Modeling processes of digital transformation of organization and waste collection of farming households

Irina Krasnikova[1*], and *Irina* Kulibaba[1]

[1]Moscow Polytechnic University, 107023 Moscow, Russia

Abstract. The article justifies the necessity of using software tools to organize the processes of waste collection, sorting, temporary storage, and disposal for farms and large agro-industrial complexes. To create a specialized software product, formal models of the processes are developed which show all aspects of their implementation. The method of structural analysis is used to identify key objects and corresponding rules of their interaction. The use of Business Process Model and Notation enables the creation of models that depict the interaction of objects and the relationships between tasks, as well as the necessary resources for the developed software product. These models can be used to create a software product and technical documentation supporting the process of its operation, as well as to create job descriptions.

1 Introduction

Digital transformation is defined as organizational changes in processes caused by the application of digital technologies in existing or created production models or spheres of social life [1, 2]. As researchers note in their works, digital transformation provides not only the introduction of digital technologies into the processes of the organization, but also the management of corporate culture and business processes in order to obtain effective forms of working with customers [3-5]. All this entails the need to develop tools that work with a large amount of heterogeneous information. They should be based on mechanisms that allow to process it quickly, systematize, store, make it available to a large number of consumers and make decisions (e.g., organizational).

The creation of complex digital systems requires the development of abstract representations of real processes and objects in order to study their structure and features of functioning [6]. Such a process is called modeling. With its help, researchers in their works define the key entities of processes, their characteristics and the relationships between them [7-9]. With the help of the obtained results, the rules and constraints that arise in the behavior of objects in the subject area when changing any parameters are described [3, 10]. As noted by the authors of studies based on the digitalization of any processes, the results obtained in the course of such modeling allow to determine the software and hardware required to create a digital product, and to establish the nature of the work being carried out [4, 6, 11].

* Corresponding author: ira-nik@mail.ru

Ecology is a branch in which digital technologies are actively used. This is due to the fact that the use of such technologies allows to reduce the number of resources to perform certain tasks (e.g., automatic collection of meteorological data), automate the processing of a large amount of data and provide effective management of different resources based on the obtained data [1, 8, 12]. The analysis of works on related topics has shown that the development of a digital product that provides interaction of multiple specialists, data processing and retrieval requires the creation of models of relevant processes [2, 13, 14].

Thus, the purpose of the work is to create process models that ensure interaction between the subjects of the process of organization and management of farm waste management with the help of an information system. This requires performing tasks related to the establishment of key objects and their characteristics, rules of interaction to create formal models of behavior.

The theoretical significance of the study lies in the systematization of the processes of waste disposal organization, unification of documents required by companies to keep records of waste, conclusion of contracts with contractors for its disposal. The practical significance of the study lies in the possibility of using the obtained results to create a unified state information system for the organization and management of waste disposal and recycling processes, to ensure the availability and openness of these processes for the population, specialized companies, production and other companies.

2 Materials and Methods

In the research related to modeling of objects or processes, the method of structural analysis with step-by-step refinement at each iteration of the problem domain decomposition was used [6, 8, 9]. At each step, a list of elements and relations between them was obtained. The analysis of the obtained results made it possible to establish key aspects within the formulated objective.

Business Process Model and Notation (BPMN) methodology was used to create a process model reflecting the nature of interaction between objects. Such a model is actually an algorithm of process execution, as it shows events, executors and their responsibility areas, flows accompanying the process execution [7, 11]. Each of the graphical elements has a certain graphical representation, which determines the nature of their behavior. The study uses a type of BPMN-model, which allows to show the correspondence between the actions performed by executors and the corresponding reaction of the information system to them [1, 5, 15]. This reaction is expressed by the system receiving data for further processing, storing and forming the recommended control action, as well as sending notifications, a list of recommended actions for the corresponding action or documents to the executors.

3 Results

The use of the stated research methods allowed formalizing the processes of interaction of different categories of users with the designed information system. Structural analysis of the waste utilization process has established that there are differences in its implementation depending on the type and size of the farm.

Small farms (including personal subsidiary farms) are characterized by waste disposal with an implicit periodicity, a small number of workers engaged in the work, and a reduction in the importance and requirements for the maintenance of reporting documentation. All this determines the development of functionality in the information system for one category of users. Fig. 1 shows the model of process implementation for such scenario.

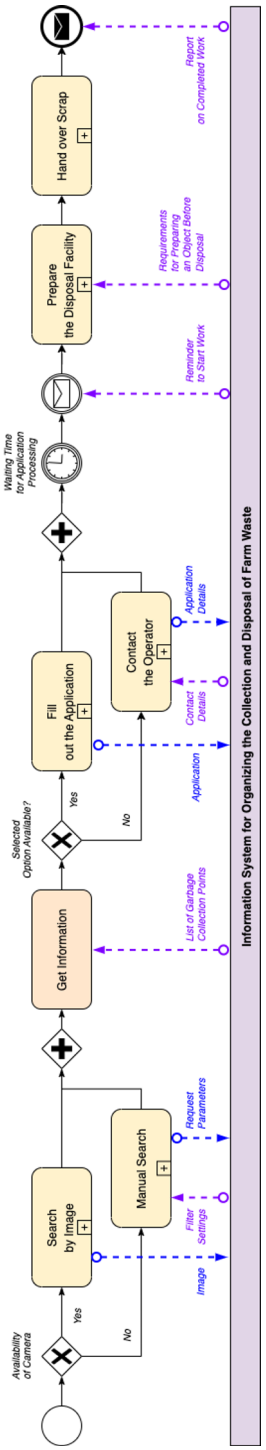

Fig. 1. BPMN-model of the process of using information system for waste management organization at small farms

Digital transformation of the waste management process consists in the farmer having access to digital resources that allow to automatically identify the type of waste and receive recommendations on how to engage contractors for its disposal. To use this function, an image of the waste is uploaded to the information system. Based on the received image, the system provides a list of organizations and locations of nearby collection points of such waste or contacts of organizations that carry out waste removal and delivery to these points. In case of absence of images, the system user should manually, by using filters and answering control questions, set search queries. As a result of processing such a query, a response will be received, which by its content corresponds to the result after image analysis.

Using the system, the farmer makes a request (or contacts the operator) and then receives information about the need to prepare the object for safe transportation. From that moment on, the system will notify the customer of the service about changes in the status of the request with a set periodicity.

For large farms or agro-industrial complexes, the waste utilization process is strictly regulated by the norms of regional and federal legislation, requiring reporting, as well as a large number of employees responsible for certain segments of the farm. The main task of the information system is to synchronize the actions of such employees, maintain coordinated documentation and comply with regulatory deadlines. Fig. 2 shows a fragment of the corresponding model for such processes.

The model fragment presented in Fig. 2 does not show the setting of access rights to the system, distribution of objects by sections (departments), operation terms and work with documentation after waste disposal. The digital transformation of the process does not have an impact on these actions, changing the nature of work performance.

"Employee" in this model is any specialist who, according to the job description, deals with facilities subject to disposal under certain conditions (waste from production activities, tools and machinery, etc.). Depending on the type of utilization object, the system automatically determines the time of their utilization (for example, waste from production activities is accumulated at certain intervals, tools and mechanisms have a service life). In this case, the system automatically requests confirmation of the relevant waste accumulation and generates a disposal request. If in the course of work unscheduled objects to be disposed of appear, the employee can independently issue a corresponding request. For this purpose, the system will provide information as prompts to enable quick and accurate generation of the requisition. In all of the above cases, all requests must be coordinated with the user who has the "Supervisor" role in the system.

The role "Supervisor" has the employee who is responsible for the organization and control of the economic part in the organization. Depending on the organizational structure such employee can be a site manager, safety engineer, etc. The manager automatically receives requests and must coordinate them. To do this, he should find a contractor who will perform the corresponding work. The mechanism of contractor search using the system functionality is similar to the realization of the same process in the model for a small farm. Once the request is agreed upon, the worker is notified of the date of the work by which he or she must prepare the object for safe transportation to the disposal site.

To unify documentation and reduce the number of routine operations, the system automatically generates documentation to support the disposal process (e.g., service contract, acceptance certificate for the disposal object, write-off certificate, etc.). At each stage after the conclusion of the contract, the system automatically informs about the next stage and adds documents on the completed work. Such documents can be further used to maintain internal documentation, prepare activity reports and export to other information systems of the organization or state monitoring systems.

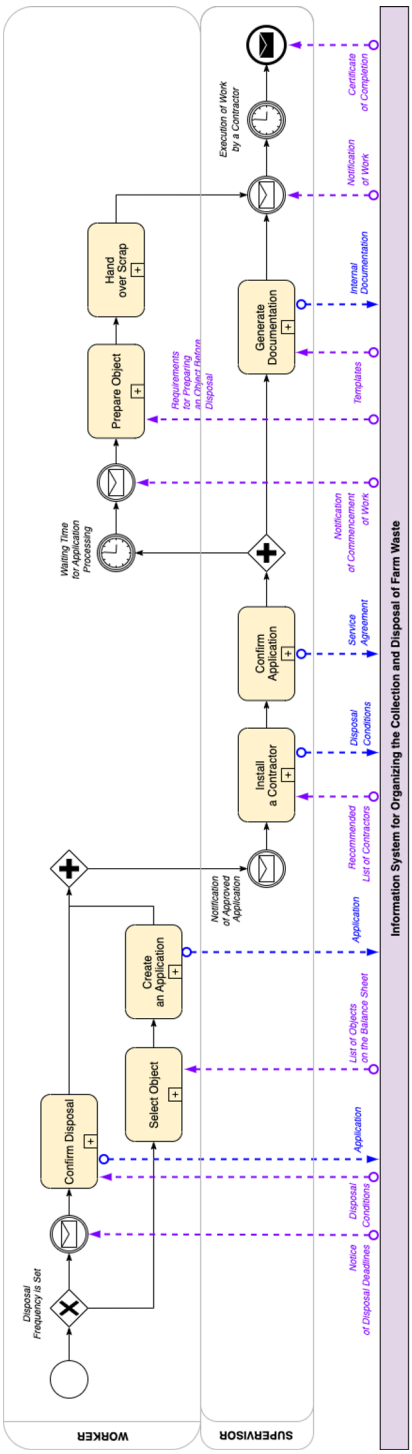

Fig. 2. BPMN-model of the process of using the information system of waste management organization for large farms and agrocomplexes

4 Discussion

The obtained results correspond to the results of studies related to modeling processes of complex systems [7, 8, 12, 13] and designing software products that provide digitalization of production and management processes [3, 5, 9, 11]. In the above studies, all the objects involved in the processes of the problem domain, the relations between them and the peculiarities of their interaction are established. All this was used by the authors of the developments as a basis for modeling and design of software products.

To create technical documentation to support and implement the above processes, researchers create formal models that reflect certain aspects of the problem domain (e.g., the structure of processed data, the system's response to external influences or changes in the characteristics of objects) [6, 10, 14]. The created models in the course of the current research allow to determine the categories of users of the software product under development, to establish the functional capabilities available to them and peculiarities of their realization. In addition, the created models allow us to evaluate the effectiveness of the process after its digital transformation, namely, to establish all its "bottlenecks". In works related to process modeling, "bottlenecks" are understood as an increase in the load on employees implementing a labor function, or unreasonably high use of software product resources when performing current tasks [2, 7].

5 Conclusions

The advantage of digital transformation of processes related to sustainable environmental development is the possibility to increase the availability of services for the disposal and recycling of any type of waste, to systematize and unify the activities of organizations for the collection and temporary storage of waste, to streamline the management of labor resources in the field of waste collection, sorting and recycling in farms and large agro-industrial complexes.

Creation of models of the relevant processes for their digital transformation allows to carry out operational management of resources, organize coordinated work of specialists of different levels, support and manage the content of reporting documentation in the implementation of individual tasks or processes.

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