

Number	Category	Requirement
1	M	**Scan and assign types of crops by associating the crop with a printed label.**
2	M	**Identify when a crop was planted.**
3	M	**Identify when a crop went under light.**
4	M	**Identify when a crop was harvested.**
5	M	**Display data in a simple layout like Microsoft Excel.**
6	S	**Keep track of how long each individual crop has grown.**
7	S	**Access the data via a website.**
8	S	**Send information about each lot to a co operating system.**
9	S	**Export data in .CSV file format.**
10	C	The ability to recognize the QR code from the bag containing the seeds to register them in the system.
11	C	Keep track of the seed density for each lot.
12	C	**Keep track of when a product was shipped.**
13	W	The ability to have external tracking in their supply chain.
14	W	Identify the height of the lot.
15	W	Track the light levels.
16	W	Track water levels.
17	W	**Track the weight of a lot.**

Table 7.1: System Requirements

1-4: State changes

Requirement 1 4 all has to do with changing the current state of the lot, going from creating

the lot and registering it as sown, under light and then harvested. This is seen visualized in redesign model 6.3, 6.4 and 6.5. Where the manual entry of what produce go in what lot seen in the as-is model in Figure 4.1 is automated and automatically registers, when a lot was planted, when it went under light and when it was harvested.

These state changes are made possible by listening to the input from the barcode scanner and then in specified sequences of scans perform specified actions. These sequences can be pictured below in Figure 7.4.

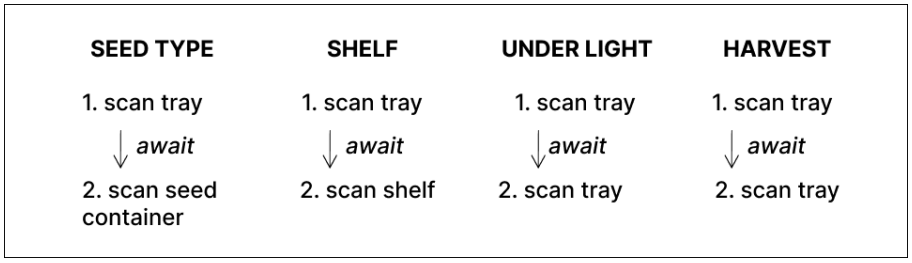

Figure 7.4: Changing the state of a lot with the barcode scanner

As seen in Figure 7.4, the seed type is first set by scanning a tray and then the seed container of a chosen seed. This initializes a new lot in the system.

Afterwards we place the lot in a shelf physically and then associate the shelf with the lot by first scanning the tray and then the shelf.

From the shelf the lot going under light can be registered by scanning it twice. Afterwards the lot can be scanned twice again to mark it as harvested.

The input sequences are gathered by the scan application running on the Raspberry Pi in the web application, which can be in Figure 7.5.

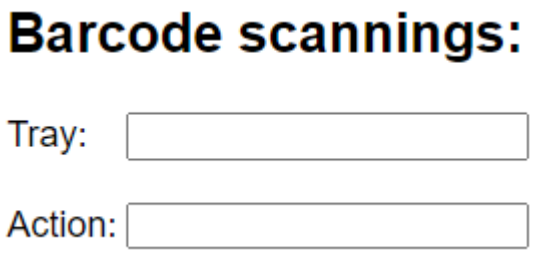

Figure 7.5: Scan application waiting for user input from the barcode scanner

The web application navigate the input commands by looking at the prefixes on the barcode as shown. T is the prefix for trays, which is always the first input as seen listed in Figure 7.4. As an example, the system know that the barcode T00000007 is a tray, S is a shelf and F is a seed barcode. In Figure 7.6, a simplification of this approach can be seen.

```
1    if(firstScan == T && secondScan == T){
2        lot.status = 'under light';
3    }
```

Figure 7.6: Change state of lot to under light

5. Display data in a simple layout like Microsoft Excel

One of the first requirements from Novefa was to display data in a simple layout like Microsoft Excel. This was simply implemented by having an admin panel that uses HTML tables to display both active lots and past lots, which have already been harvested. The result of this can be seen in Figure 7.7.

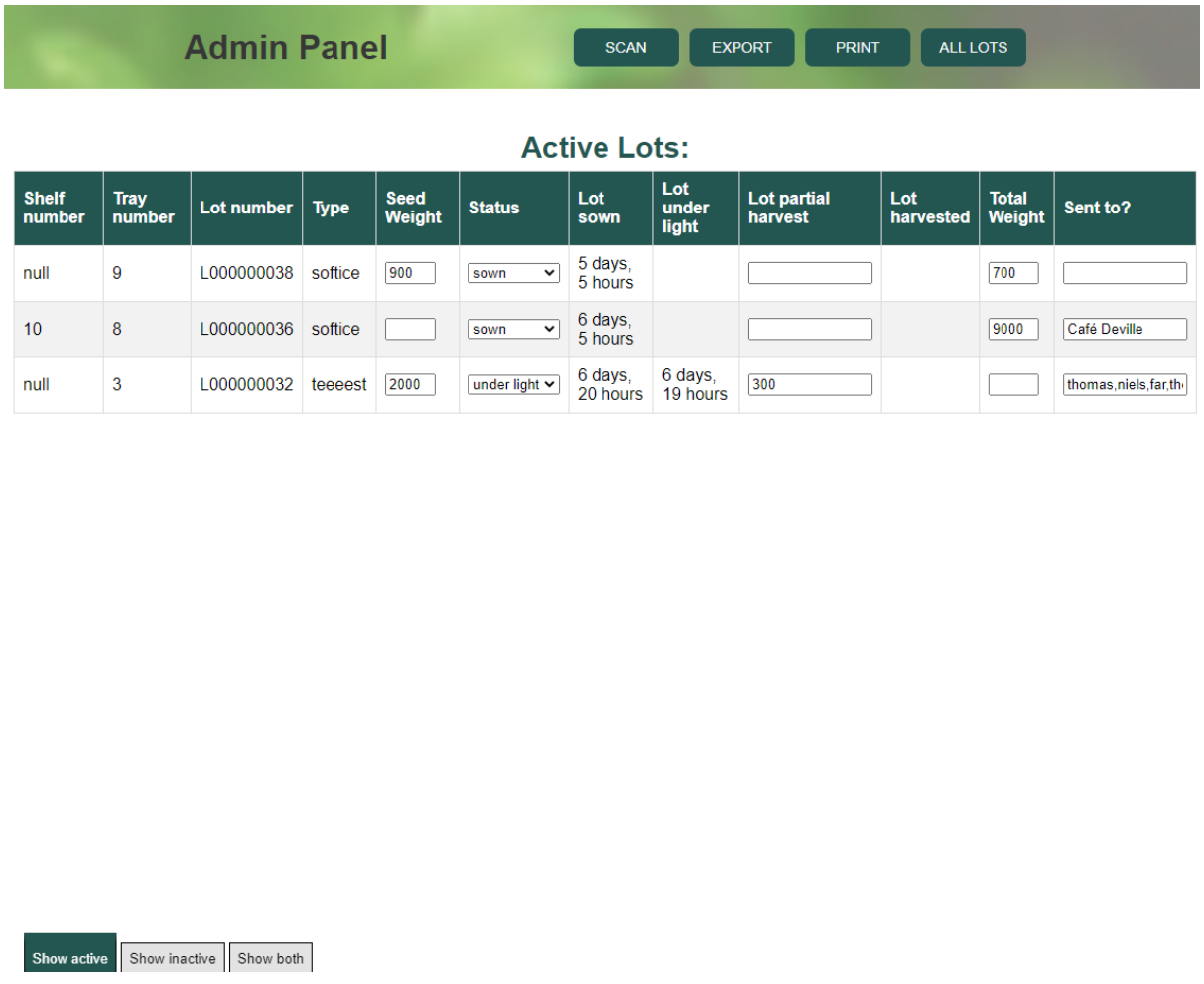

Figure 7.7: Overview of the admin panel

6. Keep track of how long a each crop has grown

In the admin panel, the requirement of seeing how long each lot has grown is also fulfilled by storing the date the lot was sown and then subtracting it from the current date. Extending this principle a timer for how long the lot has been under light was also added to provide further

variables for Novefa to optimize their growing process and see what the optimal time under light is over time. A snippet of the admin panel showcasing this can be seen in the Figure 7.8.

Lot sown	Lot under light	Lot partial harvest	Lot harvested
0 days, 0 hours	0 days, 0 hours		10 December 2020
0 days, 4 hours	0 days, 0 hours		10 December 2020

Figure 7.8: column showcasing how long each crop has grown

Simplifying the code in the application it could be written out as seen in Figure 7.9 for illustrative purposes.

```
1    var TimeInLight = Date.now() TimePutInLight;
```

Figure 7.9: Time Calculation

Prior to the implementation, this was done manually registering when a lot was grown on paper. This would then be calculated by hand if an employee wanted to know how long each crop has grown for, but is now automated as showcased in Figure 6.3, where the timer is automatically initiated upon planting of a seed, and accessible at all time.

7. Access data via a website

This requirement was fulfilled by developing the system as a web application, ensuring remote insight into Novefa's data as requested. This also comes with the added benefit of being optimized for use in all the common operating systems.

8. Send data to cooperating system

At the time of development, multiple groups from Aalborg University was working with Novefa. So in addition to implementing the described system, it also had to work in conjuncture with other groups. In order to achieve this the same database as another group was used. This enabled the system to update information in database tables that is used by another system.

9. Export data in .csv format

Novefa wanted to be able to extract the lot data into excel in order to analyze and visualize their data. This is done through the admin panel by clicking on the export button in the menu as shown in Figure 7.10.

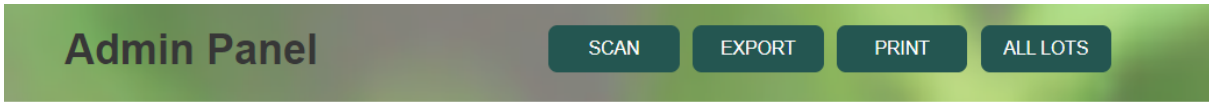

Figure 7.10: Export to .csv option in the admin panel

The export function simply loops through all of the lot data in the system and generates a new line for each lot as well as comma separating the data. However, the 'partial harvest' and 'sent to' columns contains multiple data points, which does not correspond to a single line in excel. So for each partial harvest, a new line is generated in the .csv file. All of the 'sent to' data is represented in a single column but separated by a hyphen.

An example of this function is shown in Figure 7.11. The two lots are represented as four rows in excel, because one of the lots have been partial harvested thrice (first for 800 gram, then for 900 gram and lastly for 1000 gram). Notice that the excel sheet has a new row called 'partial harvested date', which is necessary to store the date from the partial harvest column in the admin panel.

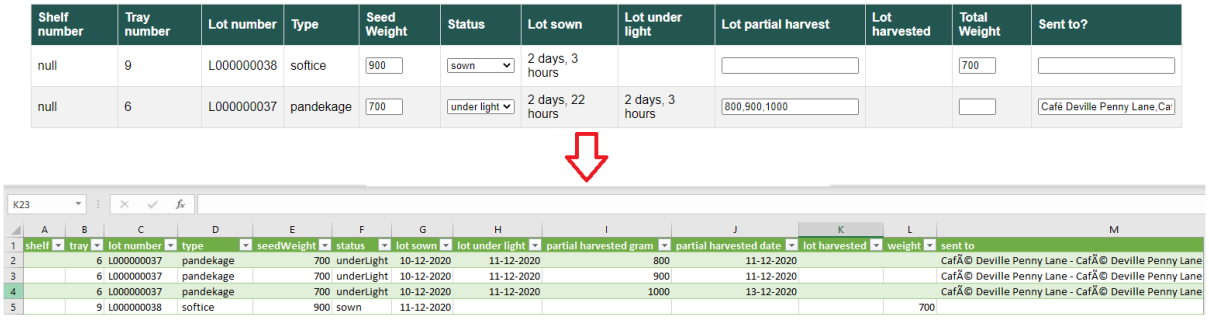

Figure 7.11: Example export result

12. Keeping track of when a product was shipped.

To fulfill the need of having a certain degree of traceability in the supply chain, the system implements a editable text field that lets Novefa insert the receivers of each partial lot, which additionally automatically asserts a timestamp marking the time of harvest for each lot. This implementation only partially implements the requirement of external tracking in the supply chain, which is acceptable as this is marked as a 'won't have this time around' in the MoSCoW model. The implemented feature can be seen in Figure 7.12.

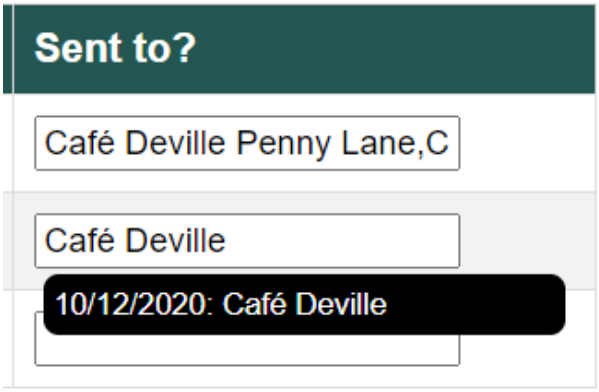

Figure 7.12: Showcase of when a product was shipped toolbox

17. Weight of a lot

In order to track the yield of each harvest and combine it with previous ones, an input field for weight is also included in the admin panel. This is essential for comparison and looking at how changing the environment for each plant changes the outcome, so as an example it can be seen how much more or less yield is gotten by having the plant placed under light for a longer duration of time. The weight needs to be manually entered in the admin panel for now, but is later planned by Novefa to be registered via a Bluetooth scale, which is left out of the initial requirements of the system to meet the deadline of the project. As of now, the weight is entered in the input field can be seen in Figure 7.13. This differentiates from the original as-is model by having access to the information in a single application, instead of having notes spread throughout the facility.

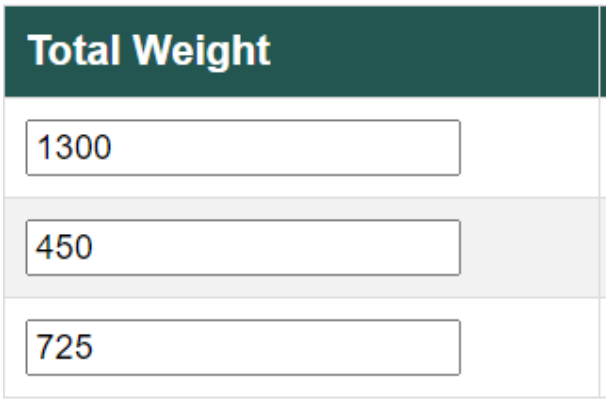

Figure 7.13: Total weight of the produce from the lot

7.6 Additional Features

After making the original MoSCoW, additional features have been discovered. This was either done in response to an earlier oversight in the workflow or a need identified by the developers or Novefa.

Partial Harvest

In the first couple of meetings with Novefa it was assumed that lots was harvested all together. Later it was discovered that the lots were partially harvested, which meant Novefa was doing multiple harvests from each tray and shipping them to different customers.

In an answer to this it was needed to make a system, which should be an abstraction of their workflow containing this feature as well. The redesign model shown in Figure 6.5 displays the process of doing partial harvests as well.

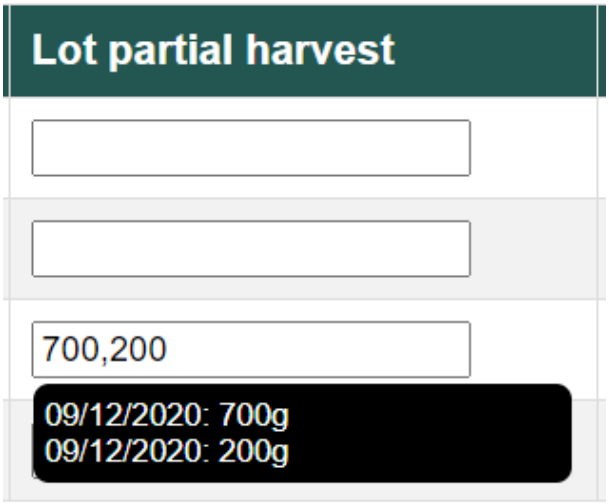

Figure 7.14: Column showcasing the functionality of partial harvest

Login

As the system works as an online application it was necessary to implement safety measures to keep unwanted visitors out of the system. This is done by registering the user and then by utilizing cookies to keep them logged in. Keeping them logged in is essential especially for the Raspberry Pi acting as a hotspot for the barcode scanner, as it is difficult to troubleshoot without bigger interventions from a developer. The visuals of the login form is depicted in Figure 7.15.

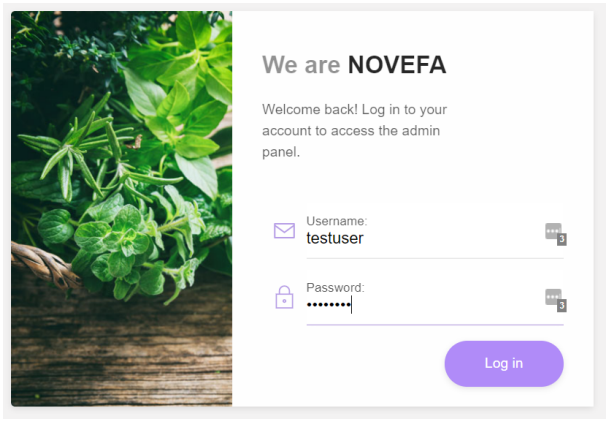

Figure 7.15: Login to the web application

Print Functionality

A feature overlooked in the beginning of making the MoSCoW model was the ability to print labels with the label printer to provide barcodes to scan.

This functionality was implemented by using the JavaScript library JsBarcode, where the desired format of the barcode simply needs to be provided and the content of it. A simplification of

this can be seen in Figure 7.16.

```
1    TrayBarcode = T000000002
2    JsBarcode("#code128", TrayBarcode);
```

Figure 7.16: Create tray barcode in format 128

This code is accessible by clicking the print button in the admin panel where it can be chosen to either print a new tray, shelf or seed barcode. These are all created on the previous barcode printed in each of their specific domains. Additionally the type of seed can be specified, which is registered in the database for a greater overview of what barcode corresponds to which seed.

In the development of this feature it was realized that barcodes could go missing or get exposure to water, so additionally it is possible to print a custom barcode, if a previous one got destroyed for some reason. Access to all of the above mentioned features can be seen in Figure 7.17.

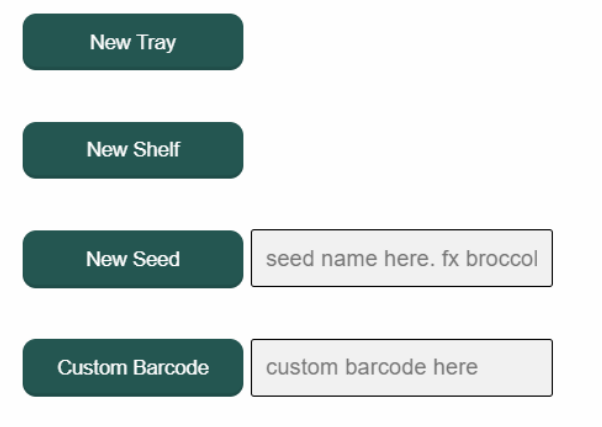

Figure 7.17: Custom print functionality in the admin panel

7.7 Reflection on Development

Summing up the system implementation, all MoSCoW requirements which was set out to be delivered was fulfilled. This can be seen in the to-be process model, where every described activity is usable and the following MoSCoW model where all desired features are implemented in the system. Additionally, some none expected requirements was also delivered which originally was listed as *could have* and *won't have this time around* in the MoSCoW model, which objectively speaking is above the expected result. Furthermore, the ability to add new features continuously to the existing system within a small time frame has proved the modularity and flexibility of the system for future expansion, scalability, and use.

8 | Evaluation

The description of each specific feature of the system was covered in the previous chapter. This chapter will focus on Novefa's overall opinion of the system which is based on an interview with András, their CTO, at their facility where the final system was implemented (Appendix B).

The overall purpose of the system is to keep track of their production. Having a system to handle this is "a lot more convenient than running around with a big piece of paper and just writing everything down [...] and faster too" (Appendix B, column 4).

The system is working as required which is stated in the reflection on development, in the previous chapter, so the overall purpose of the system is met. The implemented system is also required if they want to upscale their business, as they are currently handling the production tracking manually. This was stated by András in the interview:

> "*Realistically speaking I can't imagine doing it the way we're doing it right now in a larger scale production system it has to be something like your system.*" (Appendix B, column 6).

Right now they are using *control sheets* to track the production. This poses another problem because they sometimes lose the sheets, and sometimes another persons handwriting can be difficult to read (Appendix B, column 6). This is also solved by the system. Novefa have also experienced twice that they made some errors in the invoicing and could not remember what they just delivered to a specific customer and how many grams it was (Appendix B, column 10). András states:

> "*So you know if we screw up invoicing, that's literally money down the drain.*" (Appendix B, column 10).

The system can also reduce this problem as both the "harvested", "partial harvest", and "sent to" columns contains relevant data including dates.

In summary, the overall benefits of the system is that the production tracking is easier, faster, scalable and more stable. András' overall opinion about the system is: "I like it, [...] I like how simple it is" (Appendix B, column 14)., as well as "I also like the whole, scan it once, do this, scan it twice do this, not gestures. but that's very good"" (Appendix B, column 16).

The system was supposed to be as simple and usable as possible, which, based on the prior statements, is fulfilled.

9 | Discussion

9.1 Process Discovery Method Reconsideration

In order to have a thorough understanding of the business, the process analyst must have a extensive amount of knowledge and data on the business processes, while also being able to organize it into a bigger picture. Even though the data already provides an extensive amount of information about the processes and how they work from the inside at Novefa, one of the most predominant challenges with this paper is the availability of data, caused by the nature of Novefa being a newly established business which limited the access of previous data to compare with.

As previously mentioned, the processes discovered for this paper were gathered by employing the interview-based discovery method. The processes were modelled by continuously interviewing the employees at Novefa, getting validation and then remodeling the business processes in order to get them right. The processes were introduced by Matias and András at Novefa where they gave a vocal walkthrough of the business process while imitating the sort of activities they do during the walkthrough. However, without any real actions in an actually established facility, limited understanding and insight into the reality of the business process is gained. The optimal situation would be if there was an opportunity to observe the business processes in action. This would further increase the understanding of the time criterion for the analysis, with the question being whether the newly implemented system increases or decreases the processing time for the entirety of the business process.

9.2 Financial Aspect

A comparison between the assumptions given in the Devil's Quadrangle, as well as the statements from the interview regarding the evaluation of the system can be made by looking at the financial aspect of these. This section will be based on assumptions, since there is not sufficient data to compare the before and after of the system implementation, as a result of the system being entirely new and Novefa being in the process of setting up their facility. Looking at the cost dimension in the Devil's Quadrangle, the long term expectation of the system is an improvement in the produce quality and yield, due to more precise monitoring of each lot and having a tracking history for the lots to analyze and improve upon. Furthermore, the system

would also decrease the amount of labor hours, where the users of the system potentially can move more freely in the facility. This would also make tracking the lots more easy, without always having to return to a central place in the facility to write things down, or write them down on paper and risk loosing or being unable to read them. This was stated having happened earlier in the evaluation interview. The lack of a central hub to return to would also decrease the amount of labor hours in the long run with a very high impact if the facility were to scale to a larger place at some point. The evaluation interview furthermore attest to the fulfillment of the stated requirements and an overall satisfaction with the amount of time that is saved and money spent on the system compared to traditional IoT-systems.

In summary, the automation created by the system looks to be highly useful regarding activities that would save Novefa money in the mid to long term as well as having a very low set up cost and running cost. In total, the system is considered profitable with very low downside.

9.3 General Reflections

This paper has led to several discoveries along the way. One of the challenges that were posed was using the BPM lifecycle. One of the discoveries made derives from the iterative nature of the lifecycle process, where getting a grasp on when a process models had been developed proficiently made was difficult. This is caused by the fact that it was subject to continuous optimization along the way. The use of process models greatly increased our knowledge in regards to identifying the concrete processes at a company and translating them into abstract models. This was more challenging than expected, where the end result is derived from multiple iterations. It was also challenging to process the models into redesigned solutions, and further translate the model information to other people due to the complex nature of the various processes. Furthermore, it is challenging to work with a startup business. This is due to the nature of limited data-points to extract information from, and because that the current processes was not established fully, but were still subject to change. This was also seen present in the sense that the facility was not fully operational at the time of writing.

It was, however, very interesting to work with a start up company within an interesting industry, as we had a bigger influence on their processes, and they plan to apply our system at their facility in the future. In addition to making a system in an interesting industry, it was also a learning experience to work with emerging technologies such as IoT, and its application within traceability and vertical farming. Also to see the applicational value of such systems, in smaller businesses gave realizations in regards to the potential value of systems such as ours and in general the use of automation in business.

In regards to the technical knowledge attained, we also saw a great increase in use of technologies which we were inexperienced in, such as utilizing APIs, hardware components, and the general application of IoT. Lastly, a major challenge we faced were in regards to some oversight in communication regarding the implementation of our IoT system at Novefa's facility. It was

experienced that the need to be very explicit in regards to what is needed for implementation has to be established a long time in advance, so the implementation is ensured to be successful.

10 | Conclusion

The research question of this paper was, “How can an IoT system improve the tracking of the production at Novefa?”. This was done by using BPM theory and methods, and subsequently a hands-on development approach. The project showcases an implementation of a tracking application that sought to assist Novefa’s growing process. This was done by identifying their current processes, scoping them out in an as-is process model, analyzing the strengths and weaknesses of the growing process in regards to the value it adds to the process, illustrating a specific process redesign in a to-be model, and finally an implementation of said process. The result of this was an IoT system consisting of a web application, a barcode scanner, a printer, and a small computer in the form of a Raspberry Pi. The barcode scanner is used as an input device for the system in order to track the creation of new lots and shelf positions, as well as the current status of the lot. The web application is used to track the harvesting and weight of lots. The printer is used to print labels that the barcode can scan, which is done directly through the website interface.

In conclusion, the research question is solved by making an IoT system that makes the production tracking faster, easier, more scalable and less error prone. The result is further established through partaking in an evaluation with Novefa, who where satisfied with the system and the fulfillment of requirements which was initially listed.

The solution for this project is tailored for Novefa. That being said, the use of BPM can be of use to any company willing to improve upon their processes. This project also showcases the value an IoT system can have for a smaller company, but it can have a bigger impact for a larger company where the need for such a system is even more apparent.

11 | Future Work

This chapter will reflect on potential future work in order to optimize the system as well as challenges that needs to be met in order to make the system fully operational.

11.1 Raspberry Pi Feedback

When Novefa uses the barcode scanner to make actions in the system via the Raspberry Pi, they do not receive any feedback from the system. As a consequence, they cannot recognize when they make scanning mistakes or if the system makes a mistake. This is called “visibility of system status” and is one of Jacob Nielsen’s ten usability heuristics (Harley, 2018). This problem could be solved by connecting the Raspberry Pi with a small screen that shows the scan page. In this way they can look at the screen to know exactly what the system have registered. The problem could also be helped by connecting the Raspberry Pi to a speaker that makes a sound every time an action is made in the system.

11.2 Tracking Lot Weight

The weight of a lot could also be tracked by the system. This could be done by having a scale connected to the Raspberry Pi via Bluetooth. The advantage of implementing a scale is that more data is generated, which increases the basis for analyzing and optimizing the production. Furthermore, it could also be integrated in the system in such a way that they do not need to weigh their harvests but instead simply put the tray on a weight. The harvests could be triggered by the system by scanning the tray and then scanning the scale. Then the system could calculate the weight difference after the harvest. This could control the partial harvests but also potentially the full harvests. This could eliminate all user tasks in the admin panel, so that the admin panel inputs could run completely independent without needing a person to update it:

- "Seed weight" could be calculated by the scale.
- "Lot partial harvest" could be registered by the scale.
- "Total weight" is calculated by the scale or the sum of all partial harvests.
- "Sent to" could potentially be connected to their billing system.

The only user tasks would be via the barcode scanner, and not through the website.

11.3 Security

Following the development efforts of the project group, a further emphasis on security in the application might be necessary. As this system was developed on a relative tight deadline, it would be advisable to look on the security on the platform. This would include adding countermeasures to prevent SQL-injections, Cross-site scripting (XSS), and encryption of personal data that should be kept private. In addition to clean cut security measures, it should also be investigated if the right amount of try-catch statements is in place to prevent the system from crashing at any point in time to limit the amount of resources used on including developers to troubleshoot their issues. In short. the system should not be able to be compromised by external users, and should be stable enough to have Novefa run it without it crashing at any given point in time.

11.4 Fully Fledged System

Upon asking Novefa's CTO about how the system might evolve in the future, he answered the following:

"*you know integration with a fully fledged ERP-system of cause, that would be nice, you know, you can always make it more sophisticated,*" (Appendix B, column 12).

From this it is clear that the development of software in or related to the system is an ever-changing story. In a growing industry with a high access to data and optimization. With the right tools in place, one can effectively continue optimizing the system far out in the future.

"*you can like cross-reference data with environmental data for instance [...] you can also look at if doing a partial harvest on the lot potentially does something to increase or decrease seals for the rest of the tray [...] There's always somewhere to go with food production,*" (Appendix B, column 12).

As seen in the statement, there is a high demand for always improving the software. Effectively, all variables can be controlled in the photosynthesis for each plant and can tweak each external parameter to the plant in the pursuit of optimal growth. In the long run, such a system would need to be implemented as the business scales. This could then be integrated with a fully fledged ERP-system that also tracks their full supply chain, sales and the remaining MoSCoW requirements to gain full control of their facility from a single application. This would be advisable to follow technological demands in a highly software-dependent market.

11.5 Issues using Existing Hosting

In our implementation efforts several issues arose in the more practical spectrum. Upon trying to add our application to Novefa's existing hosting solution, which contains their content for novefa.dk. It was discovered that it did not provide support for node.js applications. This made putting the system online as intended unfeasible within the given deadline of the project, which now has to be created on a separate web host, at a later date, to provide remote access to the admin panel. Additionally, the database was not accessible if the hosting would be at their provider, which further restricted the possibility of meeting the initial deadline of implementation.

11.6 Availability of Resources during Implementation

In relation to implementation following the last issue, it was also discovered upon arrival to the facility that no PC was accessible to install the admin panel on, caused by the lack of available personnel during the lockdown in the Aalborg municipality caused by COVID-19. The implementation was then further challenged by the factor that Novefa wished to change the router for their Wi-Fi, but had not set it up at the time, making it unfeasible to use their network at that date. Following this issue, the system is planned to be fully implemented in January 2021.

List of Figures

References

Benyon, D. R. (2014). *Designing Interactive Systems* (3rd ed.). Pearson.

Kvale, S., & Brinkmann, S. (2015). *Interview - Det kvalitative forskningsinterview som håndværk* (3rd ed.). Hans Reitzels Forlag.

Fødevarestyrelsen. (2017). *Vejledning om sporbarhed - fødevarer* (1st ed.) [Accessed: 16.12.2020]. https : / / www . foedevarestyrelsen . dk / SiteCollectionDocuments / Kontrolstyring / Vejledning%20om%20sporbarhed%20-%20f%C3%B8devarer%202017.pdf

Dumas, M., Rosa, M. L., Mendling, J., & Reijers, H. A. (2018). *Fundamentals of Business Process Management* (2nd ed.). Springer.

Harley, A. (2018). *10 Usability Heuristics for User Interface Design* [Accessed: 16.12.2020]. https://www.nngroup.com/articles/ten-usability-heuristics/

IoT Analytics. (2020). *Why the Internet of Things is called Internet of Things: Definition, history, disambiguation* [Accessed: 19.10.2020]. https://iot-analytics.com/internet-of-things-definition/

Nielsen, N. A. (2020). *'Vertical farming' viser potentiale: Skal fremtidens grøntsager dyrkes i højhuse?* (1st ed.) [Accessed: 10.12.2020]. https://videnskab.dk/teknologi-innovation/vertical-farming-viser-potentiale-skal-fremtidens-groentsager-dyrkes-i-hoejhuse

Novefa. (2020). *Novefa - Vertical Farming* [Accessed: 19.09.2020]. https://www.novefa.dk/ansvarlig-produktion/

Signavio. (2020). *Process Manager* [Accessed: 24.11.2020]. https://editor.signavio.com/

A | Interview with Novefa

Interviewers:
Simon, Thomas and Lasse

Interviewees:
Matias and András

Date and Location:
November 17, 2020
Novefa Production Facility

Column	Name	Statement
1	Simon	Det er jo bare spørgsmål som vi lige skulle være i tvivl om, og måske nogle gentagne spørgsmål, der godt kunne komme igen
2	Matias	András do you wanna be in the interview?
3	András	I don't know, do you guys need me? I'm happy to oblige
4	Simon	You are welcome to
5	András	Then we are gonna have to do it in english if that's okay
6	Simon	Yes that won't matter I think
7	András	Sure
8	Simon	So the interview is mostly to do with the process from like the order from a customer to the actual cash in hand with you and also about the it system, like the barcode scanning system so we can track the stages of the plant throughout its cycle, so we can see, when was it planted, when was it grown, when was it done and so on, so we were thinking about, how do you get orders, so are you planting crops continuously, or do you only plant when you get an order as an example

9	Matias	We always plant like, so for example peas, they take approximately 15 to 17 days to grow so we have to grow just, right now it’s just based on our assumptions, how much can we sell in 15 to 17 days, so it would be very nice to have some forecasting so that it’s not just our assumptions and our gut feels
10	András	Right now we are definitely overproducing
11	Matias	Mmmm, we haven't thrown that much
12	András	It's not about throwing out,´for instance we had to specifically ask if they want, was it vusk? if they wanted the peas, we actually went ahead and asked them, do you want this extra, granted it was also a really good batch
13	Simon	And do you have customers mostly, that continuously buy from you, so okay every week we get this from you, or is it one time customers, ok we want to try?
14	András	Right now we have both actually, right now there is one that just tried it, but hopefully it will become a weekly thing
15	Matias	Yeah, it will be a weekly thing, so of course if they can taste once that this is way better quality, they can actually save a bit of money because they don't have to throw half of it out as they are doing right now, then why not buy it every week
16	András	Well it's actually not weekly, it's usually twice a week we deliver
17	Simon	And it’s business to business, the focus is, and none b to c
18	András	We are not doing b to c, we are not even planning to do b to c
19	Simon	Okay nice, and you are setting up a webshop or something similar, you talked about it in the beginning
20	Matias	It’s just to make it possible to order it online, but actually we have found out that it's nice to have that possibility, but it’s, so everybody ordering through

		the phone, or even on facebook, im facebook friends with one of the chefs, so yeah, it's not that urgent actually, to get the webshop, up and running
21	Simon	And the customers we were talking a bit about, and the customers are primarily restaurants as of now, and maybe get into supermarkets, you were talking about?
22	András	Potentially yeah retail as well, salling, we have an ongoing dialog with salling
23	Matias	But they are taking quite a large cut of the revenue, so the contribution margin are not that high, so salling will be added once we have enough capacity to not only delivering to restaurants
24	András	There is also something to be said about packaging
25	Simon	Yeah you talked about that
26	András	And various other thing we need to adhere to when we are selling to retail
27	Simon	Alright can you try to walk me through the process of like, your getting an order, and order the different things that happened until you get the cash in hand. So you are contacted by a customer in the beginning, and then what kind of processes and things, into the very detailed. You get the order, you write it down somewhere? maybe
28	Matias	Yeah, so we get the order, the often call or write on facebook, or maybe we call them to ask, and then, right now we have so few customers that we can just, what we are doing right now is to write on facebook, "tomorrow rusk wants 200 grams of peas'' for example. So then facebook kind of remembers it, but of course that's not the way to do it when we have more customers. And then we just like, harvest it, package it into condi bøtter, do you know what condibøtter is?
29	Simon	No

30 András If you look up there on top of the last

31 Matias The boxes we package in, like it's the same box you use for bland selv slik

32 Simon Yes

33 Matias Then we harvest it, weigh it, like quite precise, we have these controlling sheets. If you look closely on the tray, you can't see it from here, but on each of the trays where the plants are in, there are numbers on, and then we have documented how many grams we have seeded, when they were seeded, when they were put under light, like right now, these are not put under light, when they are put under light, when they are harvested. So after the harvest, we document that, we document how many grams

34 András We document sanitation procedures (can't be heard 07:07-07:18)

35 Matias Then we document that, and then we, like the same day as it is harvested, actually like, before going out delivering, like just before going out delivering, we harvest. So it’s only one hour old when we deliver it, right now at least, and then we deliver it by car

36 Simon Okay, so you deliver it yourself?

37 Matias Yeah, right now, but that will also change when we get more, customers. After delivering, not directly after, maybe the day after, whenever i have time to make the invoice i do that, send it the same day as i’ve invoiced it, but actually one of our customers, restaurant Rusk, have asked us to only bill them once a month, so there i just have a sheet saying what they have gotten so far. But all the others i bill right away, and our payment terms is 8 days, and then they just come into our account, and then i document it in our economy program, that now we have received

38 Simon So I’ve noticed that you are like, you continuously taking from the sheets, at

		the beginning i was thinking like we would take like a part, and then ship it out, but you take it and weigh it in grams from the total
39	András	As in there are partial harvest in the trays is what u mean?
40	Simon	Yeah
41	András	Amaranth is the purple stuff, is not the best example of that, because we had a bit of trouble growing that, so it looks quite ugly, but for instance some peas, there you can see, yeah that is something that we do. Like now we actually see hightent yield. That tray you see partial harvest of peas that's going to be 1.7 kilos at least
42	Simon	How much difference is there in like the weight of your yield, your total harvest. Does it differ much or is it like approximately the same
43	András	So if don't screw up the actual tray, then it’s relatively consistent, of course it depends, but as we are getting better at what we are doing, it is steadily climbing
44	Matias	So do you mean for the same plant, or do you mean between different
45	Simon	Yeah the same plant
46	Matias	Yeah it has differed quite a lot now, because we haven't had this setup that long, we haven't had it running at least, so in the beginning, we were, at one tray of peas i think we, do you remember how much our first peas were?
47	András	The first one was 700 grams, but that was also very low seeding density. Last one was 1.515, but it is like this, i just, u know just by measuring it, and seeing how much the partial harvest was, that two days, one day ago
48	Matias	No, It was yesterday
49	András	Okay then, it was 1.6 kilos estimated so now it probably more, you now the longer

it grows

50 Simon And how many people are you, you are you two, you run the operation, or what do you say, and you have some partial workers, or how does it function? or is it just you two still going?

51 András Yeah we have Mark, but he doesn't like when we call him an intern, he works with us you know, we met him when we were working with the kommune, we are hoping to involve him more as we go on, now he is sort of freelancing with us

52 Matias He’s, I completely forgot what i wanted to say, yeah now i know, he is our sustainability manager

53 András And he consistently tries to kill my plants

54 Matias Not very sustainable

55 Simon What would you do like, you get an order, and the peas took like, what was it, 8 to a little bit more days

56 András 14 days

57 Simon Okay, so what would you do if you had an order, and you didn’t have it in store, plant based on the order? or say you don't have it?

58 András Well I would tell Mathias, we don't have that. But so, our customers are pretty flexible like that, and usually works well, always we can get a substitute, sometimes that's okay, sometimes we just deliver at bit less, or say that you can have that in two days, or something like that, because from what we have seen, they don't always order stuff in the same day they wanna use it, and because we are harvesting you know like, we are processing it so fast, and giving it to them so fast, that, what was it , the radish, that was like one week old

59 Matias Yeah we had a, from a restaurant called (can't hear the name 13:56) they ordered

		just all the radish that we had, they didnt know how much we had, and we said, well we do have quite a lot of it, so that was 2.2 kilos
60	András	And that was one tray by the way
61	Matias	Yeah that was one of those trays, so yeah I think they were a bit surprised, but they were even more surprised that one week and one day, so 8 days after, it was still like crisp, and tasted same, the've never ever experienced that, like they are throwing half of it out actually, of what they got previously, and like it was completely like, you couldn't use any of it after 3 days ish
62	András	There is a couple of reasons for that, one is that some of these are being pesticides, and that of course is not so good, and long delivery times
63	Simon	Yeah, i saw some reviews on your website, it looks really nice now, you had a guy, or have you sit
64	Matias	We just paid 13.500 for our webpage
65	András	That's a cheap webpage just for the record, that's very cheap
66	Simon	Yeah, they run hot
67	András	But yeah we need some not stock photos on there
68	Simon	But it looks nice, it looks very nice now
69	András	It better
70	Matias	Yeah but we got, or we are getting some money return, because we are in this program, eu funded program, so we get some of that, 75 percent of those money returned
71	Simon	Okay nice, and do you get additional funding from that program, or in other ways how do you fund?
72	Matias	We got 15.000 kr that we can only spend on consultancy

73	Simon	You also have like a bunch of other university students work with you, how many groups are you working with currently?
74	Matias	I actually don't remember
75	Simon	It's quite impressive
76	Matias	Yeah, but it is Marco, he is doing most of the collaboration. I think András and I only have two or three groups that we are engaged with.
77	András	There is like a whole class of ucn students that we work with as well
78	Matias	Yeah and we are still in the program called scandinavian growth creators which is an eu program, and there we also have some students, but they come from all various different kinds of educations
79	Simon	In regards to customers, how many different customers are you currently, returning customers do you have, you have rusk was it?
80	Matias	Yeah Rusk, and (can't hear the name 17:25), and then we have just, or at least i hope we are starting a collaboration with skagen fiskerestaurant, we've also been talking with
81	András	Textur
82	Matias	Yeah, but they are not customers yet, but Fusion, but they actually get okay quality, but there are something that they can't get with their current suppliers, so they are more looking into like unique things that we can supply, and the same with Textur and (can't hear the name 18:08), and then we have i think Marco scheduled a meeting with Applaus, and I don't think we have any
83	András	And we would also like to get back to We Feat
84	Matias	Ja
85	András	Cause we had some talks previously, and i

		definitely think their profile fits ours
86	Simon	It's mostly like higher end restaurants, like in the little bit more expensive spectrum? quality restaurants, that's the word
87	Matias	Yeah, but still Isidor Henius that's not gourmet, that's not even close to gourmet, but they are just using it, so it's really a good quality no doubt about that, they are just using a lot of micro greens
88	Simon	And in regards to suppliers, is it one supplier you have now or is it multiple different ones in regards to the seeds?
89	András	Seeds come from one place it’s Shuba seeds, an italian supplier
90	Simon	Oh italian okay, and all of them are based on your needs, or monthly?
91	András	We usually just get a bigger batch, cause the shipping
92	Simon	Yeah okay
93	Matias	Last time we ordered 250 kilos of seeds
94	András	Yeah but you know 90 kilos of that is peas, so it also depends, like a kilo of amaranth seeds for instance that can last so long, it’s tinsy tiny seeds
95	Simon	Yeah and they hold their shelf life for a really long time
96	András	1 to 2 years if you really like kill them, so they don't go bad like this but, you know but like the successful germination rate drop give or take 5 to 7 percent a year
97	Simon	Okay
98	Matias	But we are not having them one year, there is much faster turnover
99	Simon	What is your like, vision, you have this facility, and do you have plans on like expected growth, or do you want to grow out of here?

100	András	Would be like to do something in Dubai
101	Simon	Oh okay yes
102	Matias	Yeah i think so we can talk a bit about our vision, but in regards to what András say, i think we should take it when we turn of the microphone
103	Simon	Yes
104	Matias	Yeah but our general vision is to inspire more sustainability, and innovation in tomorrow's food production, and we really mean the thing in the word inspire, because we don't want to be farmers the rest of our lives, we don't want to be food producers. What we are during right now is to show that there is a business case in growing microgreens, in growing herbs, growing leafy greens, stuff like that vertically, because we want to supply the equipment and our knowledge to farmers instead, and then they will be the actual farmers
105	András	It's also a learning experience i guess where we can say that, yeah okay this works, this doesn't work so
106	Matias	Yeah so that's definitely what we are aiming for, and we thought that we would be 5 to 7 years in the future before being able to transition to our (can't hear what he is saying 22:12) we are actually already starting to do that, one of the thing is that we have become
107	András	Resellers
108	Matias	Nah dealer of the lights we have, so in the beginning we were looking to become like manufacturer of equipment and sellers of that, but maybe we will still be because we can still see that there is room for improvement in some of the equipment but right now i think it will be a much wiser way to just be like a system integrator, so be dealers of different types of so for example the lights, but also the trays or yeah, we also have some equipment down in in the corner over there

		maybe be dealers of that, and then we can always supply the very best from the different manufacturers, and then just integregrate everything into a system, i think that will be our approach right now at least
109	Simon	That's pretty cool, so like wholesale equipment like at some point, additional also microgreens, or like faze out of that potentially?
110	András	Whatever the client need, but as acting sort of middle man and knowledge base
111	Matias	Yeah wholesaling is a bit more risky, because then you buy the equipment from the manufactures and then you sell, so you build up stock, and right now we are dealers, so we are just going out in scandinavia, have you tried this light, do you want to try it, do you want to buy it, we can give you a good price, yeah we are the selling company, but it is actually an astrian company that then starting the manufacturing, sending it, and yeah so dealers slash freelance sales people
112	Simon	And this places great marketing for the product as well, so it's amazing
113	Matias	Yeah you know, we are building up our own business case for the transition, and we of course also have a budget and then we show, well there is actually, you can earn money as a farmer on this
114	Simon	Some more technical questions in regards to the system, how good of an internet connection do you have out here?
115	András	We actually talking about this before, i think we are going to have to get a private link wifi something something router, cause i mean we have wifi, but everybody uses that so
116	Simon	Shared wifi
117	András	So we probably should have but, it's only like a few hundred kr

118	Matias	But it is a really good connection we have right now
119	András	So i don’t know if it’s your guys’ expertise, if you can incorporate that
120	Simon	We can build the system so it can fit to both, we can put it on a web server i think, yeah we’ll to look more into that stuff, but we can build the system to fit to whatever
121	András	Yeah, if your down, just give me a call
122	Simon	But maybe that will be later down the line, then we can call again after the project or something like that. Do you have a computer at this location like at all times?
123	Matias	Not right now but it would definitely be worth having that at some point
124	Simon	Because we are thinking like, we have a label printer, that print out labels that you can put on lots, that is an identifier for that lot, so that would have to be somewhere in the facility, maybe where you put the lots together, so it would have to be connected to something, a computer yeah
125	András	Ideally
126	Simon	Yeah ideally that would be very nice, but yeah doesn't have to be an expensive one
127	András	Shoot us some details of what it is it actually have to do, and maybe we can scavenge one
128	Simon	Yeah, cool we will try to see if there is any (can't hear 27:19) also then. Ane we also have a barcode scanner for the system, and it needs 35 meters connection it has, so bluetooth connection to a raspberry pie which is the receiver for the barcode scanner, mini computer, so maybe it would be ideal to place in the middle of the room, even though we have 35 meters it would probably work, but because of the shelves it might be better to maybe mount in the

129	Matias	Yeah that's not a problem
130	Simon	Yeah so ideally how would you, like without us telling like what we are thinking about in regards to scanning the produce and tracking the stages, how would you like imagine it would work? what would the end idea of it be, like without it being too much of a hassle
131	Matias	I'm not completely sure I know, so how would we like it to work?
132	Simon	Yeah ideally
133	András	I would like to work well
134	Simon	Okay i'll write that down
135	András	But realistically i mean, you are looking for us to describe an ideal process i guess, that we are looking to do
136	Simon	Yeah but it is kind of abstract perhaps, to just do that
137	Matias	Yeah but we can talk about the process, so we would like to
138	András	Just gonna get some water, will be right back
139	Matias	Jamen så kan vi lige slå over på dansk, jamen det det må gerne være sådan, vi har nogle bøtter med frø i, ville det ikke være nemmere hvis vi lige gik turen derude, så kan jeg ligesom også visualisere.
140	Simon	Er det vand i har i dem her? is this for watering at the moment?
141	András	Potassium chloride and irrigation water
142	Simon	How often do you spray the produce?
143	András	Depends, quite frequently and sometimes you see for instance at this tray that growth is uneven, then you like after water a bit and then you can see at (can't hear 30:16) that it catches up sort of, and after like a few days you can't really see the difference

144	Simon	What was it called, natrium chloride?
145	András	Potassium chloride
146	Simon	Potassium chloride, and what is this?
147	András	That's irrigation water, right now we are not buffering the ph, now that is hydium peroxide, to add a bit of oxygen to the irrigation water
148	Simon	Okay, i'll look that up at home
149	Matias	We can also put in fertilizers and stuff like that
150	András	It is actually organic
151	Simon	Organic, very nice
152	Matias	Yeah but, i can walk you through the process that we have thought about, so right here we have the seeds, there also seeds up there, but yeah this is where we are taking the seeds from, so the barcode scanner can start being used here because then this is (31:32) for example, then we scan, that now we are sowing(31:39), and then we are taking this one over here where we have this (31:44), and we start sowing the (31:47), and then there would maybe be a barcode here, or either here. Would it be better if it was on the shelf? but then we can't really move
153	András	Then that doesn't follow so it should be the trays
154	Simon	We were thinking maybe having one on the shelf and this one so we can track where each product is in the building but yeah might come in handy at some point, but for the lots
155	Matias	Yeah that would follow the tray
156	Simon	Yeah that's the product and the shelf is just for location in the facility. So we put one on the lot as an identifier for what is in this, and have we planted this and so on
157	Matias	Yeah, then there is a scanner, we scan the

		tray, then we know that these seeds are in this tray, and i don't know yet if we should, maybe you have an idea András, should we here note how many grams of seeds we are sowing, or would that number just be predefined everytime? so is it always 80 grams, or should we also take fluctuation, so 82 grams in one and
158	András	I think it's easier to just have it preset
159	Simon	Yeah also we have to manually type it in each time or have a wall with number
160	Matias	So then the system will already know when you take (33:46) then it’s 80 grams for example
161	András	And it is pretty consistent so
162	Simon	Okay
163	Matias	And then we scan this one so that we know (33:55) is in here, and then when it is sown, then we move it over here, where there is no light. The seeds don't want light, like imagine if it was soil, then it would also be covered and not get any light. And then we’ll know that when we have scanned this tray once, then it’s because it’s under cover, and then when we scan it the second time, that's when we are putting it under light, and then it's there for an x amount of time for (34:37) maybe 6 days, and then after 6 days then we are scanning the tray again, and then we know now it’s getting harvested, and when we harvest it, actually there might be a problem here, because if we do partial harvest, then that's another scan, but maybe you can figure out a way, that could maybe in relation to also scanning
164	Simon	The partial harvest there might be a need to do some manual typing or something, because it's hard to predefine it when it can change so much
165	Matias	Yeah because right now we are actually when we are doing the controlling sheet, András are you listening? when we are doing the partial harvesting, then we are

		just guessing, okay this is maybe 2 fifth, or 3 seventh of the whole tray, and then we are writing it two places that yeah first it was 100 grams, and when we finalized the harvest some days after, then it's additional 120 grams, so we are writing that down manually, but it would be nice if the system could like say okay this tray is the same as the other partial harvest so then we multiple those two, and also having the date of when the first partial harvest was and then when the full harvest was
166	Simon	I think in regards to the partial harvest we might need to do some manual typing of some sort unless you have like predefined sizes as, a quarter, a half, a whole, but that might not work when it is grams, yeah that might not stick
167	Matias	But we will, so lets say that for example they call, when we get 4 customers calling us today saying now they want radish, where was i going with this, yeah, and this is ready to be harvested, this one could be good to have a bit longer time under the light, but this is not enough for 4 customers, so we will have to cut a bit from this as well, so then it would also be nice you know to have a scale, because of course this is not the same amount of grams, so there will be something, we need to note how many grams each harvest will, i don't think we can avoid that, and it will differ from time to time especially these for example, here you can see some seeds that has not sprouted, and on the next batch they might sprout, so there is a bit of fluctuation there, that we need to
168	Simon	So i think the computer we talked about earlier might come in handy to have that, also then you can, if you go and scan this and you accidentally scan it twice you have it in a state that you don't want it in, so you can go over and manually edit and troubleshoot your process
169	Matias	Okay when we harvest it what we want to,

		it to have this trolly, because right now we are taking it down on this table, but if we had a trolly where we could harvest directly on, so yeah that is also nice that the scanner is portable
170	Simon	Okay, so when the lot is harvested this items seeds, nej okay let me rephrase that, so when you send it off to customers we can take the same tray and put it over there and use the same barcode?
171	Matias	Yes
172	Simon	Okay, so tracking who the customer is sent to might not be a part of our system
173	Matias	Yeah that's what i think two of the groups are working on
174	Simon	You are gonna have a lot of systems
175	Matias	Yeah and it is also a matter of integration those systems but yeah
176	Simon	I think it seems doable, just each time you scan it, it goes to the next stage, so if you scan it over there, the product is sown, and if you scan it again it's maybe you scan the shelf, it's put on this shelve, the third time it's under lights and so on
177	Matias	And if you guys can come up with a smart way of differing between a partial harvest and a full harvest as well, and if you have time also include a scale, so we know how many grams that
178	András	That would be very nice to to be able to just you know, not have to manual
179	Simon	Think we might not have time to order in the scale and build that part of the system unfortunately because getting hardware takes a whole lot of time so
180	Matias	Yeah, do you get it from china?
181	Lasse	Germany
182	Matias	Okay

183 Simon But again we can do it after the project is over if you want to set aside a small or a little penny or something like that i think we could manage that maybe, some of us at least would like to do that, or me only

184 Matias That sounds great

185 Simon Yeah, i don't have anything else

186 Matias But is it possible to type if you don't have time right now, would it be possible to in the system make a place where you can type in manually the yield grams?

187 Simon Yeah i think that's what we are gonna do, do it manually

188 Matias Okay great, and then when we have the scale

189 Simon Yeah some other programmer or some guy could integrate it into the system, with relatively little effort, and it could just be hooked up to the raspberry pie that we have hanging from the ceiling or something, that should be doable i think. And also the computer we were talking about earlier would be nice as we have this label printer, so you can set it up to automatically print when you scan a barcode on the wall or something like that

190 Thomas I think in terms of if you make a mistake, i think just make a redo button maybe on the computer, so you just want one scan when you go to the next, so this is under light click, and then this is harvested click

191 Matias Yeah that would be great, and if there is an undo button then that would be great as well, maybe so what i talked about before for example here you can see that this is tray number 35, and that is what we put into our controlling sheet right now, but it would also be nice to either have it directly on the label that this is number 35 or when you scan it you can like identify it, so it can both identify it and it can also move the tray into the

		next stage
192	Thomas	So it's only one tap?
193	Matias	Yeah but then you can yeah
194	Simon	We can make so the first one is like select the tray, and if you do it again, then it will go to the next stage, but for the first one for checking you would have to go to the computer to see the data, just so you are aware but we could give the barcode the same 35, we could giver the barcode number 35, so i don't know if there is more info
195	Matias	What would you think András, should the barcode just identify on the computer which tray we are dealing with because then you need to go over to the computer to see which tray, or should it be incorporated on the label with the barcode
196	András	Can I check it on my phone?
197	Simon	Yeah, it should be possible to do so yeah
198	András	
199	Matias	Also within time? Like your time
200	Simon	Yeah that's the plan, like we have it on a secure kind of application, and you can do the entire factory, what shelve, and what state it is in, when it was in the different stages, and so on
201	Matias	And it doesn't matter which devices you log in with?
202	Simon	Nope
203	Matias	But András are you sure that's a good solution, because we have also talked about sanitation and phones that's not really
204	Simon	Yeah so you could yeah, any device
205	András	Well how often do you have to check like realistically?
206	Matias	If you are in doubt which one has grown

		the longest for example, i don't know
207	András	I think it's fine to just go there and check, i don't think we you know, or i don't at least you know, i can tell what this is and from the growth i can tell approximately when it was seeded and when it was lit, so not for my sake, but potentially for Marco especially if he is going to handle this facility alone at some point, then it might be very relevant, because he says that this is broccoli and we don't even have broccoli
208	Thomas	Maybe we do that in the lot number, so if it starts with 1 it’s broccoli and 2 it's something else
209	Simon	Then we would only have dedicated, what's it called trays for each food product if we integrated in that and we need to make a new barcodes every time
210	Thomas	But don't you have one for the tray and one for the lot?
211	Matias	Yeah so a lot number that shifts every time we are delivering
212	Thomas	So you want one lot here right, and then when you harvest this
213	Matias	We don't want a lot on the trays, we want a barcode, and then when you scan that barcode then that identifies a lot. So the lot number itself should not be on this tray, but the act of scanning would then identify which lot number, and like it’s not like they can rotate, like after a 1000 then we get to number 1 again, i think you can, i think you can but if it can just be continues all the time, then that will be great
214	Simon	I'm a little bit confused, so this number 35, this changes or does not changes?
215	Matias	This tray will always be number 35 but before we sow the radish, there might have been peas in
216	Simon	So after it's harvested and you put a new

		thing in it, will you like to store the old items that were in there?
217	Matias	Yeah we need to store it, both to get the data, so how much yield did we get out of this, but also to like to have the lot number, yeah i know we might not need to save it after 10 days, because after 10 days then the produce will be thrown out if it isn't used already, but we need to track it for some time the lot number, because if someone get sick of this exact tray, we need to call back all the deliveries that we have had with this one tray
218	Simon	Okay so maybe 30 days plus minus, we can always extend it i think that won't be an issue
219	Matias	Like the data of how long it has been under light, how long it has been under cover, how much yield those things we would like to keep, possible forever
220	Simon	Okay, and you've talked about putting it in a format so you could put it into some sort of graphics tool microsoft something
221	Matias	Yeah microsoft power bi
222	Simon	Do you know what kind of data format it uses?
223	Matias	It's just an excel sheet
224	Simon	Cool, we'll make it able to export into excel then
225	Thomas	Just a comma separated file right, so it goes into excel?
226	Matias	Well it's not like we need to make it graphically, what's it called put it into power bi all the time so it can just be one button that says export this months data to an excel, whatever works best for you i think, we are quite flexible
227	András	When we are starting to make changes to the setup right, so for integrating lets say co2 (50:30) then it's important to see what kind of material we have

228	Simon	One little stupid question, so the lots, im a little bit confused about the tray and the lot and the difference between them, so the lot is just the whole thing in the tray, so there are not multiple lots in the tray?
229	Matias	No, the lots will follow the trays, and then when we harvest it in the condibøtter, then those condibøtter that get this produce, they will get the same lot number as this tray. So it's the trays that defines the lot number
330	Simon	Sweet sweet, har i andet?
331	Thomas	I have a prototype of how the barcode scanning should be, do you want to see that?
332	Matias	Yeah definetly
334	Simon	Should I stop the recording?
335	Thomas	Ja

B | Evaluation with Novefa

Interviewers:
Simon and Thomas

Interviewees:
András

Date and Location:
December 15, 2020
Novefa Production Facility

Column	Name	Statement
1	Simon	Okay, are we recording? Let’s just put this here for good safety measures… This is a couple of questions regarding the evaluation of our system and yeah, it will just be a short amount of questions which you can answer freely however you want.
2	András	Yeah.
3	Simon	So in short, can you define what need the system fulfills, like what’s the initial idea of the system or what’s the purpose of the system?
4	András	We needed some way to track what we do in the production essentially, we needed to know, you know, what tray was where, like, what was going where, something that was a lot more convenient than running around with a big piece of paper and just writing everything down, so that, and you know faster too.
5	Simon	So in that regard, how do you see yourself, how should I phrase this, saving time using this system, like, in the long run maybe?
6	András	So realistically speaking i can’t imagine doing it the way we’re doing it right now in a larger scale production system it has

to be something like your system. because naturally the way we're doing it now is that the one who is sewing or harvesting would write down after measuring the exact number and then we would manually type it. Which is not only double work, but you know, occasionally you lose post-it notes, sometimes it's like: "What did he write here?". So it's, yeah, it's just a massive time thing.

7 Simon Yeah, so a bit more on the financial side, how much money do you think a system, this is like kind of a stupid question, how much money do you think this sort of system would have cost you, if you were to go to a… a programming guy... It's a very vague question

8 András I really wouldn't know, but what i can attest to is significantly more. (laughing) I don't have illusions about this, as of course it would be, yeah...

9 Simon Mhmm. yeah.. How do you see yourself saving money using the system in the future?

10 András Well the easiest and most immediate answer is the time use, right, because our time is money of course and you can always spend it doing something else and not try to figure out the other guys handwriting, but i also think that… I know that at least once, nah actually two times. Where we had problems remembering: "What did we just deliver, how much was that?" So you know if we screw up invoicing, that's literally money down the drain.

11 Simon ehh, yeah. And how could you maybe see the system evolving in the future? Like your software here, have you any thoughts on how you might expand the use of software here in your facility and the system maybe?

12 András Well you know integration with a fully fledged ERP-system of cause, that would be nice, you know, you can always make it more sophisticated, like you can like

		cross-reference data with environmental data for instance and that also gives you like a "okay, then this was harvested" you can also look at if doing a partial harvest on the lot potentially does something to increase or decrease seals for the rest of the tray. There's a lot of ways.. There's always somewhere to go with food production.
13	Simon	Mhmmm. yeah yeah. And yeah just, what's your general thought, what do you think about the system that has been implemented?
14	András	I like it, you know of course we've had our back and forths, you know, i like how simple it is. Well of course my side is simple (laughing), when what you guys have on the other end is probably very convoluted and sophisticated, yeah i like it.
15	Simon	Is there anything you would change about the system?
16	András	Not immediately, and i also like the whole, scan it once, do this, scan it twice do this, not gestures. but that's very good
17	Simon	Yeah, i think that was it pretty much
18	András	Good job guys