Traceability of continuous processes

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Abstract

This thesis focuses on the growing demand for traceability in continuous processes within the food and beverage industries. Three market-leading companies have contributed valuable input to this thesis to identify common interests. Using modern technology, a demo application has been developed to show the power in gathering several data sources and traceability into one graphical user interface, GUI.

The application stands on a strong theoretical ground by taking several international standards, needs assessment and user interface theory into account. By doing so the final application emits a strong understanding of the current traceability needs and trends. This thesis was carried out together with ABB in Malmö.

Acknowledgements

The author would like to take the opportunity to express his gratitude towards several people. Firstly, his supervisors in this project, Anna Åstrand and Pontus Nordin from ABB and Charlotta Johnsson at Lund University. They have all been supportive and offered their valuable knowledge during the thesis. Secondly, the people at the ABB office where the thesis was carried out for their friendliness and encouragement. Finally, my family for their continuous support throughout my studies.

Contents

1. Introduction

Chapter One describes the background and motivation for this thesis. Specifically, the following section will discuss the aim of the thesis, methodology and the structure of the report.

1.1 Background

There is an increased demand for efficient and precise traceability within industrial production. Many solution providers are already offering traceability solutions to their customers. This thesis will focus on traceability solutions for the continuous process industries. The thesis is carried out in collaboration with ABB, a solution provider, with input from three of their clients from the continuous process industry. The thesis will review current solutions and look for both improvement points and alternative implementations. Improving traceability can lead to many advantages such as less costly implementation, more precision and less waste. The focus will be on food and beverage production.

1.2 Project Goals

The initial goal of this thesis is to identify common traceability interests from different industries producing different kinds of food products. Mainly, traceability within the factory will be researched in this project although some research will be done during the needs assessment to explore the impact of improved traceability on the end consumer. Then, these findings will be analyzed and broken down into the smallest common denominators. With the given results, one or several user-friendly applications providing derived features will be developed, with the data coming from a simulated production process. All three industries involved work under the same framework as all are certified against the International Standard ISO 22000 or equivalent.

1.3 Resources and Tools

This thesis is carried out in collaboration with ABB. ABB is providing valuable business contacts with selected clients from the continuous process industry and thereby ensuring that needs assessment will be done with relevant stakeholders. ABB is also providing valuable knowledge about traceability as well as expertise in the tools needed for doing the system design and implementation, and for building the graphical user interface. In addition, a test environment for implementation purposes is also provided by ABB. The tools used are:

- Microsoft SQL Server
- ABB’s 800xA system with the ProBase library as test environment
- ABB’s Decathlon Software Platform for implementing functions and graphical user interface

1.4 Outline

The theory, system descriptions and prerequisite knowledge for this thesis will be presented in Chapter 2. Chapter 3 covers the outcomes from client interviews. Chapter 4 contains a detailed explanation of the system design. Chapter 5 contains details about the system implementation. Chapter 6 thoroughly describes the graphical user interface. Then, Chapter 7 and 8 discuss further development and conclusions.

2. Method

Chapter Two describes each step of the design process and methodology of the thesis.

2.1 Process Steps

The thesis was carried out in the following order:

1. Needs assessment
2. Process findings
3. Write requirement specification
4. System design
5. Implementation
6. Graphical user interface development

2.2 Needs Assessment

This part was carried out by interviewing company representatives from three different companies at an early stage of the thesis. The questions were based on [9] and [10], as well as elements of interviewing theory to get the most accurate data out of the interviews.

The main purpose of these interviews was to map and understand current traceability practices within different food production factories. The interviews also investigated areas for which traceability would be of use in the future, both for themselves and what value it may bring to their customers. The interview questions can be found in Chapter Five.

Interviewing Theory

Gathering knowledge may be done in many ways depending on which kind of information one needs. This thesis is dependent on in-depth knowledge concerning the inner working methods within food producers' factories. Hence, interviews were the chosen method to gather valuable data. Interviews have several benefits when it comes to gaining a detailed understanding of a process. It is easy to ask well-fitted follow-up questions, a one-on-one setting may result in more detailed answers than conducting group interviews and the interviewer may identify nonverbal behavior of the person interviewed. Disadvantages of conducting personal interviews are the large time commitment, contradicting information and subsequent difficulties with analyzing the outcomes, according to [23]. Nevertheless, this was decided to be the most accurate method for gathering data. Often, an interview is recorded to allow the interviewer to transcribe the interview afterwards. However, it was decided to only take notes during the actual interview. This to promote a relaxed atmosphere during the interview process. The process followed the pattern below as proposed by [23]:

- Identifying information needed for a successful needs assessment, with priority on the different requirements and align the questions with regards to whom is to be interviewed.
- Figure out desired end results for each interview.
- Find appropriate people to interview. These individuals may not be experts, as entry level expertise may be of value for understanding the entire process.
- Design a protocol for each interview to follow while interviewing.
- Coordinate a time and place to conduct the interview. Communicate the purpose of the interview and how information confidentiality will be maintained.
- While conducting the interview, take proper notes and follow the protocol.

- Promptly after the interview, notes shall be reviewed and consolidated to avoid any missing pieces of vital information. Any unclear information shall be remediated as soon as possible
- Corroborate relevant findings from the interviews with other trustworthy sources.

Active listening includes paraphrasing, taking notes and using friendly body language. These are all keys to a successful interview and should be used during the interview. While formulating questions, leading questions should be avoided at all costs to ensure the interviewer remains neutral and to mitigate bias in the responses. It is essential to gather important aspects from others in a low pressure atmosphere. If the interviewer's opinion is clear to the interviewee, then there is a major risk of the interviewee providing answers they interpret as "right or wrong" answers. A good practice to understand a process is to use the "critical incident technique" which essentially asks the interviewee to connect actual examples to their answers.

Open-Ended Questions and Probing

Using open-ended questions is a great way to maintaining unbiased interviewee responses. Some simple steps and formulations shall be followed to ask proper open-ended questions. The following are some example questions based on [20]

- What do you think of the solution?
- How did you feel about the change?
- Where do you obtain new information?
- What do you like about the new changes?

The following suggestions are bases on [20]

- Start generic and transform into specific questions.
- Use uncued questions first then follow up with cued ones. An uncued question could be "What is needed?" while the cued one would present a list and ask for additional points.
- Make the interviewee rank their answers.
- Avoid questions which can be answered by a "yes" or "no".

Probing questions are used to gain additional information or clarification without affecting the answer. To avoid general answers, probing for clarity could be of use. For each answer the interviewer may ask follow up questions containing words such as "which", "why" or "what" to make answers more specific. When a clear enough answer has been received, the interviewer may use probing questions for additional information such as, "What other reason did you have?" Other good probes could be well-placed silence, asking for examples or clarification through asking the interviewee to re-state their point in a different way.

2.3 Process Findings

By using the gathered notes from the interviews, conclusions about similarities and differences could be deducted. More about the interviews and conclusions drawn can be found in Chapter 5.

2.4 Write Requirement Specifications

With the deduced conclusions, the next step in the process was developing requirements for the application. Highest priority was given to requirements relevant for the most companies to ensure relevance and impact of the application. These final requirements can be found in Chapter Six.

2.5 System Design

This step was a time-consuming part of the research process as the final system needed to be easily adaptable and useful in the future. In general, the "learn by doing" approach was used. This approach entailed using dummy data to ensure that the desired functionality was working properly. The interaction between the database and stored procedures was emphasized in this design process. Chapter 6 contains more details about system design. In addition, Figure 11 illustrates the data flow.

2.6 Implementation

With the central database structure in place, the implementation step focuses on the interaction between the different layers and ensuring the correct data are gathered and passed on to the layer above. Implementation details are found in Chapter Six and Chapter Seven.

2.7 Graphical User Interface Development

When the exchange of data between the layers was in place, the development of a user-friendly graphical user interface began with strong attachment to theory. Final results can be observed in Chapter Eight.

This section will focus on the theory behind the developed interfaces by explaining both fundamental design principles and defining some useful terminology.

Design Principles

According to [14], there are five fundamental principles to follow while developing a user interface and an additional principle closely related. The principles may be interpreted as guidelines for the designers to ensure all important aspects are covered. However, it is not an exact description of how to design each element [16].

Affordances- "The term *affordance* refers to the relationship between a physical object" [14]. In the real world, it is easier for a person to create an idea of how one can interact with an object than the virtual. A good example from the real world would be a chair; if one spots a chair, there are immediate assumptions on how one may interact with it. For instance, an individual may sit on it, move it around or stand on it. Another good example would be a door handle; which interaction ideas does it spark? Pull the handle? Spin the handle? Just push or pull the door? Affordance is simply all the ideas in the sense of interaction with an object, physical or virtual, when the user spots it.

Signifiers- Slightly different from affordance, signifiers indicate where interaction may take place. Returning to the door handle example above, a "Pull" label would be a signifier indicating which way the door functions.

Mapping- This refers to the layout of controls and displays. There has to be a logic behind it; for example, if a user interacts with one control to heat up a stove plate, the mapping must be clear so that the user easily understands how to use the system.

Feedback – According to [14] feedback shall be immediate, not too frequent and informative. It is important to provide feedback to the user and it can be done in several ways, such as visually, with audio or vibrations.

Constraints- Constraints can be introduced in several ways but they serve the same purpose of making the interaction more seamless while eliminating potential errors. A good example of physical constraints would be puzzles, where the pieces are constrained to only fit well with a few others. Then there are cultural constraints which are of great importance, as a product delivered worldwide must be designed carefully to appeal and be functional for everyone. In addition, there are semantic and logic constraints focusing on where there is the most intuitive meaning and logical patterns.

Conceptual Models

This is the very center of designing user interfaces. A conceptual model is the conception the user has of how the system operates and reacts to interaction. If the conceptual model is ineffective, the designer's conceptual model may differ from the user's conceptual model. This leads to a product with bad performance and, quite often, a frustrated user. Hence it is common practice to strengthen the conceptual models with metaphors. One of the more obvious examples of metaphors would be the graphical user interface used by most operating systems designed for PCs. They all mimic a desktop environment, which works as a metaphor in the sense of files, folders, and a desktop. Text editors try to behave as the user is typing a letter or digital newspapers simulating a page turning. The purpose of these metaphors is to make the user feel familiar and more likely to experience the same conceptual model as the designer. In addition, it will reinforce a precise understanding of the user interface as many users are already familiar with a desktop environment and it gives them an intuition on available interactions.

Harmony

[13] states “Harmony describes the effect, seen at the level of the whole, of the pleasing interaction of the parts.” Meaning that the user is sensitive to the outline of the graphical components. Hence, while designing, it is then necessary to experiment with width and height of components and spacing.

Means of Interaction

The finished application will allow the user to interact with either a mouse or touch. Various input methods give the possibility for variation; on the other hand, the user must learn how to interact with the application twice. Mentioned by [22] a mouse offers high precision while it may take some practice to master it fully. [22] also mentions that interaction with a touch display can offer extended functionality in the sense of multi-touch although it does not work if the user is using protective gloves. The last part is essential to the solution developed in this thesis, as the location where a producer would like to use the application may vary. It might be useful to use the application within the factory but the factory may require thick protective gloves which render touch inputs impossible or precision insufficient. Therefore, it is beneficial to offer different and ergonomic ways of interaction according to [7].

3. Theory

Chapter Three contains necessary theory and system descriptions for understanding the scope and purpose of this thesis.

3.1 Industrial Production

Producing competitive products in large quantities is of vital importance in today's global market. Several different business sectors exist, such as food and beverage, pharmaceutical, automotive and several more. All business sectors operate from the same basis, see the Figure 1 below.

Figure 1. Industrial Production Flow

Transforming raw materials into products is the most essential in the production process. However, the production process may be executed in three different ways: continuous, discrete or batch production. All of these methods have their own key aspects.

In addition, the company must have a production strategy, of which there are two main types: "make-to-stock" or "make-to-order". Make-to-stock may be interpreted as a traditional approach and is dependent on accurate demand forecasts. In contrast, make-to-order allows customization to the customers' satisfaction. The downside is that the customer must wait while the product is being produced. Hence, the chosen approach should reflect how long it takes to produce the product and how long the customer is willing to wait. [12]

Continuous Production Process

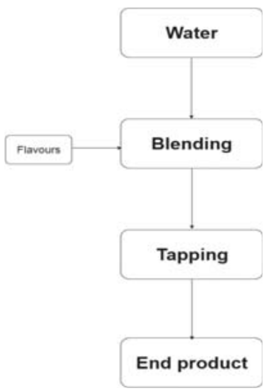

Figure 2. Continuous production process

As one can observe in Figure 2, it can be interpreted as a continuous stream of water going into a blender where flavor will be added and then move on to tapping and finally have the end product. This is one the clearest indicators for a continuous process. In addition, it is often invisible, in the sense that raw materials go in and out on the other side comes the end product.

Discrete Production Process

This method focuses on assembly of pieces into products. Unlike continuous processes, this process is typically "visible" and has well-defined work cells corresponding to each stage in the production process.

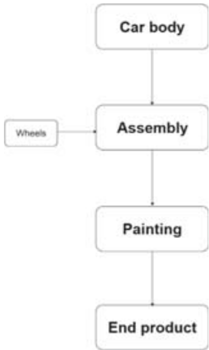

Figure 3. Simplified discrete process for car production

Batch Production Process

In this process, a predetermined interval or amount has been set for production following a recipe. When the production is running, it may look the same as a continuous process although the flow of materials is discontinuous.

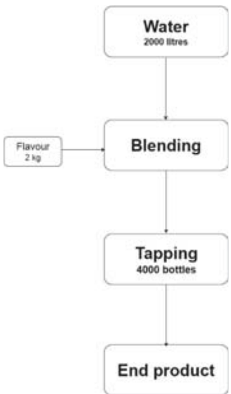

Figure 4. Simplified batch production process

3.2 Traceability

How accurate can one follow the flow of raw materials within the automated production process? Batch production processes are rather straightforward to track and trace as a finished batch is marked with a unique identifier. Imagine a continuous process and how a batch is defined. The need of traceability is high in both processes and even a requirement if a company wants to get certified against certain standards. A central document for this thesis is ISO 22000:2005, "Food safety management systems – Requirements for any organization in the food chain". In addition, a company may choose to certify itself against ISO 22005:2007, "Traceability in the feed and food chain – General principles and basic requirements for system design and implementation". There are many areas of use for a working traceability system such as trend observation, backtracking in case of hazards, and many others.

ISO 22005:2007

"Traceability in the feed and food chain – General principles and basic requirements for system design and implementation" is a standard closely related to ISO 22000:2005. Using ISO 22000:2005 as a basis, ISO 22005:2007 works as a complementary for introducing proper traceability into a system already fulfilling ISO 22000:2005. One should notice that only implementing ISO 22005:2007 is insufficient for achieving proper food safety. The general objective for traceability may be concluded as "Traceability systems should be able to document the history of the product and/or locate a product in the feed and food chain".
Principles state that the traceability systems should be verifiable, practical to apply and results-oriented, among other factors. Before implementing a traceability system, the organization shall identify one or several objective(s) the system shall complete. Objectives could be:

- Meeting customer specifications
- Determine the origin of the product
- Work as a tool for withdrawal of product(s)
- Support quality objectives

System Design

Verification is of vital importance, hence the system must be designed in a way that allows proper verification. While designing the system, several aspects must be covered, such as:

- Objectives
- Flow of materials
- Feed and food chain coordination
- Documentation
- Products/materials within the system

A standard must be set for how much information shall be gathered from the organization's suppliers, what information shall be gathered regarding the actual processing and what information shall be passed on to their customers. Procedures must be established for thorough documentation, for example:

- Lot definition and identification
- Information retrieval protocols
- Flow of materials

In addition to the above mentioned, all relevant steps in the chain of production must be documented.

Current Trends in Traceability

Traceability is a growing trend, and all three companies that have been involved in this thesis all agree that mastering proper traceability is beneficial. According to a case study carried out by Tetra Pak, arguments for improved traceability are increased production efficiency and added brand value. Tetra Pak's current solution adds tracking value to each individual milk carton. [18]

During the interviews, it was revealed that one of the companies has their own patent for a traceability solution. Their solution offers a possibility to their customers to backtrack the origin of the product through the phone or online.

[6] suggests that most consumers do not really know what traceability means. While an evaluation among consumers was done, in the same paper it was found that, in some countries, more than 50% where willing to pay more for a product offering traceability. The most desired information is the origin of the product.

[5] draws the conclusion that the future will include heavier use of RFID and sensors, not only for tracking the goods but also to monitor quality of the products.

3.3 ISO 22000:2005

Released by The International Organization for Standardization, ISO, this document titled "Food safety management systems – Requirements for any organization in the food chain" sets an international standard for food production. This document is closely related to ISO 22005:2007, "Traceability in the feed and food chain – General principles and basic requirements for system design and implementation". ISO 22005:2007 will be explained in the next chapter.

Food safety hazards may be introduced anywhere throughout the production chain, it is therefore essential to have proper control all the way from grain until the finished product reaches the customers. This standard is followed to successfully obtain food safety at consumption, and ensure that no food safety hazards have been introduced throughout the food production chain.

Fulfilling the requirements of this document are centralized around four key areas.

- Interactive communication
- System Management
- Prerequisite programmes
- HACCP principles

Interactive Communication

Obtaining and keeping this international certification demands extensive and transparent communication to make sure everyone involved in the food chain stay informed and updated.

> *"Top management shall provide evidence of its commitment to the development and implementation of the food safety management system and to continually its effectiveness by communicating to the organization the importance of meeting the requirements of this International Standard, any statutory and regulatory requirements, as well as customer requirements relating to food safety." [9]*

As seen, it takes both internal and external communication to fulfill the standard. In regards to external communication, the organization shall communicate with

- Suppliers and contractors
- Customers/consumers
- Statutory and regulatory authorities
- Any additional organization somehow connected or affected by the food safety management system.

Internally speaking, the information flow concerning:

- Raw materials, ingredients and services
- Cleaning and sanitation programs
- Knowledge regarding food safety hazards and control measures

Among other criteria together with the ones mentioned above the organization shall communicate these matters effectively.

System Management

Centered around regular reviews of the food safety management systems deployed at the organization's premises, it must be managed in a way so that it may be verified.

> *"Records shall be established and maintained to provide evidence of conformity to requirements and evidence of the effective operation of the food management system." [10]*

The system shall also be managed in a way so that relevant personnel has required competence in the sense of proper amount of training.

Prerequisite programmes

Prerequisite programmes, (PRPs) define basic conditions that are essential to keep a hygienic environment throughout the whole food chain. Each PRP should bring value in the sense of helping to control the plausible introduction of food safety hazards through the work environment, contamination from a physical, chemical and biological point of view and food safety hazard levels throughout the production. Numerous aspects must be covered while choosing PRPs, such as lay-out of premises, water supplies, cleaning and sanitizing.

Once sufficient PRPs are in place, one should move onto preparation steps to enable hazard analysis. In its simplest sense, it means a team of experts shall be appointed and all data of relevance must be gathered. Data of relevance may be origin of raw materials, storage conditions and characteristics of the end product. In addition, the organization must produce a flow diagram of the production process. The flow diagram will work as decision basis for evaluating where food safety hazards may be introduced, occur or are increased. Hence, an accurate and detailed flow diagram is of great importance. Flow diagrams should, according to [9], contain the following:

- The full sequence from raw material till end product
- Anything that has either been outsourced or subcontracted
- Where raw materials or other substances enter the process
- Sequence for recycling must be marked
- Where raw materials or other substances exit the process.

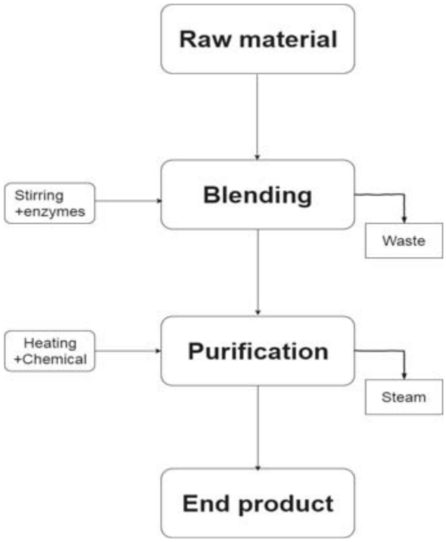

Figure 5. Example of flow diagram.

Given that all prerequisite material has been collected and a flow chart exists according to mentioned criteria, the team of experts can then conduct a hazard analysis and assessment. The fundamental idea behind the hazard analysis and assessment is to find every possible hazard and define how to handle it. For each potential introduction of hazards, the team must consider several things, such as equipment in use at the specific operation, and steps preceding and following this operation. Upon completing the hazard analysis, the team of experts shall move on to hazard assessment, where each hazard will be evaluated. Hazards shall be evaluated by the likelihood of occurring and jeopardizing the food safety of the final product. The control measure for each hazard shall be categorized by either operational PRPs or become part of a HACCP plan. Several parameters are relevant for categorizing the measurements for identified hazards although the most essential approach is to have a logical approach. Hence a systematic approach should be in place for evaluating each hazard following criteria such as:

- How feasible it is to monitor the control measure
- How severe a failing control measure is
- The control measure's placement relative to other control measures

HACCP Principles

Each control measure decided to be included into the Hazard Analysis Critical Control Point (HACCP) plan will be described as a Critical Control Point (CCP).

Each CCP must be thoroughly explained, documentation must include key facts such as:

- Which food safety hazard(s) are to be controlled at the CCP
- Which control measure(s) that is/are involved
- Critical limit(s)

- How the CCP shall be monitored
- How to handle deviations exceeding critical limit(s)

Critical limits are of great importance, as exceeding them severely jeopardizes the food safety. Hence critical limits must be measurable and the decision basis for them must be documented.

4. ABB

This chapter introduces the reader to the company ABB itself and their products relevant for this thesis.

4.1 ABB Systems

ABB is a multinational company focusing on power electronics and process automation. Their products can be found all over the world in factories and power plants. More information about ABB and their products may be found at their webpage www.abb.com.
ABB has extensive experience in delivering automated systems based on their Distributed Control System 800xA to customers in the pharmaceutical and food industry. Traceability and follow-through for batch producing processes are both supported by 800xA already fulfilling the ISA-S88 standard issued by the International Society of Automation. The traceability provided also fulfills the pharmaceutical industry's harsh requirements for traceability according to GAMP/GMP.

However, continuous processes have not been as extensively explored, and there have been several attempts to implement traceability in continuous processes. One approach was to use one of ABB's products, Enterprise Connectivity Solution, which is a system for integration of business and maintenance systems. Although it could provide desired functionality it was shown to be unfeasible due to high costs and require an additional layer of process modulation.

ProBase is an extensive library containing functionality for controlling transmissions, queues, product swaps, product codes, operating conditions and so on. Having ProBase working with 800xA it is possible to derive enough information from the system to offer traceability fulfilling 178/2002. Although at this very moment no such implementations exist.

ABB recently deployed a new software platform, Decathlon Software Platform, which contains a starter kit for product information and analysis. The technical possibilities are many and the current thoughts are to use this platform and develop a lightweight solution offering easy traceability in continuous processes.

DCS 800xA

Distributed Control System 800xA is an advanced automation system developed by ABB, where "xA" stands for extended automation. Extended automation means the system may integrate successfully with for instance third-party hardware or a customer relationship management program. The system is deployed in more than 100 countries with more than 10 000 system installations and differentiates itself from other systems by having several focus areas. Traditional control systems focus on controlling the process while 800xA adds in additional features to monitor energy efficiency, energy savings and operator effectiveness. More detailed information about 800xA may be found online [2].

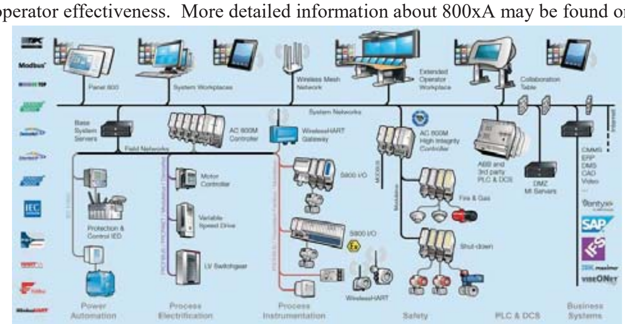

Figure 6. 800xA Architecture [1]

ProBase

ProBase is a scalable template library for 800xA containing many functions for handling different parts of an automated process. The data presented in the final application will be gathered from an 800xA system with the ProBase template library simulating an automated continuous process according to Figure 7. More detailed information about ProBase may be found online [4].

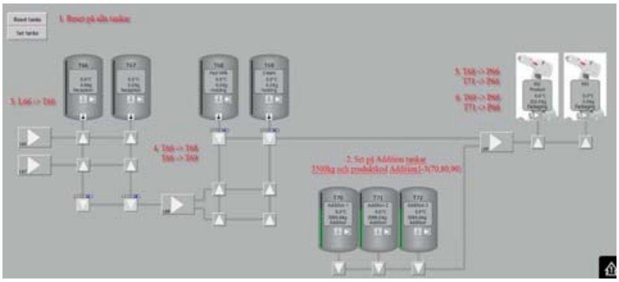

Figure 7. ProBase Demo Application

Decathlon Software Platform

A new platform aimed at introducing "apps" and a fresh user interface. Functionalities of the new platform include viewing and analyzing data, creating reports, gather data from arbitrary sources and storage of history data. The platform is based on the coding language C# and makes use of Windows Presentation Foundation (WPF) which makes the design of user interfaces easier.

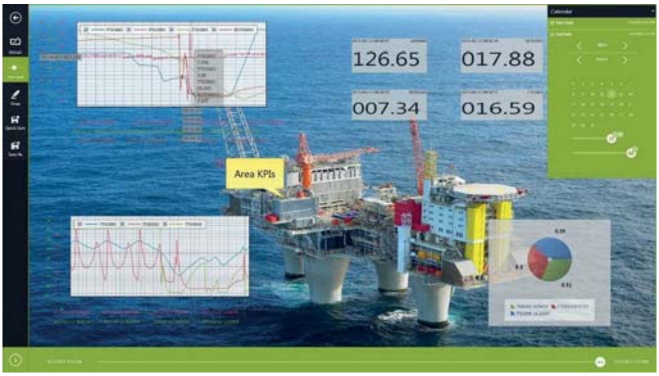

Figure 8. Example of a Decathlon Services application [3]

As the reader can observe in Figure 8, the application allows many different controls facilitating interaction with the user. On top of C# and WPF, ABB has developed a Software Developer Kit, SDK, standardizing fonts, menu icons and color palettes.

5. Needs Assessment

This chapter contains the results from the company interviews, answers and deducted conclusions. The chapter also contains the questions used while interviewing the clients as well as the answers.

5.1 Interview outlines

The focus of the questions has been adapted to properly fit each company. In particular, while interviewing, certain questions have been prioritized and others omitted from the interview. Since some questions may have been addressed while answering another question closely related or the questions are of less relevance to the specific company.

The interviewees were informed that the gathered data will form the basis for the functionality in a demo application, and also used anonymously in a public report.

5.2 Interview questions

The questions used while interviewing clients are listed below.

- What is your working title?
- Which standards do you fulfill in addition to ISO 22000?
- How many products are produced simultaneously?
- Which data is saved about your raw materials and end products?
- How far ahead and back are you able to trace your products?
- How do you label the end product to effectively backtrack it?
- Could you mention the three most severe hazards identified in the Flow diagram? How are hazards classified?
- How do you currently monitor critical control points?
- Which data do you use to effectively maintain your food safety?
- How do you save the data that's being used? Which data would you identify as "key data" for traceability? Currently, do you have any graphical overview of these "key data"?
- How is product quality verified?
- What happens with an end product not meeting required quality standards?
- A strong argument for traceability is the possibility to minimize the quantity affected by recalls. How do you handle recalls today? Please describe the whole sequence.
- How does the traceability affect personnel workload?
- How does external revision work? Please describe the sequence of events.
- How often do you conduct internal revision?
- With your experience, what's your opinion on the current traceability system?
- Please provide a relevant example where traceability has been useful
- Could you give an example where the lack of traceability has been an issue?

- What traceability features would you like to see in the future?
- What kind of traceability do you currently offer to your customers?
- Recent research has shown that customers are willing to pay more for products offering traceability. Have you considered providing this service in the shape of a QR code for instance?

5.3 Answers

All data gathered while interviewing clients are listed below.

What is your working title?	
Senior Project Manager	Company A
Project Engineer	Company B
Process developer	Company C
Which standards do you fulfill in addition to ISO 22000?	
ISO9001, ISO14001, ISO50001, OHSA18001	Company A
FSSC 22000, GMP+B2, ISO50001, OHSAS18001, ISO14001, ISO9001	Company B
ISO 9001, ISO 14001, Krav, BRC	Company C
How many products are produced simultaneously?	
1	Company A
100+	Company B
Several	Company C
Which data is saved about your raw materials and end products?	
Raw material- supplier, truckload weight, test results. Finished product- timestamp for starting and stopping to fill storage container. Quality test.	Company A
Which drivers whom delivered during the day, truckload weight, test results, timestamp for starting and stopping to fill storage. End products can be tracked using LotNr and batchNr	Company B
Quality test results e.g. protein-, fat levels, freezing point and more. Test results from finished products are saved as well.	Company C
How far ahead and back are you able to trace your products?	
Barcode can backtrack to storage container of finished product.	Company A
LotNr can backtrack to which day of production sometimes even production line.	Company B
End product can be traced back to the date of raw material delivery.	Company C
How do you label the end product to effectively backtrack it?	
Barcode	Company A
Lot number	Company B
Production line and time stamp	Company C

Could you mention the three most severe hazards identified in the Flow diagram? How are hazards classified?	
One, metal within the process. Rinsing and filtering	Company A
One, metal within the process.	Company B
Pasteurization temperature	Company C
How do you currently monitor critical control points?	
Metal separator	Company A
Metal detector	Company B
Automation system	Company C
Which data do you use to effectively maintain your food safety?	
Spot-checks and batch numbers	Company A
Spot-checks	Company B
Continuous testing throughout the process.	Company C
How do you save the data that's being used? Which data would you identify as "key data" for traceability? Currently, do you have any graphical overview of these "key data"?	
Excel sheets, database, meeting minutes and binders.	Company A
BCM, SQL database, LIMS, PIMS, Deviation Database, Excel, SAP. Where 800xA is in use ProductionDataLog separately.	Company B
Management system, sample database, binders, LIMS	Company C
How is product quality verified?	
Chemical tests, sensory tests.	Company A
Tests	Company B
Continuous testing throughout the process.	Company C
What happens with an end product not meeting required quality standards?	
Dilute with product meeting requirements or process again.	Company A
Reprocessing, made into a different product, digestion	Company B
Decision is taken based on nonconformity.	Company C
A strong argument for traceability is the possibility to minimize the quantity affected by recalls. How do you handle recalls today? Please describe the whole sequence.	
-	Company A
Order Number gives Lot Number gives Day/Production line	Company B
Timestamp and production line allows proper backtrack.	Company C
How does the traceability affect personnel workload?	
Not mentionable, part of the job.	Company A
Demands a lot of knowledge to trace.	Company B
A lot of manual work for successful tracing.	Company C

How does external revision work? Please describe the sequence of events.	
Present excel sheets containing necessary quality control results.	Company A
60 audit days per year. 30 minutes to track a product a customer brings. Takes time for tracking and explaining.	Company B
Yearly basis, procedure defined in BRC standard.	Company C
How often do you conduct internal revision?	
Every third year	Company A
-	Company B
-	Company C
With your experience, what's your opinion on the current traceability system?	
Satisfying but interested in solving recurring remarks from external auditing.	Company A
It works but not without a hassle.	Company B
Satisfied	Company C
Please provide a relevant example where traceability has been useful	
None	Company A
Trace nonconformity	Company B
-	Company C
Could you give an example where the lack of traceability has been an issue?	
External audit	Company A
No preference on desired parameters in batch reports, Hard to find recurring alarms over time for parts such as a valve.	Company B
-	Company C
What traceability features would you like to see in the future?	
Simplified troubleshooting, graphical overview of key data and easily look back over different time durations.	Company A
Search over time e.g. valves.	Company B
Simplified Graphical Overview, Optimization	Company C
What kind of traceability do you currently offer to your customers?	
None	Company A
None, focus on locally produced products.	Company B
Some products can be traced mainly to promote Swedish raw material.	Company C
Recent research has shown that customers are willing to pay more for products offering traceability. Have you considered providing this service in the shape of a QR code for instance?	
Not at this point, RFID has been discussed. Traceability has been used as an authenticity indicator in certain markets	Company A
Not at this time	Company B
Already providing it for some products with the help of timestamp and production line as unique identifier.	Company C

5.4 Conclusions

Even though the three companies are all producing foodstuff, there are distinctive differences in their desired system requirements and the ways they operate. Therefore, differences and similarities will be presented in this chapter followed by conclusions.

Differences

- One company produces a product with short expiration date
- Operates in different markets, Swedish, European or world wide
- One company has their own patent for traceability
- Two companies have time stamp and production line as their key information for traceability.
- One company offers a traceability feature to their end consumers
- Two companies have a two-step production where, at the first stage, a raw material is refined in the first factory and then transported to a second factory to produce end consumer products.
- Mark their end products differently e.g. barcode, lot number or time & production line stamp

Similarities

- The companies save their data within more than one system.
- No graphical interface for traceability
- Demands manual work to perform traceability
- Demands deeper knowledge to trace and explain the links
- All three companies have at least one CCP
- Samples are taken on raw material
- Verifies quality with chemical testing
- Markets Swedish raw material(s)
- Certified against ISO 22000 or equivalent.

A distinctive common denominator from these interviews is that all companies could benefit from a user friendly and easy to use solution for tracking products or raw materials within their processes. The fundamental obstacle is the use of several systems to store data which complicates tracking. In some cases, data is kept on paper in binders, meaning the tracking solution may be restricted or limited by the amount of available digitized data, allowing user input as complementary data could remove some limitations and still improving traceability.

Even though several differences are listed, these should not make a tracking application for an arbitrary food producer impossible. Each production process is unique, nevertheless key indicators are very similar, meaning the graphical representation may have to be adjusted for each company and critical limits adjusted to fitting HACCP plan. The bullet point addressing two-step production may introduce security concerns as it demands safe communication channels to properly synchronize necessary date to enable traceability on both sites.

6. System Design

This chapter describes which requirements were kept in mind during development and a brief description of the database logic and structure.

6.1 Functional requirements

These functional requirements have all been derived to satisfy the conclusions drawn from the company interviews.

- The user should be able to type in key data for tracking
- The system should offer self-explaining quality indicators
- The system should let the user track any product through the whole process.
- The tracing function should include any severe errors from the system during the production of the given batch.
- CCPs' average values should be included when tracing an end product.
- Chemical test results should be included for any traced product
- The system should be able to track any changes to data in the system
- A well-structured error message should be shown to the user in case of any error.
- The system must provide a graphical interface.
- The system should keep track of total amounts produced and in stock.

6.2 Quality requirements for the interface

The following requirements have been engineered to ensure a user-friendly interface to interact with.

- The tracing results must be presented to the user within reasonable time
- The graphical interface must be intuitive and responsive.
- The interface should be easily operated without need for prior knowledge.

6.3 Use cases

Based on the interviews and developed requirements two use cases were formulated and will serve as the purpose of the developed application.

Use case 1

Actor: Operator
Prerequisites: Have tracking code available
Scenario

1. Operator types in tracking code and presses the button "track"
2. The system gathers data and presents it rapidly.
3. Operator can then follow a timeline of the product containing information about each step, CCP values, and chemical test results and when the end product was delivered to the customer.

Use case 2

Actor: Operator
Prerequisites: Batch number for desired raw material to track
Scenario

1. Operator types in raw material number
2. System gathers necessary data rapidly
3. Operator can then see in which batches the tracked raw material is present.

6.4 Database

The database is managed through Microsoft SQL Server which brings a graphical user interface that simplifies the editing of tables. In addition, it allows coding of stored procedures. A stored procedure can be seen as a prepared query which takes input variables and may return either a set variable or a table. The stored procedures used in this thesis all return a table with one or several columns.

```
ALTER PROCEDURE [dbo].[spVerifyBatch]
    (
        @batchID AS NVARCHAR(MAX)


    )
AS
BEGIN

    SELECT COUNT(*) AS total
    FROM Batch
    WHERE Batch.batchId=@batchID


END
```

Figure 9. Example of Stored Procedure

In Figure 9 one can observe a short stored procedure which takes one input parameter and executes a query. The query is a select count statement which return the number of occurrences of the underlying condition. This stored procedure is called every time a user tries to track something. It verifies if the database contains any information related to the given input.

Database design

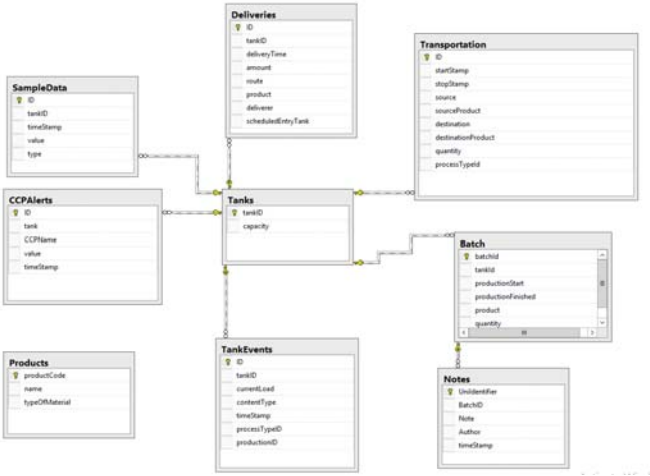

Figure 10. Database design

- Tanks- Describes a tank within the system.
- TankEvents- Describes in which state a tank is, either does it contain something or it is empty.
- Deliveries- Describes a delivery delivered to the factory. Specifying when it was delivered, which tank it will be transferred to and other key facts.
- Transportation- Whenever something is transferred from one tank to another within the system a row is generated in this table.
- SampleData- Handles data from a quality test or routine check.
- CCPAlerts- Whenever a CCP reaches an unacceptable level, this table generates a row.
- Products- Contains a description and name of each product code.

The most central part in obtaining traceability lies in TankEvents and Transportation. The data from these two tables alone can offer traceability in a continuous process. Other tables add additional features to traceability but are not essential to the traceability itself. They make it easier to present related data of interest and providing more useful text to the user. Figure 10 displays the complete database structure.

7. Implementation

This chapter contains descriptions of the dataflow and structure of the developed application.

7.1 Implementation Introduction

The implementation is split up in several layers to pass on the data to the Decathlon application. This chapter will explain each layer to the extent necessary for the reader to understand the general flow of data.

7.2 Data Flow

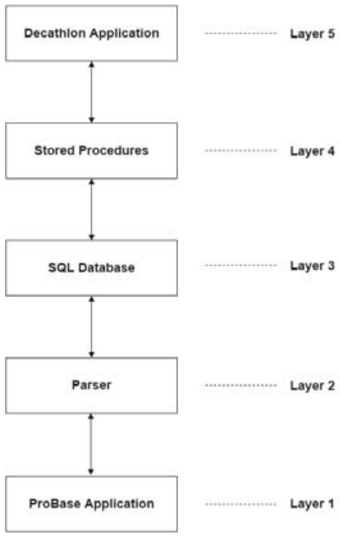

Figure 11. Data flow

Layer 1

This is where the data originates from when the ProBase demo application runs it generates history data. The history data represent what happens in the system while the continuous process runs.

Layer 2

A parser can be seen as a translator receiving something in a certain format translating it to another. In this case, it takes history data generated by the ProBase application and translates it into entries suitable for the different database tables.

Layer 3

The SQL Database receives the data from the parser and stores it in the structure shown in Figure 9. The actual storing is done by calling a Stored Procedure. This Stored Procedure only accepts parameters to prevent SQL injections which may have severe results. In addition, it has a safety mechanism, in case something goes wrong while adding the new row to the table it automatically rolls back to the state it was before executing the Stored Procedure.

Layer 4

Stored Procedures are part of the SQL database. However, their main reason is not to structure the data but to pass on the requested data to the above layer. The traceability solution uses numerous Stored Procedures each one with its own function. The collection of Stored Procedures ties together the information exchange between layer 3 and layer 5.

Layer 5

The Decathlon application is the only thing the actual user will see, meaning all underlying layers are invisible for the end user. Depending on how the user manipulates the graphical user interface the application will call suitable Stored Procedures to gather and present relevant data to the user.

7.3 Decathlon Application Class Structure

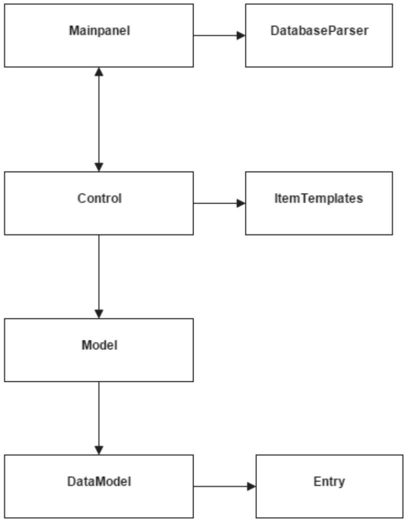

Figure 12. Decathlon application classes

Mainpanel

This class represents the graphical user interface and calls methods depending on the user interaction.

DatabaseParser

As described earlier, this is where information is taken from layer 1 up to layer 3. This class is used whenever the user wants to bring in new data for traceability features.

Control

Whenever the user requests some data through the graphical user interface the Mainpanel will interact with the Control class. This class then interacts with the Model class to gather data and sends it back to the MainPanel.

ItemTemplates

Mainly used by the controller, this class can generate graphical controls dynamically such as textboxes, labels, grids and stackpanels.

Model

The main purpose of this class is to gather data from the underlying database with the help of Stored Procedures. At the same time, it maintains the DataModel.

DataModel

Used by the Model class, DataModel keeps a data representation of what is currently shown to the user. Which is necessary as the graphical user interface needs to update dynamically depending on where the user clicks.

Entry

DataModel keeps a list of entries which represent the tracking path the user has chosen by clicking ahead in the graphical user interface. Each entry is then transformed into a graphical intractable element in the Control class and sent back to the MainPanel and presented to the user.

7.4 Implementation Simplifications

Some simplifications have been made to adapt the workload and ensure that a demo application would be functional within the timeframe of this thesis.

- All components within the simulated process are seen as tanks. This means that P66 and P67, which are production lines, are also seen as tanks. A production line is simplified to a tank that receives transports for a given duration of time and pack the content of the "tank" into cartridges. A delivery is interpreted as a mobile tank.
- The system does not take tank concentration into account. Meaning that the only way to decide if a tank contains a certain material is to search for when it was most recently cleaned. Even though the system may have already transferred one specific material further into the production process without cleaning the tank.
- The system handles liquid at this moment although companies often have raw material which is not in liquid shape. A delivery may be transferred to a silo, thus creating "layers" of independent deliveries. A function to map these layers to deliveries would be useful. It would also have to keep track on how much raw material that is transferred into the factory to properly remap the content of the silo to deliveries.

These simplifications have lightened the workload in the database structuring as well as the coding in Decathlon Services as many things can be treated with the same or similar logic.

8. Graphical User Interface

This chapter will guide the reader through Use Case 1 step-by-step and explains each step, the ideas behind the design and the graphical elements. Use Case 2 will not be explained as it uses the same graphical user interface as Use Case 1 and offers similar functionality. The fundamental difference is if the user tracks ahead or back in time.

8.1 Start screen

This is the first screen the user will see when the application launches successfully. Following the principles of the "F-pattern", meaning that the user tends to scan the screen in the pattern of an "F" [21], the headlines have been placed on top of the screen and icons on the left. This improves the likelihood of the user finding relevant controls and functionality. As seen in Figure 13, the top part has been carefully divided into three different columns where the first one on the left will display data concerning the batch, middle one will display all transportations in the system that has been transferred to the production line during the time interval for the given batch. The last one on the right can display related messages to the given batch. These messages could be anything from an operator mentioning some issue that occurred while the given batch was produced or whom released the batch from the factory. However, here, which data that are shown is not the point, rather any data can be bound to any given batch. Then which actual data it will be can be tailored for each factory. The application generalizes and aims to collect non-conformities to display in this data grid.

Figure 13. Empty Start Screen

8.2 Entering Batch ID

Studying Figure 14 closely, one can identify only one textbox that has white background color. This is done on purpose as a signifier to the user that this box is different from the others and to catch enough of the user's attention so that the user would click inside the box. Immediately when the user clicks inside the box, visual feedback is provided as a blinking indicator telling the user the application is ready to accept input. In addition, the gray color is often used to tell the user no or limited affordance is available for the element [15]

Figure 14. Start screen with entered batch number

8.3 Entering incorrect Batch ID

The system ensures the user has typed a valid input by counting the number of occurrences of the given Batch ID in the database. Since the Batch ID is a unique identifier the only acceptable answer is "1", if it's anything else the error message in Figure 15. Will be displayed.

Figure 15. Error message

8.4 Initial search

Once the user has put in a correct batch ID the "search" button must be clicked. Located on the top left its optimized for catching the user's attention, in addition it has both text and picture. Upon clicking it, direct visual feedback is provided in the shape of a quick color change. As seen in Figure 16 a lot of data are gathered rapidly.

Figure 16. Batch overview.

The user may now observe start and stop of production, which product was produced, how much and if any CCP Alerts occurred in the system during the production. Notice that these boxes stay gray in color to send the signal that this data may not be altered. In the second column, the headlines updates to display which production line was used to pack the product and all transportations to the production line. Notice the color scheme on the transports, they've turned white with an alternating color. White meant affordance and interaction, staying consequent with color codes and signifiers strengthen the user's conceptual model of connecting white with affordance and interaction possibilities. The user may at any point search for a new batch by entering a new batch ID and press "search" again, all old information will be swiped immediately.

8.5 Clicking a Transportation

From the view in Figure 16, it's possible to click any row to track one step back in the production process. Each row contains information about where it came from in the system, when it started and finished the transfer, quantity and what was actually transferred to the production. The result of the user clicking a row can be observed in Figure 17 where a new element has been generated.

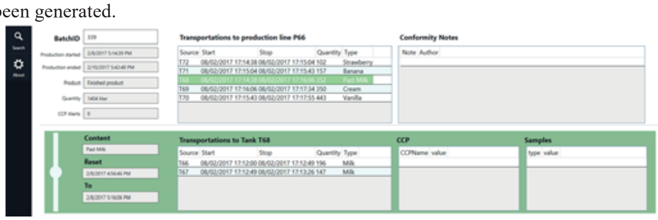

Figure 17. Transportation row clicked

8.6 The generated element

Each time the user clicks a transportation an element seen in the lower part of Figure 17 is generated. Pay attention to the three columns that are maintained; transportations are always underneath each other, with interval and content data listed as well. Conformity Notes stay aligned with the two smaller grids “CCP” and “Samples”. Figure 18 shows only the generated element and it will be thoroughly explained starting from the left. At the very left there is an image with the purpose of sending the signal this is “one event on the timeline”. Then the element gives information on what was in the tank at the time and a time interval. The interval is calculated as the time the clicked transportation finished back to when the tank setting was latest reset. In this situation, reset means when it was cleaned or emptied. A tank contains a product for a while, resets and contains another one afterwards. Then the user may observe all transportations to this tank during the calculated interval, again white means the possibility for further interaction. The next data grid contains information about CCP alerts for the given time interval, in case a CCP has surpassed a certain threshold it should be logged in the system and viewed here. The same goes for the last data grid where any samples taken in the tank will be shown.

Figure 18. Generated entry

8.7 Finding a Delivery

The user may continue to click transportations and another entry like Figure 18 will automatically be generated underneath the clicked entry. In the case where not the last entry was clicked all irrelevant entries are removed from the screen giving room for dynamic interaction and flexibility. At some point in the interaction the user may have successfully back tracked to a delivery which is also identified as a transportation as it is at some point transferred into the system.

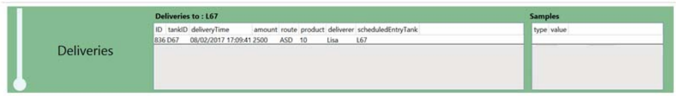

Figure 19. Delivery entry

The delivery entry as observed in Figure 19 looks slightly different. The image on the very left has the dot on the bottom representing that the user has reached the end of the timeline. This is as far as the system can backtrack a product. Giving the user key facts about the delivery from which the transportation originates from, for instance it entered to the system through L67 as seen in picture Figure 19.

8.8 Clicking a CCP or Sample Row

The rows in the grids for CCP and Sample are also white meaning that they should according to the conceptual model offer affordance and thereby interaction possibilities. In case the user click the empty white row, a message as shown in Figure 20 will be displayed to the user. These are features to be implemented in the future and will be further discussed in Chapter 8. At this point they offer feedback to the user to prevent any confusion.

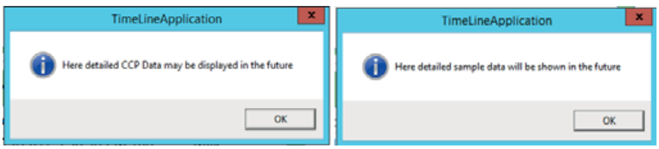

Figure 20. CCP and Sample messages

8.9 Complete tracking

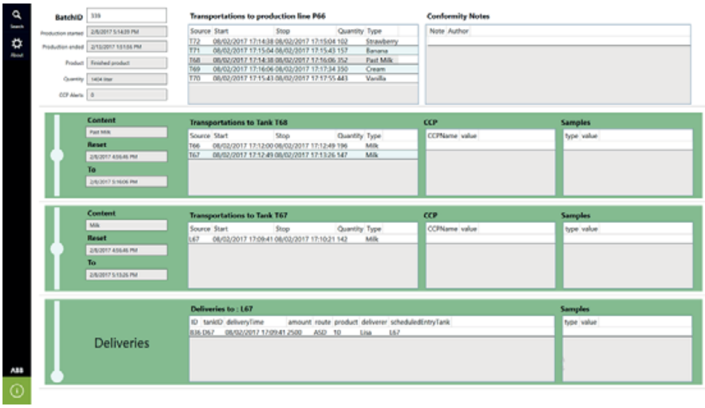

Figure 21.Complete tracking

The reader can in Figure 21 observe a complete tracking with the application from and entered batch ID all the way to a transportation that leads to a tank containing three deliveries. The timeline clearly shows to entries before arriving at the end where the user may find deliveries. Data grids are as aligned as possible since some entries demand other grids. The user only should click desired path to track, it does not take any more typing than the actual batch ID. Hence this solution is suitable for both a normal computer but also with a touch interface.

9. Future Work

This chapter contains suggestions for future development of the application.

9.1 Current State

The application has reached a level where it may be displayed to existing customers as a demo to showcase the potential in adapting a Decathlon Services platform. The first of its kind, the application combines new technology with a user-friendly interface. The current solution should be seen as a demo product to display the true power within Decathlon Services, and this chapter will suggest future work necessary to transform the application to an end product ready for the market.

9.2 Further Traceability

Currently the application offers traceability within the factory, which has been the core purpose of the thesis, where the starting point is a delivered raw material and the endpoint is the batch it ends up in. By interviewing company representatives, it was brought to attention that it is common to interact with several systems to trace a raw material or product. To show a stronger potential, it would be of great interest to implement the functionality of letting a user track either further ahead or back in the food chain. For instance, raw material in liquid shape from one delivery may originate from several farms, all belonging to the same pickup route. Allowing the user to track further on the pickup route to see which farms are included may be of interest and, from here, the user could see if any samples were taken from any farm before the raw material was transferred from the farm's tank to the truck's tank. This information could be further processed to show statistics from each farm on the amount delivered over the desired time, average quality based on samples or any other stats possible to derive from available data.

It would also be useful to further track a batch of a finished product, see how many lots it consists of, who bought which lot, its time of departure from the production plant and other data related to customer contact. Further points of interest for implementation would be the ability to zoom in on a specific customer to analyze buying trends, order history or other desired data related to a specific customer.

The current implementation should allow for adding further functionality without any greater hassle as it is almost generic since any desired data or control may be added in an entry row.

9.3 Validated User Input

The field "Conformity Notes" currently contains no data. In the future, this field should serve the purposed of validated user input, meaning that any operator interacting with a batch must be logged into the system with a personal account and interaction with a batch will be logged and displayed in the "Conformity Notes" field. This would let any user using the application to search for irregularities in handling of the given batch. Reconnecting with ISO 22000:2007 that states traceability must have verified records, companies would greatly benefit from validated user input when verifying themselves against ISO 22000:2007.

9.4 Implementation Simplifications

The simplifications mentioned in 5.3 should be implemented before this application functions as a finished product. The most important would be to consistently track the concentration in a tank as this makes the application more trustworthy.

9.5 Parsing from Additional Sources

All interviewed companies mentioned Microsoft Excel sheets being used to store or log some data. From an ISO 22000 perspective this is not an optimal solution as Excel does not offer editing history, jeopardizing verification responsibilities stated by the ISO standard. Implementing a smart parser processing excel sheets into the traceability database would improve verification possibilities and enable extended functionality as more data would be available.

[5] mentions the future increase of systems with RFID technology therefore it would bring great value to further investigate how RFID would work together with the application and how to handle the collected data from RFID tags.

9.6 CCP/Sample Design

As displayed in Figure 20, the grids for CCP and Sample are currently interactive but empty. The popup that shows when the user clicks a row in any of these grids needs to be designed to display relevant data in a pleasant way. Although the data may differentiate from different factories a more conceptual design could be enough as a start to display the intended functionality and underline the possibility for adaptability.

9.7 Environment

As briefly mentioned in the theoretical chapter, a future aspect that must be taken into consideration is where the application will be used. What restrictions are present if it should be used at production? Dust could result in less usability due to a less visible interface. This will of course be dependent on the client but may affect how well the current implementation will serve its purpose.

9.8 Professional Quality Assurance

The code is inspired by the Model, View, Control (MVC) [19] design pattern although not following its principles strictly. The code should be examined by professionals and certified against fitting standard. In addition, it would be essential to perform performance tests as currently small amounts of data are handled. Processing large amounts of data will be demanding and it should be examined how it affects the user experience. Especially since the application continuously makes database requests, it will greatly decrease the user experience if a database with large amounts of data introduce time delays.

9.9 Marketing Strategy

The marketing strategy and how it involves this application should be decided. Which functionality have the highest priorities among potential customers? Given the conclusions in 3.4, that the application is currently based on, it may be of interest to consider adapting it to different industries. This would improve the chances that companies find it useful enough to invest in. The conclusions in 3.4 from the carried-out interviews could be further analyzed to potentially deduce new conclusions. Further analyzing and further customer contact are both necessary to find out how companies can monetize with their improved traceability investment. This is essential as the interviewed companies seemed to be interested in the concept but could not see a clear return of investment. Two of the participating companies had their production spread on two different sites, which could increase the benefits from investing in an easy to use traceability solution.

Quoting Steve Jobs, “A lot of times, people don't know what they want until you show it to them.” [11] Referring to the quote, the first impression is vital when showcasing the application. Especially since the companies lack user interface as of today, an easy to use application may create a curiosity to learn more about its potential.

10. Conclusions

This chapter will discuss conclusions based on data gathered throughout the thesis and some speculations.

10.1 Traceability

Solving traceability for continuous processes was the overall goal of this thesis and it has been accomplished with some simplifications. As mentioned in Chapter 7.3 the monitoring of concentration in a tank has been omitted. The solution is optimized for liquid, a big silo with for instance grains from several farms would have to monitor the layers within the silo. A system to do so has not been developed.

The centralized logic in the traceability solution developed, lies in timestamps. Defining that between two timestamps all packages coming from the production line belongs to the same batch. Where each tank provides traceability by using two timestamps, the stop timestamp from the transportation selected by the user, and when the tank was most recently cleaned.

During the interviews, it was found out that two companies have more than one production site. This results in more challenges in the sense of syncing data for traceability between the sites and how to communicate securely between the sites. For now, the developed solution is fitted for one production site although in the future a solution for multiple sites may be of interest to develop.

10.2 The Application

The data structure within the database is stored in a way to offer flexibility. Giving future developers the advantage of adding or removing functionality to the database resulting in little of no affection on the remaining data, where the core must continue keeping track of transportations and when a tank was last cleaned. This is the absolute core for how the problem was tackled and if another approach is to be used, it is suggested to build a new database from scratch. Nevertheless, this solution may work as a guideline on how to divide functionality.

Utilizing the timeline metaphor, the application tries to connect with something the user already knows. In this particular case, flow diagrams which are mandatory for each product if a producer is verified against ISO 22000:2005. Given the purpose of the application and the user’s habit of reading flow diagrams, the application should be easy to interact with. A future improvement would be to imitate flow diagrams even closer.

Currently two use cases have been implemented and are at a stage where they are stable and can be shown to potential customers as a demo. A third use case was developed but in the end omitted due to two factors. The solution utilizes data from within the factory and the third use case would need from the complete supply chain. The workload would have been excessive as it was unlike use case 1 nor use case 2. It would require a new graphical interface and new stored procedures, therefore it was omitted and work was focused on finetuning use case 1 and use case 2.

10.3 Theoretical conclusions

[17] mentions one of the derived conclusions from the interview. Current status is that many food producers have good, often electronic traceability systems internally. Although they also mention there is no seamless communication between different internal systems. Making the traceability a challenge. Further complications occur when many companies have chosen to implement paper-based traceability systems [8]. Hence the future will demand serious changes to allow one digital automated central information source.

[9] clearly states the requirement for continuous commitment to improve food safety meaning producers will continuously look for improvement points. Where traceability currently is an emerging interest among producers, highlighting the importance of mastering ISO 22005:2007 to stay relevant to producers.

10.4 Feedback from client

At the end of the thesis one of the involved clients was contacted to discuss the outcomes and accuracy of the finished application. By evaluating the graphical user interface and discussing future potentials, then comparing them to the conclusions from the needs assessment and suggestions for future work discussed in chapter 9 it was possible to get a clear view of how relevant the finished application became.

The timeline and flow diagram metaphors were both appreciated from a design perspective and it was concluded that the application is easy to interact with and user friendly.

Concerning future work the importance of observing traceability trends was empathized. Especially since end consumers are still creating their own image of what traceability is. When it changes, companies must be ready to keep their brand strong and trustworthy.

10.5 Final words

The final product is a responsive application with a strong theoretical basis. Therefore, it will serve well as a demo application as it truly understands and incorporates the current trends in traceability. Although traceability is a growing market, it will require continuous work not to appear outdated. The application will be a great asset in gathering more information about traceability and get an even deeper understanding of where traceability trends are heading.

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Abstract

This thesis focuses on the growing demand for traceability in continuous processes within the food and beverage industries. Three market-leading companies have contributed valuable input to this thesis to identify common interests. Using modern technology, a demo application has been developed to show the power in gathering several data sources and traceability into one graphical user interface, GUI.

The application stands on a strong theoretical ground by taking several international standards, needs assessment and user interface theory into account. By doing so the final application emits a strong understanding of the current traceability needs and trends. This thesis was carried out together with ABB in Malmö.

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