Group Report Template

Stefan-Daniel Horvath*, Hi IM Micahel*, Student 3*, Student 4*, Student 5*,
University of Southern Denmark, SDU Software Engineering, Odense, Denmark
Email: * {Stefan-Daniel Horvath,student2,student3,student4,student5}@student.sdu.dk

Abstract—

Index Terms—Keyword1, Keyword2, Keyword3, Keyword4, Keyword5

I. Introduction and Motivation

The advancement of technology is at an all-time high and the possibilities using technology are expanding rapidly. Several industries are benefitting using assembly robots, self-driving forklifts, etc. People, machines, and products are directly related to each other. The term "Industry 4.0" describes the intelligent networking of machines and processes for industry with the help of information and communication technology [?]. The principles of Industry 4.0 result in several benefits, including the possibility of flexibility within production, ability to quickly change a production line for a different task, and many more [?].

This concept introduces the need for many different systems to be able to communicate in one way or another, which is one of the big challenges Industry 4.0 is faced with [?]. Therefore, for a system to successfully adhere to Industry 4.0 principles it must be capable of communicating between subsystems and various types of hardware within the system.
Industry 4.0 might originally have been coind for the manufacturing industry, but the potential of the concept is not limited to this industry alone. There is great potential for farming to adapt to the principles also. By incorporating the power of real-time data, IoT (internet of things) and analytics, farmers can respond to more nuanced changes in the environnment and the health of the animals. This not only has great benefits for the productivity of the farm, but also has benefits for a more sustainable farming industry.
In this paper the intent of the project is to create a system that can handle various aspects of production, including monitoring biometrics, managing feed, and handling orders in a fully automated livestock farming system.

Therefore this paper designs and implements an architecture based on a smart livestock farming system. The system is evaluated by its ability to adhere to stated quality attributes. The motivation behind designing such a system is based on the need for interoperability between different systems, which in its current state in farming is one of the major challenges. The lack of communication between these technologies hampers their synergistic use by farmers [?]. Through our work, we aim to address these challenges and contribute to the seamless integration of diverse technologies.

The structure of the paper is as follows. Section II outlines the research question and the research approach. Section III describes similar work in the field and how our contribution fits the field. Section IV-A presents a use case of the system, which gives us a better representation of what the system is able to do. The use case serves as input to specify QA requirements for the system IV-B. Section V introduces the proposed software architecture design for the system. Section VI evaluates the proposed architecture on tests conducted on the system and analyzes the results against the stated QA requirement.

II. Problem and Approach

Problem. Productivity in livestock farming har big implications on the environment. While traditional practices have served the industry, their capacity to adapt to rapid changes remian limited. The Industry 4.0 framework offers a solution through its emphasis on intelligent networking and interoperability across systems. By adapting such a framework, efficiency in farming operations can be significantly improved, leading to higher productivity and potentially higher living environment for livestock. Moreover, this could also benifit the principles of sustainable farming. By addressing the challenges of system integration and real-time response to environmental and health variables, the industry could unlock the potential for a holistic, automated livestock farming model that is scalable and future-ready.

Research questions:

1) How can different architectures support the stated production system requirements?
2) Which architectural tradeoffs must be taken due to the technology choices?

Approach. The following steps are taken to answer this paper's research questions:

1) Develop the overall architecture of the system.

a) Identify the services and servers that are needed to support the production system.
b) Identify the usecases that the system should support.
c) Identify the Quality Attributes that the system should support and how they are prioritized.
d) Identify the non-functional requirements that the system should support.
2) Research the technologies that could be used to support the system and the tradeoffs that are made by using them.
3) Develop a prototype of the system.
4) Evaluate the prototype based on the Quality Attributes that are identified in step 1.
5) Analyze the results and answer the research questions.

III. Related work

This section addresses existing knowledge and contributions by examining Industry 4.0 and its current use within the livestock and agricultural domain. In total, eight papers are investigated using a systematic literature review.

Over the past years, large parts of the industry have been undergoing the revolution to Industry 4.0, integrating higher levels of technology into the lifecycle of products. Order systems, production environments and shipment as well as maintenance of products became more automated and integrated different, interconnected smart systems. However, the primary sector, mainly the agricultural part of industry, has not kept up with the rapid changes to modern production standards [?].

With this project, we plan to design an architecture for a prototype of an Industry 4.0 system in the livestock farming domain. For that, we first evaluate which needs and challenges are already reported on for similar systems in the domain and find existing suggestions for designing such systems. In detail, we perform a small but concise systematic literature review considering the following research questions:

- What functional requirements are considered important for agricultural industry 4.0 systems in existing literature?
- Do suggestions for parts of the architecture and technologies of systems exist that support the requirements of agricultural industry 4.0 systems?
- What are current challenges within agricultural industry 4.0 systems in use?

To answer these questions, we examined scientific reports about Industry 4.0 concepts and software in the livestock farming and agricultural context. For the process of identifying appropriate research, we used a semi-automated search strategy as well as snowball techniques after finding promising starting point papers. We utilized a combination of various academic digital databases, including MPBI, ProQuest, DOAJ, Google Scholar and ScienceDirect. We applied a set of inclusion criteria with the purpose of gathering appropriate articles, reviews and case studies published in English within a timeline of the last 7 years.

Our keyword search focused on a list of keywords and key phrases related to our research questions. That list included the words Industry 4.0, agriculture, agriculture 4.0, farming, livestock, and any related phrases. When evaluating the search results, we chose the ones which were applicable to the above-mentioned criteria and related to our research questions and challenges (excluding for example some papers with a focus on machine learning, since they were not related to the architectural parts of software design). Additionally, we ensured that the papers present a balanced view by considering various perspectives and supporting their arguments with evidence from diverse sources, such as references and/or observed data. We also checked that the authors have taken care to present the information objectively, avoiding bias in their analysis.

To report similar or different aspects covered in the different papers, we determined three categories covered in most of the papers. These categories are “Functional requirements and quality attributes”, “Architectural aspects” and “Existing challenges/problems”. For each of them, an overview of the most important points made is given below.

A. Functional requirements and quality attributes

The most common quality attribute for agriculture 4.0 systems throughout the list of papers is interoperability of different subsystems. All the listed papers either mention this attribute directly or refer to middleware products, which are the heart of interoperability between different subsystems. Similarly, flexibility of the system, for example being able to add new subsystems or change parts of the software, is addressed as an important attribute in several papers [?], [?], [?], [?]. Another common attribute is scalability, which papers [?], [?], [?] directly address. In the context of a farm there is a possibility of it growing over time, it is therefore important that the system capable of scaling and can adapt to larger amounts of data and the added workload. A few of the papers [?], [?] also mentions security as an important attribute of large-scale systems, so that the data and system can’t be tampered with. While there were little contradicting opinions on attributes, different papers had different focus points. A few attributes worth mentioning include component availability [?], reconfigurability [?] or accuracy of systems [?].

B. Architectural aspects

Several of the papers formulate guidelines or opinions on different architectural aspects of agricultural 4.0 systems. To address the above mentioned interoperability requirement, most papers [?], [?], [?], [?], [?], [?] directly focus on middleware components that are used to orchestrate and abstract between different subsystems. In this context, they also mention well-defined interfaces for the communication between different components. Another directly addressed aspect is the virtualization [?], [?] of different components in the actual physical farm, so that they can be included in the software ecosystem. While different explicit technologies are addressed by different papers (Docker, Kafka, etc.), a more abstract technological term across different papers is "IoT" [?], [?], [?], [?]. Since many systems in the agricultural context rely on sensor data and physical devices (robots, vehicles), the inclusion of IoT devices is necessary for agriculture 4.0 systems.

C. Existing challenges/problems

Several of the papers [?], [?], [?], [?], [?], [?], [?] come to the conclusion that many technologies exist that try to make livestock farming smarter and more efficient, but the problem with the technologies is that often coordination problems occur making the interoperability difficult to achieve. A gap in this is the need for common communication protocols or orchestration middleware that these technologies can share so data can be used for shared interests. Additional reported challenges exist within the integration of 4.0 systems to the actual farms, which include high financial costs and missing expertise for technological equipment and systems [?], [?], [?]. To counteract some of these issues, there could be governmental policies, which are at this point still undeveloped [?]. Another reported issue might be bandwidth problems in rural areas, which would restrict large interconnected systems with many components [?], [?].

All contributions provide valuable knowledge about Industry 4.0 and its usage within modern agriculture and livestock farming. However, a notable gap in existing literature is the absence of real-world examples of successful or unsuccessful implementations of livestock farming systems that apply Industry 4.0 principles. Developing practical examples can help provide a clearer understanding of how to solve the challenges of Industry 4.0 within the livestock farming domain.

IV. Use Case and Quality Attribute Scenario

This Section introduces the use case and the specified x QASes. The QASes are developed based on the use case.

A. Use case

B. Quality attribute scenarios

V. The solution

This section will describe a proposed design of that aims to achieve the stated QASes stated in the previous section.

VI. Evaluation

This Section describes the evaluation of the proposed design. Section VI-A introduces the design of the experiment to evaluate the system. Section VI-B identifies the measurements in the system for the experiment. Section VI-C describes the pilot test used to compute the number of replication in the actual evaluation. Section VI-D presents the analysis of the results from the experiment.

A. Experiment design

B. Measurements

C. Pilot test

D. Analysis

VII. Future work

VIII. Conclusion