

# Virtual Segments Formation of Administrative Apparatus of an Industrial Enterprise

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**Abstract**—The article contemplates with actual issues of structures virtualization of the administrative apparatus of an industrial enterprise in the conditions of digital transformation, which allows to create an optimal organizational chart and effectively implement modules of intelligent information systems and accumulation of knowledge in the corporate information system of the enterprise. A synthetic model of virtual segments implementation is being suggested, the levels of which are represented by a set of virtual enterprises, virtual workgroups and virtual working places as structural elements of virtual segments. For each model, based on the object-process approach and algorithms for analyzing large data sets, knowledge accumulation mechanisms are formed that allow updating fragments of the corporate knowledge base in an automatic mode and using the accumulated managerial experience for information support of decision-making at all levels of the administrative apparatus of an industrial enterprise.

**Keywords**—digital economy, industrial enterprise, virtual enterprise, information flows, logistical approach, knowledge accumulation.

## I. INTRODUCTION

Nowadays, one of the privileged directions of implementation of the mechanisms of the digital economy is the digital transformation of industrial enterprises. The priority tool for the digital economy development in the Russian Federation is "the transition to advanced digital, intelligent manufacturing technologies, robotic systems, new materials and construction concepts, the creation of systems for processing large data amounts, unsupervised machine learning and artificial intelligence" [1]. In order to achieve the targeted results, research in the development of highly intelligent digital platforms and technologies for the accumulation of large amounts of knowledge is becoming a priority. One of the directions of digital transformation of industrial enterprises is the optimization of the administrative apparatus through the introduction of virtual segments, which has been studied by domestic and foreign scientists for more than a decade. The introduction of virtual segments allows to restructure the administrative apparatus in the ideology of "resource saving organization", reducing the levels of management.

The urgency of the research problem is due to the fact that the introduction of virtual procedures in the administrative process in the future can lead to a radical restructuring of the entire administrative system of an industrial enterprise. It is obvious that the process of

implementing virtual segments in the administrative apparatus is impossible without a methodological framework based on the study of the experience of enterprise resource planning (ERP) implementation.

At this rate, the aim of the study is to improve the methodological framework for enterprise architecture development, containing virtual segments of the administrative apparatus. The object of the study is the administrative system of an industrial enterprise. The subject of the study is a set of business processes of an industrial enterprise implemented through a virtual environment of interaction in the global information space, the processes of information support for management decision-making in the conditions of enterprise digitalization.

## II. RESEARCH METHODOLOGY

The research methodology is based on the works of domestic scientists devoted to the problems of improving the administrative system of an industrial enterprise in the conditions of network translation of subject relations [2, 3, 4]. As a tool for improvement, the corporate information system is considered, expanded by modules of decision support systems, including the use of intelligent information technologies. Using selected tools, it is possible to introduce virtual segments into the enterprise administrative system that implement network forms of interaction in the global information space.

The basis of virtual segments design the concept of Internet-representation of the industrial enterprise is taken [5], which determines the number of categorical new units of administrative structure of an industrial enterprise, stated in conditions of economy digitalization and transference of economic agents interaction in a virtual environment. These include the concepts: virtual procedure, virtual working place, virtual enterprise, virtual working group. In the context of the study, the above virtual entities are considered as the main types of virtual segments of the administrative apparatus of an industrial enterprise. Use of virtual segments in an administrative apparatus, gives a number of significant competitive advantages, such as: automatic forming of a single economic and information space interaction of virtual units, in particular of virtual enterprises geographically distributed as economic agents; process optimization and sales of raw materials and finished products by greatly reducing the time of information exchange between plant administration and a network of partner companies, regardless of their distance barriers.

However, in common with the unconditional advantages obtained as a result of virtualization of administrative system segments, there are a number of open ended methodological issues related to the segmentation procedures of the administrative apparatus and the implementation processes of virtual segments, namely: the introduction of virtual segments, in fact, representing the design forms of the organization, is always associated with problems of adaptation of the existing astringent organizational structure, this is always associated with a variety of expenses and organizational risks; the existing enterprise information infrastructure is determined by the current architecture of the ERP, in most cases, the introduction of virtual segments requires its transformation.

At this rate, it may be said that there is a broad range of methodological problems, arising in the virtual segments implementation, for the solution of which it is necessary to explore existing approaches to the introduction of organizational units in the administrative structure of an industrial enterprise. The basic principle of any restructuring is always creating the value chain of the enterprise, the essence of which is that restructuring must ensure "the effective implementation by the entities of initial administrative functions to maximise the end results of industrial enterprise activity" [2]. Modern approaches to restructuring based on the enterprise architecture analysis, [6] which allow to draw up optimal chains of business processes with respect to modern information systems implemented in the administration process, including decision support systems based on intelligent information technologies. The approach described in [6] makes it possible to solve the problem of avoiding the inconsistencies in the modeling of complex multi-level enterprise architectures, including those typical for large industrial enterprises, in particular, as a tool for solving the problem, the use of the model checking principle for formal verification of models is proposed. In the research, this approach is used to segment the resulting enterprise architecture model; the resulting enterprise architecture segments are taken as the basis of the functional model of the virtual segment of the administrative apparatus, as a optimality test in this case, it is advisable to choose the classical approach, which is based on the principle of "forming a value chain creation in the enterprise" [6].

Presently, the forming approach of business process of administrative structures focused on all stages of the product life cycle (CALS-technologies), (Continuous Acquisition and Lifecycle support – continuous supply and information support of the product life cycle) is successfully used. The main competitive advantage of using this approach is the improvement of procedures for the information accumulation concerning the product, as there is an automatic aggregation and information structuring obtained at all stages of the product life cycle. This advantage is provided by the fact that the CALS approach involves the integration of all processes occurring during the product life cycle.

Furthermore, there is a continuous accumulation of large amounts of structured information, which is a resource for long-range processing as a result of using this approach. Nowadays, various DataMininng technologies focused on processing large amounts of data (BigDate) are being intensively developed. In works [7, 8] methods and algorithms of the BigDate class used for processing of the information received during the implementation of a production

technological cycle are presented. The practical implementation result of the algorithms presented in [7, 8] are knowledge-generating subsystems (DataMininng).

From the standpoint of the research subject, the fact of automatic accumulation of large amounts of structured information can be considered from the allocation at all stages of the production life cycle of automatic accumulation poles of knowledge, either of which can be implemented as an intelligent information system to support decision-making. The projection of these information systems into the virtual space is a segments chain of the administrative apparatus with information support for decision-making at all stages of the life cycle. Thus, the CALS approach allows you to clearly segment the structure relation to the specificities of administrative functions at each stage, which certainly contributes to the effective implementation of virtual segments for each group of specific administrative functions.

Separately, we would like to highlight the CRM approach that allows establishing direct marketing communications and building long-term relationships with customers [9]. In fact, the CRM approach, being quite new for Russian enterprises, is based on traditional approaches. In order to implement the CRM-concept of customer relationship management at the enterprise, it is necessary to cover such divisions as logistics, marketing, and, directly, production, in addition, such divisions as service and customer support is involved. The main advantage of the concept used is the fact that it is necessary to concentrate efforts not on increasing the transactions number and coverage of new market segments, but, by increasing the customer satisfaction degree, to stimulate an increase in the volume and regularity of sales focused on a particular client, which helps to reduce marketing costs.

In the textbook treatment, a centralized database of clients is created for the implementation of the CRM concept, while such requirements as platform and software compatibility with corporate information systems already existing in the enterprise are imposed on it. In the reseach, the CRM concept is being be incorporated by means of a distributed data processing system; the distribution is implemented in the virtual segments of the administrative apparatus.

For the processes analysis of subjective interaction in the virtual environment, the research also uses an approach based on the principle of building effective logistical chains [10], which forms the movement process of the main material flow of an industrial enterprise, in which partner enterprises and other economic agents are involved. At this rate, in the movement process of the main material flow, a chain of interactions between subjects is built, in the process of interaction, information is exchanged. Provided that, the logistical chain efficiency depends on the precision of information input, its processing, aggregation and transfer to the next entity will be organized. One of the most important characteristics of information in this aspect is its reliability, as this characteristic of information affects the quality of relationships with partners. In this fashion, while building a virtual projection of the logistical chain, it is necessary to build a clear information links system between partners with safe channels of information transmission, aggregation and verification systems.

On the research subject, virtual segmentation allows to create organizational units, the functioning of which is

provided for limited time (the period of sustainable route of material flow), when changing external conditions, such unit should be eliminated with minimal expenses and create a new one, adapted to the changes. The above requirements are ideally met when using the organizational form of the virtual enterprise as such units.

Improvement of enterprise administrative information systems through the introduction of intelligent decision support subsystems based on knowledge processing, initiates the problem of updating knowledge bases, as in modern conditions of intensification of virtual interaction of economic agents updating knowledge bases through experts is a high-cost and prohibitively time-consuming process. On the basis of object-oriented and process-oriented approaches to the problems of knowledge accumulation, presented in [11] and [12] in the research, scaled structures are formed that allow the addition and updating of knowledge bases in automatic mode.

### III. RESULTS

In order to form an effective administrative innovation tool based on virtualization, it was necessary to identify many new categories in the enterprise administrative system that arose in the development of modern corporate information systems: virtual procedure, virtual working place, virtual enterprise and virtual working group.

A virtual procedure can be defined as a business process (business processes chain) implemented in the interaction process of economic agents of wide area. Physically, the virtual procedure is implemented using screen forms and information processing modules that are part of the corporate information system, and computers connected to the global information network.

A virtual working place (VWP) is a set of business processes defined by the functional responsibilities of an employee. At the physical level, the VWP is implemented as a separate subsystem of the ERP, located on a wide area computer with the ability to access the global network via wireless connections (WiFi). Thus, the virtual working place consists of two parts – working place of the employee with special equipment and a network that supports enterprise information system infrastructure and provides a connection point for virtual working places according to their profile. Technically, the working place of an employee is a personal computer that meets the hardware requirements for

connecting to the corporate network, on which an information system is installed that implements the functional duties of the employee.

Due to the fact that the online collaboration involves the exchange of large amounts of information, as well as the availability of storage and knowledge accumulation (support poles of knowledge accumulation) to the corporate network are quite high technical requirements. The hardware of virtual segments must support distributed storage and information processing, because when connecting a virtual working place to an access point, the employee working in virtual mode must be provided with the following capabilities:

- to carry out mass data loading located on corporate network servers;
- being able to store the information generated in the virtual working place on the corporate network servers;
- to process and update databases hosted on corporate network servers;
- to carry out continuous information exchange both with the employees working on other virtual working places, and with the employees of the administrative apparatus, located in a corporate network.

Virtual working group (VWG) is an experts team, organized according to project principle, each of the specialists provided a virtual working space. VWP in the group are combined in a single network with host-centric connection to the global network (Intranet technology).

Virtual enterprise is an established term studied by domestic and foreign scientists. In the process of research, the basic definition of a virtual enterprise was reduced to the concept of an open business system as a set of temporarily combined resources of several entities in order to create a final product or service. With the development of Internet technologies, the concept of a virtual enterprise has been expanded by the introduction of a tool for interaction of geographically remote entities – some multifunctional Web-platform that allows users to store and process data in a single database. From this point of view, virtual enterprises can be considered as some associations of economic entities (possibly on temporary basis) in order to produce some final product.

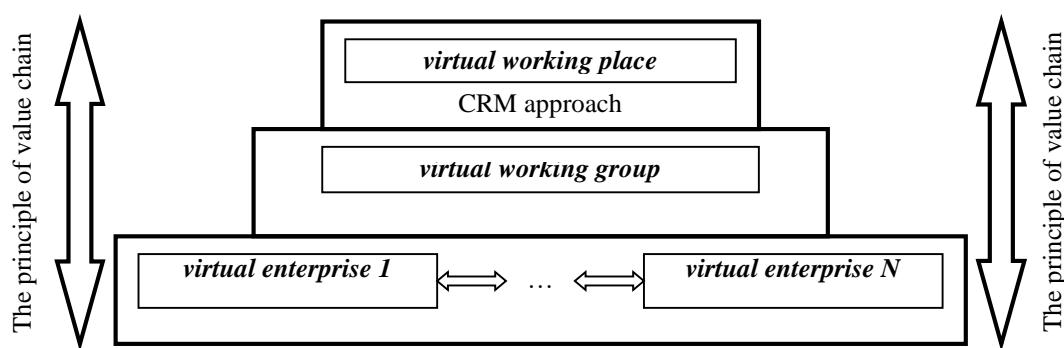


Fig. 1. Synthetic model of virtual segments implementation.

This incorporation is carried out on the basis of cooperation of joint use of technological resources. In this context, virtual enterprises are a business system that has acceleration capacity and adaptability to changes in external conditions. The key feature of such system is the ability to aggressively rebuild the cooperating communities structure of economic agents and create a unified technological and information environment without additional expenses.

The authors propose a synthetic model for the virtual segments implementation, which are a virtual working place, a virtual group and a virtual enterprise. The model is based on all the above approaches to the virtual segments formation (figure 1). In the presented model at the first (basic) level according to the principle of formation of effective logistic chains, there is a flexible network consisting of a set of virtual enterprises interacting with each other according to a stable route of material flow for the running period. At the second level, the work coordination of virtual enterprises is carried out by a virtual working group implementing a set of business processes through the use of CALS-technology; the level is represented by functional models of business processes implemented by a virtual working group. At the third level, a virtual working place of a decision-maker at the strategic level is organized, where an information system built according to the principles of CRM is located.

At the basic level, both virtual partner enterprises and separate technologically and organizationally separate divisions of the enterprise, derived in virtual segments, can be located. In fact, the units that can be geographically distant from the main material and technical complex of the enterprise are potential objects of virtualization (except for production units). Potential virtualization objects include: departments for administration interaction with suppliers and customers; units providing transportation and storage of raw materials and finished products, as well as units providing the infrastructure of the administrative system. This can significantly reduce operating expenses and public utility charges. As it was mentioned above, the virtual segment is a subject-oriented information system. Accordingly, at each level, information systems have an architecture determined not only by the problem-subject specifics, but also by the level of administrative decisions. In order to improve administrative processes at each level, a decision support system module based on knowledge processing and analysis can be integrated into the information system. At the same time, virtual segments allow users to accumulate knowledge automatically, without the participation of experts

In order to make primary structures of knowledge accumulation, the multiagent approach is used [13], allowing to consider virtual enterprises as agents, autonomous control system of either of which is the information system of the enterprise and the information infrastructure of their interaction can be deemed as a multiagent environment. The methodology of multiagent architecture of the interaction environment of regional enterprises presented in [14], based on the use of frame-production model of knowledge representation, was chosen as the basic one. In the research, the structures of knowledge accumulation are focused on the accumulation of factual and expert information characterizing the fulfilled administrative decisions. According to the specifics of the frame-production model, the accumulated part of knowledge is products constructed according to the classical cause-and-effect scheme "antecedent →

consequent". To generate products as elements of the knowledge base, a synergistic approach is used, according to which the information accumulated in the above structures is evaluated to identify "sustainable management strategies" and transformed into finished products, which are a full-fledged fragment of the knowledge base.

At the basic level, the mechanism of knowledge accumulation is implemented by mass data accumulation concerning material flow movement in the interaction process of virtual enterprises (agents). On the basis of algorithms for processing large data sets [7, 8], stable structures (tuples) are identified, the aggregation of which allows to form a structure containing knowledge concerning material flow movement. At the second level, functional business process models cover all stages of the product lifecycle. Data accumulation concerning the results of each stage of a certain virtual group in cooperation with a certain set of virtual enterprises of the basic level allows to accumulate composite knowledge structures that reflect the managerial experience of decision-making. At the third level, the data accumulation concerning the behavioral trajectories of clients allows the accumulation of knowledge structures used to make strategic decisions.

#### IV. CONCLUSIONS

All model levels are concordant within the framework of the approach focused on the creation of the value chain of the industrial enterprise. The proposed model allows developing and implementing virtual segments adapted to the existing organizational structure of the administrative apparatus and the architecture of corporate information systems. Conversely, virtual segments introduction helps to reduce administrative levels optimize business process models, significantly reduce the cost and maintenance of the enterprise administrative apparatus.

The mechanisms suggested of knowledge accumulation at each level of the model contribute to the transition of the administrative system to a new level of informatization, fully using the accumulated managerial experience accumulated in knowledge bases as an additional administrative resource.

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