Elaboration of architecture of the enterprise of dairy animal breeding

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Abstract. The actual task of dairy enterprises is to increase the efficiency of resource use, optimize business processes, reduce water and energy consumption, deploy a reliable traceability system that improves transparency, safety and product quality, providing detailed information about the product for the consumer. The specific task for dairy farms is monitoring the behavior of cows and their maintenance in order to improve their well-being and prevent morbidity. In turn, it will lead to better enterprise management, increasing of productivity and quality of production. It is possible to solve the set of tasks only with the help of digital technologies, which are vital for achieving the competitive advantage of dairy farms. It requires the elaboration of enterprise architecture for optimizing many disparate processes in an integrated environment, which will achieve the right balance between IT efficiency and business innovation. Enterprise architecture provides a strategic context for the development of IT systems in response to the ever-changing needs of the dairy industry environment. The research presents the “As Is” model of the architecture of typical dairy farms, developed using the ArchiMate language. As a result of its analysis, the discrepancy between business and IT requirements was found. An insufficiently high level of application of digital technologies was noted, allowing only to identify animals, but not giving the opportunity to determine their condition, to signal about its change and the need for urgent measures. The insufficient level of application of digital technologies does not provide support for decision-making by employees and managing specialists, and also does not allow to monitor in real time the parameters of the conditions of the animals, the quality of the products, the preparation of balanced feed and their individual dosing, automatic milking, storage, sorting and packaging products. The conducted studies are the basis for the creation of the standard architecture “To be” of dairy farms using modern digital technology and sensor systems for providing high quality and efficiency of production of dairy products.

Keywords: enterprise architecture, dairy farming, digital technology

1. Introduction
Nowadays the activity of dairy livestock enterprises is characterized by ever-increasing complexity and multidimensionality, because their sustainable activity requires improving the efficiency of resource
use, safety and quality of products, compliance with environmental requirements, and reducing resource consumption.

The recently observed growth trend in the size of dairy farms [1] and an increase in the number of large farms present new, higher requirements to management [2]. In this case, an important management tool [3] is the introduction of reference business processes and best management practices supported by digital technologies [4].

The dairy farming enterprise is a complex system, the feature of which is the need to track and maintain the optimal state and development of biological objects and the environment. For this purpose, not only the state of the biological object and the environment, but also the nutrition, energy and technological impacts actually received by the animals and their environment are constantly measured, recorded and monitored. It allows you to identify patterns of development of animals and the formation of a product of production depending on the composition and amount of nutrients and energy, environmental parameters and the state of the cow. Important processes such as monitoring, planning and control can be supported by a wide range of digital technologies, hardware and software systems [5]. In addition, digital technology is an important factor in reducing labor costs, increasing animal productivity and reducing the likelihood of disease [6].

Creating a model and regimes for the formation of conditions conducive to the best development of animals and optimizing the objective function of production of maximizing the product or profit, taking into account real labor and technological resources and food and energy resources, is also impossible without the use of digital technologies. Therefore, there is an increasing role of IT in ensuring the efficiency and effectiveness of business processes on dairy farms, and in connection with it there is a constant increase in the requirements for the resource characteristics of information systems.

For the effective management of a dairy farming enterprise, which is a complex, multi-component system, it is very difficult, almost impossible to coordinate its parts and various aspects of the work; to keep in memory both the activities of people, and the work on managing the regime of keeping animals, and software, and the work of hard ware with communication and system soft. That is why, some authors of research in the dairy industry note that they did not find a real obvious economic benefit after the introduction of digital technologies [7], or it took a long time to find out how to use the advantages of digital technologies with the greatest return [8, 9].

To ensure the main characteristics of the enterprise and its activities, a common vision of the structure and functions of business systems and IT systems throughout the organization and a single strategic development of IT in accordance with business requirements, it is advisable to develop an architecture model. This is a system model that allows you to control the inherent complexity of systems and manage it in a changing environment.

The architecture of the enterprise allows you to make strategic decisions based on a holistic view at predefined goals, to change management, avoid duplicate costs of IT infrastructure, and also manage project risks [10]. The architecture allows you to formalize the problems and requirements to IT on the part of the business; shows how specific tasks are solved and how business requirements are realized in IT systems. Therefore, the development of the architecture of a dairy farming enterprise is an actual and important task, since it provides a stable and flexible environment for the enterprise.

The implementation of enterprise architecture requires two main components: the Architecture Framework, the results of which are architecture artifacts (models, diagrams, documents) and the methodology for its implementation [11, 12].

To demonstrate how the various components of an enterprise, such as organizational units, business processes, employees, and information systems, are interconnected and work in general to achieve goals [13], first the enterprise architecture “As Is” is developed. The second stage of this process is the assessment of the created architecture according to the criteria of efficiency, effectiveness, maturity, quality of results and functionality [14]. Based on the results of the assessment, the desired architecture (To be) is elaborated and the plan is presented for the transition from the existing to the desired enterprise architecture.
The objective of this study is to develop the “As Is” architecture of a typical Russian dairy farming enterprise.

2. Materials and methods
The study is based on a systematic approach, since the architecture of the enterprise is a complex system that includes IP as a fundamental component, as well as people, processes, information and technology of the enterprise, their relationship with each other and with the external environment. In addition, we used functional and logical analysis, as well as a synthesis of domestic and foreign theory and practice of creating enterprise architecture and features of the dairy industry of livestock.

To create the architecture of the enterprise, the study used the TOGAF technique, which is a tool for creating a wide range of diverse architectures and describes the process of creating architecture artifacts. Its utilized description format provides the management and the non-specialized target group with an easy-to-understand method for the development of all layers of architecture, adaptation to new business conditions and the possibility of implementing new plans in the company.

For the projecting of enterprise architecture, the ArchiMate language was used [15]. This language provides the ability to abstractly construct multi-layer enterprise architecture and the flexibility to work with various models and subject areas and describe the architecture from the point of view that is necessary for solving specific problems.

3. Results and Discussion
Based on the study and generalization of the activities of Russian dairy enterprises, the architecture of a typical enterprise was established, which includes several levels (Fig. 1). The business level describes the business elements and their relationships in the field of business architecture. The application level supports the business level and describes the elements of the architecture of the software application and their relationship. The infrastructure level describes the elements of an IT architecture domain and the relationship between software and hard ware. In a service-oriented architecture, a service is a unit of functionality that a system provides to an external environment. To obtain a list of services, the activity of business users of a typical dairy farming enterprise was analyzed for operations performed during work and access to certain sources of information.

After obtaining general information, the data was grouped by functional attribute into the following list of services: artificial insemination, management of animal welfare, veterinary control, production of dairy products, cooling dairy products, primary processing of products, sales of products.

These services provide the functionality necessary for operations in the activities reflected in the name of the service. In addition to services, the main external and internal business roles of the enterprise, representing the abstract user of business services were identified.

The analysis revealed the following internal business roles: artificial insemination specialist, livestock breeding specialist, veterinarian, technical services, workers, milkmaids. External business roles are: a supplier of insemination material, a supplier of equipment, a supplier of consumables, state regulatory authorities, buyers of dairy products, and buyers of calf meat. After the description of the main business roles and business services, each service and business role that is implemented by the business functionality were matched.

The next step in filling out the business layer was to highlight the levels of business functions and business processes. It was preceded by a lot of work on the study of the activities of dairy farms, formalization and analysis of the business processes taking place in them [16]. As a result of the work done, the main business functions of the enterprise were identified: herd reproduction, organization of the dairy herd, production of livestock products, management of the regime of keeping animals. Business processes that implement the herd reproduction business function: insemination, calving, rearing.

Business processes that implement the business function "Organization of the content of the dairy herd": placing the herd, feeding the herd, caring for the herd, veterinary control.
Figure 1. Architecture model of a dairy farm
Business processes that realize the business function “Production of animal breeding”: dairy production and transfer of dairy products. Business processes that implement the business function "Organization of the content of the dairy herd": placing the herd, feeding the herd, caring for the herd, veterinary control. Business processes that implement the livestock production business function: dairy production and transfer of dairy products. Business functions “Management of the sale of livestock products is decomposed into a business process for cooling, primary processing and collecting milk in a storage tank.

The formation of the business layer of architecture is being completed by establishing links between business processes and services that are implemented using this business process.

During the description of application level, the service level and the level of application components were highlighted in it. Application services expose application functionality to users. During the analysis, the following application services were identified: statement of feed consumption, statement of animal weighing, report on indicators of keeping, diet, basic information about animals, keeping regime, identification of animals, journal of veterinary control, various reports, waybill for shipment of products.

The next step after studying application components is to describe the level of application components and to map the components and their services. The main applications used at the enterprise are: MS Excel, MS Word, software for reading information from the ear tags of cows, the information system "1C: Enterprise", a software product for compiling feeding diets "CORALL" and the information system "Seleks Milk".

The elaboration of enterprise architecture ends with the formation of a technological layer. The enterprise architecture at the technological platform level is represented by hardware in the form of a working computer, servers running Windows Server and network equipment.

During the elaboration of the architecture for provision the required performance and scalability, it is necessary to simulate equipment and system software carefully and thoroughly. The elaboration of enterprise architecture makes consider the availability of its modules and layers carefully, to establish relationships showing how the activities of the enterprise serve customers, the software services the work of those responsible and the work of other programs, the hardware services the work of the programs and the work of another hardware. As a result, on the resulting architecture models, the mismatch of activity and the lack of proper software support becomes clearly visible. Therefore, there is a need to develop new architectural solutions "To be" taking into account the existing "As is". The evaluation of the developed model of architecture of a typical dairy farm in terms of efficiency allows us to help the company achieve its goals [17], identify shortcomings and make practical decisions to improve performance.

The analysis of the developed architecture model of typical Russian dairy farms made it possible to establish that they do not fully utilize advanced production tools, high-tech, digital technologies, and effective management methods based on decision support for specialists, that reduces the possibility of achieving high production results and makes it difficult to achieve strategic enterprise goals.

4. Conclusion
The elaboration and analysis of the architecture of typical dairy farming farms showed a low level of efficiency and maturity of the enterprise architecture due to insufficient support for production processes and regimes of keeping animals using digital technologies. At dairy farms the following are automated: animal identification, individual metering of milk production, calculation of deviations of production parameters from the reference ones and automation of accounting. Till the present date, a single information space has not been formed in the field of livestock breeding at various levels, ensuring the unification of pedigree accounting data and the adaptation of the legal framework to the real conditions of livestock breeding. There are no decision support systems that can be used to inform farmers of the best infrastructural and managerial changes to improve return on investment.

The use of digital systems is required in the implementation of processes that provide specified parameters for the execution of technological processes and living conditions in livestock buildings, the
selection of machine operating modes, including operations such as preparing balanced feed mixtures, individual dosing of feeds, automatic milking, deep cooling of milk, automatic regulation of climate parameters indoors, sorting and packaging of finished products.

Therefore the developed “As is” architecture model of typical dairy farms allowed us to reveal insufficient support and compliance with goals of business and IT. There is a need to create a “To be” model that will help to radically modernize the infrastructure, develop compromise proposals for interested parties, manage changes in the company and achieve the goals set by the company.

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