Precision Poultry Farming: Monitor and Collaborate on Health and Welfare of Laying Hens through Online Zootechnical Diary

Magdalena Stefanova[1]

[1] Department of Computing Systems, Faculty of Mathematics and Informatics, University of Sofia "St, Kliment Ohridski", Bulgaria, e-mail: stefanova.magdalena@gmail.com

Abstract. The structure of the food demand is shifting as the rising global population can afford more meat, eggs, etc. Livestock farming needs to reach superior productivity levels in an environmentally sustainable manner. In order to accelerate the development of the livestock industry, it is important to make optimal use of farming knowledge and provide farmers with adequate information technologies. This article describes the realization of a precision livestock management software that delivers monitoring and collaborative capabilities to improve laying hens health and welfare at industrial poultry farms. The online platform specified hereafter as zootechnical diary connects egg and breeding farms through cloud technologies to provide continuous data recording, automatic comparisons between actual and expected production indicators, e-networking and integrated data-flow between the two parties. Breeding farms benefit from enhanced competitiveness, improved supplier-client relationships, while egg farms enjoy management precision, timely feedback on animals' health and economic benefits.

Keywords: Precision Poultry Farming, Precision Livestock Farming, ZooTechnical Diary, Software-as-a-Service, Production Indicators, Health of Laying Hens

1 Introduction

According to the Food and Agriculture Organization of the United Nations (FAO) farmers will need to produce 70% more food by 2050 in order to feed the rising global population. Customers are looking for high quality and safe food products, at an affordable price. Moreover, both animal welfare as well as environmentally friendly animal production systems have turned into decisive factors when a consumer is filling up his shopping basket (Cumby and Phillips 2001). However, amidst these demands, livestock production must also be profitable if farming is to be chosen as a viable economic activity by future generations (Webster 2001). To fulfill these requirements simultaneously can be an overwhelming task for livestock producers (Schofield, Wathes et al. 2002). But given a thorough understanding of the process is developed and up-to-date control techniques are applied, even such complex processes can be described, managed and controlled (Gates and Banhazi

Proceedings of the 8th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (HAICTA 2017), Chania, Greece, 21-24 September, 2017.

2002). To accelerate the development of the livestock industry, it is of vital importance to boost the spread of information and encourage the adoption of information technology applications in farming. The transformation of traditional animal husbandry through modern information technology is a significant and urgent task. If farmers do not adopt data collection, analysis and precise information, livestock modernization will not happen (Huang, Guo et al. 2015). The one tool that can open up real opportunities for animal production is precision livestock farming (PLF). In contrast to previous approaches, PLF systems aim to offer a real-time monitoring and management system that focuses on improving the life of the animals by warning when problems arise so that the farmer may take immediate action. Continuous, fully automatic monitoring and improvement of animal health and welfare, product yields and environmental impacts should become possible (Berckmans 2014). The Australian researcher Thomas Banhazi (Banhazi 2005) outlines that PLF involves establishing data acquisition systems, analyzing of the recorded information, triggering management actions and activating either automatic control systems and/or human intervention. Also it is emphasized that the application of PLF practices in the Egg Industry can be framed as Precision Poultry Farming (PPF). PPF, in turn, has the potential to improve production efficiency as well as welfare and health of animals, and could also reduce the environmental impact of poultry production. In the same paper it is stated that implementing PLF technologies on poultry farms can improve profitability of these farms by improving technical efficiency. The Australian Egg Corporation Limited recognizes that the development of an integrated data analysis tool for the egg industry is a potentially critical enhancement and can lift management standards on farms. Research and examples of PLF tools have already been published for the pig, broiler, dairy industries. However, little applicable information technology frameworks and example systems have been presented for the egg industry. Therefore, on the basis of industry value-chain analysis, interviews with experts, established companies, egg farmers and literature review, this paper showcases an online platform - ZooTechnical Diary-that leverages cloud computing technology, statistical analysis, business intelligence principles and provides for integrated, real-time data and collaboration between breeding farms and egg farms. The Diary addresses a concrete market problem and leverages concrete egg industry use case. Namely, the capability to connect online breeding farms and egg farms, which allows them to realize improved animal health, improved supplier-client relationship and economic benefits.

2 Technical Architecture of the ZooTechnical Diary

2.1 Cloud Tiers of the ZooTechnical Diary

The tool employs the three standard tiers of a cloud-based application -Infrastructure as a Service, Platform as a Service and Software as a Service. It follows the model of a software deployed on a public infrastructure as a service.

IaaS Tier. The IaaS level offers servers, networks and other fundamental computing resources. The main IaaS advantage for farmers, a.k.a end-users is that they don't

have to buy and maintain cloud-computing infrastructure, but they can readily use the corresponding resources anytime, anywhere.

PaaS Tier. PaaS provides a component-based architecture platform for supporting platform configurability and efficient development environment. Also the platform level arranges for the storage and maintenance of different service components such as authorization, alerting, version management. The PaaS level results in reusability, saves development costs and shortens the development cycle.

SaaS Tier. The SaaS provides the end-user-oriented software and services. Farmers can access SaaS on common devices (laptops, desktop computers, smart mobile phones, etc.) through the client interface such as browser or web browser wrapper. SaaS has two abstract high-level layers - backend and frontend. The former is a user-oriented software application, which includes the ZooTechnical Diary business logic. The latter includes all user interfaces, which allow the farmers to manipulate and work with the software application.

2.2 Logical Architecture View of the ZooTechnical Diary

The ZooTechnical Diary is realized as a distributed application and its decomposed into several logical layers. The layers are concerned with the logical division of components and functionality. Layers help to differentiate between the different kinds of tasks performed by the components and enable component reusability and scalability. The main advantage of this approach is that it allows to scale user presentation and computer-intensive processing independently of the data layer, which is harder to scale and handled by external IaaS provider.

Figure 1 shows a high level representation of these layers and their relationships with users, other applications that call services implemented in the ZooTechnical Diary within the metadata layer, data sources such as relational databases and shared data sources. The Database Layer is located on the IaaS physical tier, while all the other layers reside within the SaaS tier and their version deployment is orchestrated through the PaaS tier.

As shown in Figure 1, the tool consists of the three basic layers widely employed by web-application professionals - Database Layer, Application Layer, Presentation Layer- along with two additional ones - Metadata Layer and Mediation Layer.

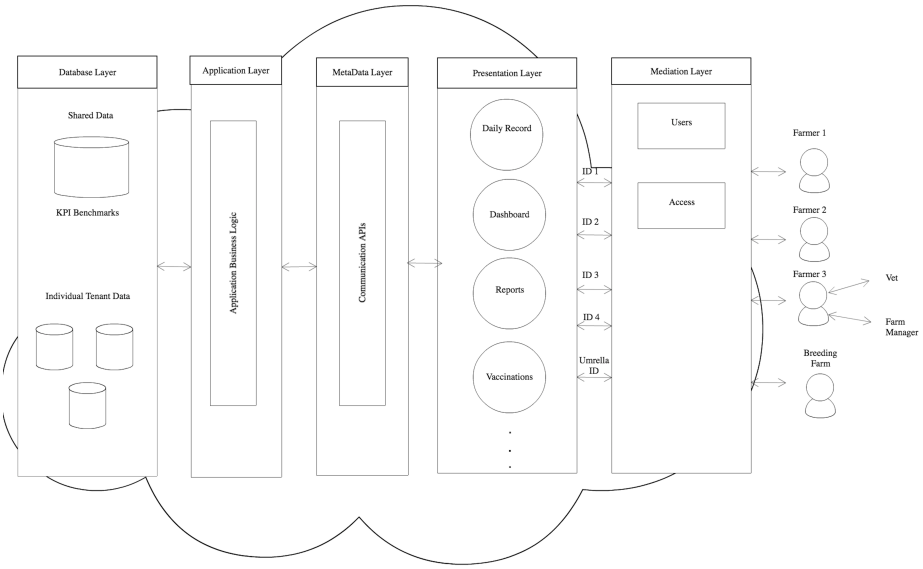

Fig. 1. Logical Architecture View of the ZooTechnical Diary

Mediation Layer: This layer handles the transformation of user account details into specific IDs associated with certain roles and access permissions. It provides a solution to two key challenges - 1) Farm employees different from the farm manager should have access to a restricted number of functionalities of the ZooTech Diary and 2) Users acting on behalf of the breeding farm should access only aggregated information and have read-only rights for the functionalities used by egg farms. In addition, breeding farms have additional functional modules available. Thus, breeding farm credentials are translated into the umbrella-type IDs.

Presentation Layer: This layer contains the user oriented functionality responsible for managing user interaction with the system, and consists of user interface modules such as Vaccinations, Reports, Dashboard, etc. that provide a common bridge into the core business logic encapsulated in the application layer.

MetaData Layer: Since the ZooTechnical Diary collects and stores valuable animal health data, it's advantageous to incorporate in its design a way for other external systems/applications to consume the business functionality and data results of the ZooTech Diary. This task is achieved through the MetaData Layer. The MetaData layer effectively provides an alternative view that allows clients to use a different channel to access the application. External clients and other systems can access the application and make use of its functionality by communicating with the business layer through Communication APIs. This allows to position the ZooTechnical Diary as a connected, integrated, single source of truth for animal health, egg production indicators and expose the functionality for integration with government veterinary and administrative systems.

Application Layer: This layer implements the core functionality of the system, and encapsulates the relevant business logic.

Database Layer: This layer provides access to data hosted within the boundaries of the system. The data layer exposes generic interfaces that the components in the business layer can consume. Each tenant a.k.a egg farm has a separate database to ensure data integrity and security across farms. Moreover, there is a separate shared data storage containing benchmark production indicators against which the actual egg farm production results are compared. The values for the benchmark indicators are specific to the laying breed offered to egg farms by the breeding farm. Another

factor that influences benchmark values is the production system employed, such as cage rearing, free range, etc.

3 The Main Functions of the ZooTechnical Diary

The ZooTech Diary is functionally separated into two main aspects: firstly, functional modules serving egg farms and secondly, read-only access to aggregated data along with a few additional modules dedicated to serving the breeding farm. The business value chain and supplier-client relationship between egg farms and breeding farm motivate such a software design. A single breeding farm is a supplier of parent eggs to its clients - multiple egg farms. The former provides guidance and knowledge to farmers for how to raise the chickens so that they become healthy, productive layers as prescribed by the breed production indicators. The latter, in turn, monitor the animal performance daily and rely on the breeding farm to provide know-how as well as scheduled new chicks deliveries. The functionality for eggs farms includes the following modules:

Dashboard: The dashboard module enables the farmer to have a fast check of the most important actual production indicators for his flocks. These averaged indicators are compared with charts or UI control tiles against the prescribed values expected for the breed at a certain age in weeks. The farmer can receive instant verification for the livability, egg laying rate, egg weight, animal body weight of a single flock. Also, he can evaluate the flock performance and detect any health problems by comparing expected egg grades to the actual egg grades the hens produce. The dashboard serves an instant snapshot of the business and animal health.

New Entry: The new entry module allows the farmer to input daily the actual production indicators per flock. In the tool the farmer enters raw value data, which has been already detected by the farm equipment and machines. Subsequently, the raw data is manipulated, calculated and associated with expected value in order to update the dashboard values, discussed above.

Reports: The reports module is presented in the form of line charts, depicting a single production indicator over an extended period across all flocks. Moreover, the expected values for the indicator are also shown. It allows the farmer to explore the animal performance of all his current flocks and detect trends or repeat problems. Some possible reports concern animal body weight, egg weight, food consumption, food conversion, egg mass, etc.

Vaccination Schedule: The vaccination schedule module serves as a calendar and reminder for upcoming vaccinations for each separate flock depending on its age in weeks. It organizes the vaccination activities and ensures preventive medication is applied on time and as prescribed by the breeding farm.

New Chicks Delivery: The new chicks delivery module is simply a form for farmers to schedule their upcoming chicks deliveries. From an IT perspective it is a simple implementation, but given seasonal variations in egg demand and the necessity to rely on highly productive flocks around demand peaks, this module has a major profit impact for the farmers.

The functionality for breeding farms includes read-only access to the separate egg farm dashboards and an aggregated read-only view to egg farm reports, vaccination schedules and new chicks deliveries. In addition, the breeding farm is provided with ranked reports for top and worst performing egg farms along with modules to update prescribed vaccination schedules and breeding guides, which, in turn, are updated on the egg farm interfaces. The breeding farm is also provided with scheduled calendar for new chick deliveries across all egg farms. Finally, if the breeding farm detects poor animal management at a given egg farm or reaches insight relying on the shared egg farm results, it can initiate online communication with the farmer via the tool. As a result, breeding farm benefit from customer loyalty, egg farms benefit from more productive laying hens and animals enjoy improved, closely-monitored health.

4 Conclusion

Precision Poultry Farming offers new opportunities to increase the efficiency and sustainability of egg production, to improve the health and welfare of animals, and to support farming as a profitable activity, thus facilitating actual adoption by farmers. Research and examples of Precision Livestock Farming tools have already been published for the pig, broiler, dairy industries. The concrete contribution of this paper is that it describes a market-validated example of application of information technologies in the egg production industry. The ZooTechnical Diary addresses the use case of supplier-client relationship between breeding and egg farms. Not only does it provide for continuous data recording and monitoring, but also allows collaboration and information exchange on animal health. Its software architecture caters to the need to ensure clear and concise farming data and offers possibility to connect farms with other systems and administrative, government institutions to ease knowledge sharing and red tape. Further research can be directed towards enabling automatic and autonomous transfer of actual production indicator values from equipment and machines to the online ZooTechnical Diary. Another area to investigate is how by leveraging the data, residing with the Zootechnical Diary, full egg production transparency can be offered to the final consumer at the grocery store.

References

1. Banhazi, T. (2005). "A National Workshop on “Precision Poultry Farming” in Australia."
2. Berckmans, D. (2014). "Precision livestock farming technologies for welfare management in intensive livestock systems." Scientific and Technical Review of the Office International des Epizooties (Paris) 33: 189-196.
3. Cumby, T. R. and V. R. Phillips (2001). "Environmental impacts of livestock production." Integrated Management Systems for Livestock(Occassional Publication British Society of Animal Science No 28): 13-21.

4. Gates, R. S. and T. Banhazi (2002). "Applicable Technologies for Controlled Environment Systems (CES) in Livestock Production." Animal Production in Australia 24: 486-489.
5. Huang, J., P. Guo, Q. Xie and X. Meng (2015). "Cloud Services Platform based on Big Data Analytics and its Application in Livestock Management and Marketing." (The fourth International Conference on Information Science and Cloud Computing).
6. Schofield, C. P., C. M. Wathes and A. R. Frost (2002). "Integrated Management Systems For Pigs - Increasing Production Efficiency and Welfare." Animal Production in Australia 24: 197-200.
7. Webster, A. J. F. (2001). "The future of livestock production: planning for the unknown." Integrated Management Systems for Livestock(Occassional Publication British Society of Animal Science No 28): 113-118.