Ontological-Oriented Technologies in the Management of Digital Production

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Abstract. The development of automation technologies, improvement of information processes create the need to change the traditional approaches to the management of enterprises' economies. The article presents the results of work on means of informatization and synthesis of digital transformation platforms. It is noted that information integration provides the operational management of production, which is especially important for the transition to fully automatic production, controlled at each stage of the product life cycle. The article presents ontological tools and applications for creating an intellectual environment of engineering interaction in managing the life cycle of products in the conditions of digital production. In solving the problem of life cycle management, an approach is presented that takes into account changes in the organizational structure and production factors that affect the efficiency of business processes. The use of such integrated solutions should provide intellectual support at all stages of the product life cycle, as well as for monitoring production processes and managing changes through the analysis of experimental data. Presented a decision on the use of ontologically oriented technologies for the interaction of local information systems and heterogeneous applications in the SAP ONTOLOGIC information environment.

1. Introduction

Scientific and technical progress in a market economy is actively provided by the directions of the new industrialization of enterprises [1].

They are united by the focus on the creation and modernization of industrial production systems, taking into account new economic conditions determined by the "digital economy".

Moreover, not only the production technologies themselves are updated, but also the principles and quality management systems that take into account not only technological shifts, but also the requirements of the external environment and infrastructure and changes in its qualitative institutional composition [2].

Digital economy and digital platforms create new opportunities for the development of industrial production as the basis for high-quality economic growth in virtually all industries and sectors of the economy [3].

Modern industrial enterprises usually have a cumbersome and complex information infrastructure, including data sources of various automated control systems (databases of different formats, spreadsheets, text files, etc.).

This situation complicates the sharing of data from various sources, reducing the efficiency and accuracy in preparing data for making management decisions at the enterprise level. The use of ontology

engineering methods in creating integrated environments involves decomposition into levels that in most cases have a hierarchical structure and interact with the resources that determine the functionality of the stages of the product life cycle [4].

When applying ontologically-oriented technologies to the development of integrated information systems supporting the product life cycle, it is proposed to use a systematic approach that takes into account the criteria values of indicators included in ontological blocks [5].

2. Issues of development of the digital economy and digital productions

Considering the evolutionary development of the economy, we can highlight the direction of new product development and the emergence of new industries. The result was a fundamental change in the enterprise as a production system.

In the course of the existing sixth wave, the question arises: what will become the core of the digital transformation. According to many authors, the integrator of breakthrough technologies will be information systems based on the digitalization of not only production, but also organizations as a whole [6]. This approach is ensured by the ideology of project activities and is the most progressive trend of the future economy [7]. Currently, experts agree that the core of the sixth order will be NBIC technologies (nanotechnologies, biotechnologies, computer technologies, genetic engineering, cognitive technologies).

Digital economy, according to the basic principles of the theory of systems, implies an obligatory process of improvement and transformation, aimed at qualitative changes and their reflection in models of digital transformation. At the same time, according to the new system methodology in economic theory, the functioning of the economy at any level - from the global world economy to the economy of an individual enterprise - is viewed from the perspective of creation, interaction, transformation and liquidation of economic systems [8].

Development, speaking as a necessary and continuous process of adapting the system to the requirements of the external environment, is the main condition for the survival of the enterprise in a competitive environment. In this regard, the modernization of the enterprise contributes to the emergence of qualitatively new, not existing before opportunities, including additional opportunities to ensure the organizational and economic sustainability of the enterprise as an economic and production system.

Currently, modernization as a theoretical concept is based on theoretical and methodological principles:

• cyclic development N.D. Kondratieff, G. Mensch;
• innovations by J. Schumpeter;
• technological dynamics and economic growth (K. Freeman, S.Yu. Glazyev, S. Kuznets, Yu.V. Yakovets), which are based on the idea of the content of the concept of modernization as a process of changing technological structures;
• evolutionary approach in economics (V.L. Makarov, I. Prigogine and I. Stengers, V.I. Mayevsky);
• institutional theory.

3. Analysis of concepts of modernization and setting goals for the transformation of an industrial enterprise

The company's goal is to increase production efficiency, which ensures profit by meeting the ever-increasing consumer demand. Therefore, the development of production processes aimed at meeting such demand is required, taking into account efficient technologies and equipment.

Modernization as a practical activity in the transformation of an industrial enterprise with due account of modern technological requirements is based on the experience of industrial revolutions in conjunction with information and communication technologies [9]:

● Industrie 4.0 [10] is the creation of digital enterprises based on the digitization of all enterprise systems (physical assets) and their integration into the digital ecosystem together with partners involved in the value chain;

• the new industrial revolution of K. Anderson's "makers" is the creation of mass customized production with the possibility of interactive exchange of ideas and developments based on the development of 3D design and 3D printing and the use of additive technologies.

The fourth industrial revolution defined the following:

a) the transition from simple digitization to innovation based on a combination of technologies;

b) information platforms that combine supply and demand and disrupt existing production structures;

c) new organizational forms and business models, for example, economic sharing and economy on demand.

The new (fifth) industrial revolution P. Marsh is a new industrialization of the economy in developed rich countries that will affect industry all over the world [11].

In addition, there are also concepts:

• Industrial Internet (Industrial Networks);
• Connected Enterprise (Integrated Enterprise);
• SMART Manufacturing (Smart Manufacturing);
• Smart Factory (Smart Factory);
• Manufacturing 4.0 (Production 4.0);
• Internet of Everything;
• Internet of Things for Manufacturing.

As a result, it is possible to identify and systematize the concepts of the life cycle of a complex technical system , which is associated with the display of changes in its states over a long period of time [12]. It provides for the integration of design, production and operation processes within a single metamodel and involves splitting the life cycle of products into stages (stages) with analyzing the interrelationships between individual life cycle processes [13].

4. Results and generalizations of the stages of the product life cycle from the standpoint of quality management

Product lifecycle management is a methodology for applying modern information technologies to improve the competitiveness of industrial enterprises, and the emphasis is on managing product data [14]. At the core of product lifecycle management is the concept of a single information space of an enterprise and an integrated data management model for digital production.

As a problem statement, it is necessary to consider the actual problems of product life cycle management, design and use of various life cycle models in digital production. As basic decisions, it is necessary to introduce into the composition of the product life cycle management system a subsystem of corporate knowledge management based on the ontological engineering methodology [15] and the model of coordinated management of the enterprise life cycles and its products. In this context, various approaches are used to provide a visual representation of information and knowledge: visual analytics and cognitive computer graphics, a graphical model of the links between technical requirements, components and product parameters, as well as intellectual analysis of visual data and visual presentation of ontological design methods [16].

The product life cycle (life cycle) is a set of interrelated processes of change in the state of the product during its creation and use.

The stage of the product life cycle is its conditionally allocated part, which is characterized by the specifics of the work performed at this stage and the final results. Thus, product quality assurance consists of quality assurance procedures at each stage of the product life cycle (LC).

Quality begins with research needs. This is the most important stage of the life cycle of any product or service. it is on it that the general idea is decided [17]. Errors at this stage are most critical, since if the needs are incorrectly determined, the goods will turn out that no one needs [18].

Business processes are formalized using previously constructed ontological blocks (OB). At the same time, business functions, action implementers, resources and objects (documents) used in the processes should already be defined in the OB. Such an approach to describing business processes

based on ontology also provides additional control over the enterprise's business environment; changing business processes requires a corresponding change in the ontology (for example, changing the ontology reflecting the organizational structure of the enterprise), and changing the subject area due to external or internal factors leads to adjusting business processes.

In general, an information environment is an agent platform that provides autonomous agents for individual operations (Oi) with the knowledge to perform certain actions (Aj). Agents based on control connections (Pk) interact with each other and make a logical conclusion to solve their business tasks.

On the basis of ontology and agent platform, the level of support for business processes and the level of their management in the form of a multi-agent business process management system (SMS) are formed.

A fragment of the graphical representation of the ontological unit for the task of placing an order is shown in figure 1. Operations are depicted by geometric rectangles whose end edge represents an image of logical operations: arc-logical "and", triangle-logical "or", polygon- "case ". The process of describing business processes is a key step in the construction of SMS, since a prototype of a multi-agent system is created on the basis of a formal description of business processes. In order for the description to meet the needs of a system building solution, it is necessary that the elements — actions additionally indicate the performer of the action for operation Oi and the ontological objects in which the action is performed.

The rules and goals, reflecting the logical interrelationship of the concepts of a specific ontology, are written down by the developer in the form of rules and goals; syntactic constructions and predicates are used for this. Knowledge "a priori", that is, knowledge that is already known at the time of the creation of a specific ontology, is recorded in the form of facts. The accumulated knowledge (experience) is only regulated by the developer in the form of dynamic predicates of the data on which the database is built. It is accumulated facts that play a decisive role in logical inference.
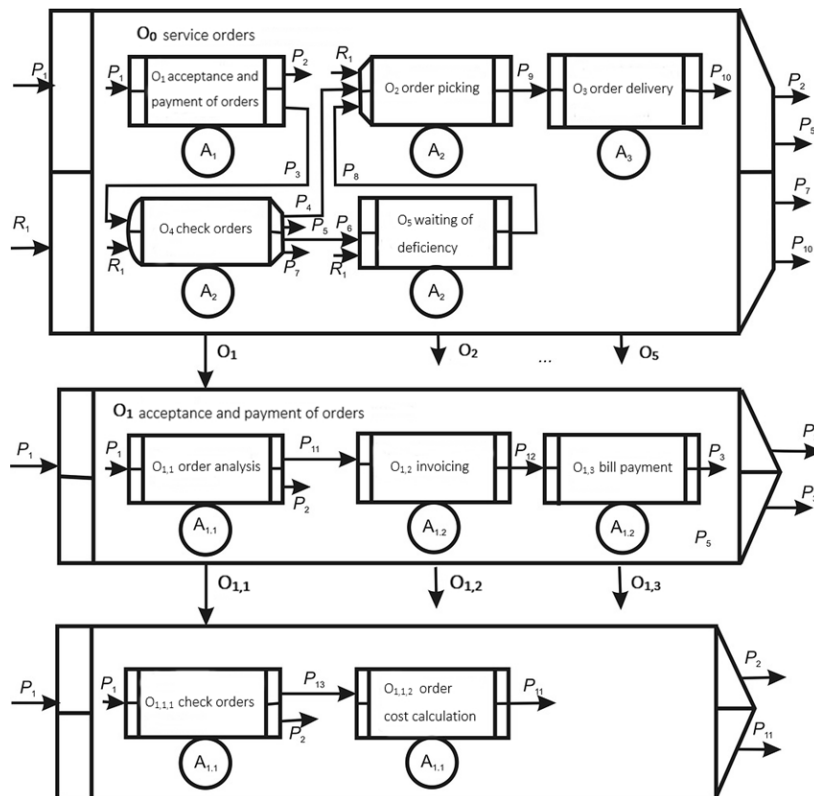

Figure 1. The ontological scenario of the production process.

In quality management, there is a ten-fold cost rule. The cost of the correction of marriage in the transition from one stage of the life cycle to another increases tenfold. The continuity of the life cycle stages prompted the quality problem model to the quality assurance model in the form of a continuous chain (circle), the components of which are the individual stages of the life cycle. As a result of the research, 12 stages of life management are proposed.

1. At the stage of marketing research, systematic work is carried out on the study of markets and customer requirements for the company's products; operating conditions and product consumption; capabilities of material resource suppliers in terms of quality and supply discipline; competitor studies.

2. At the stage of drawing up technical requirements and technical specifications, consumer requirements identified by the results of marketing are transformed into technical requirements.

3. At the design and product development stage, a draft and working draft is created. The result of the design are technical documentation (design and technological documentation) and a prototype. Preparation and development of production processes. The combination of all the actions of people and implements carried out at the enterprise for the manufacture of specific types of products is called the production process.

4. In the procurement process (logistics), the organization evaluates and selects suppliers based on their ability to supply products in accordance with the requirements of the organization.

5. Production quality is ensured by the following activities:

• Planning of manufacturing operations, documented in detail in the work instructions.

• Technical control of production processes.

• Creating conditions that exclude the possibility of damage.

• Materials, semi-finished products and products during production (appropriate storage, protection and movement).

• Verification, calibration and testing of equipment, tools and accessories.

When providing a material service, the technological process of execution (preparation of a dish, dry-cleaning of a product, preparation of goods for sale) is carried out in accordance with technological regulations.

6. Product verification includes monitoring, measurement and testing (if necessary) carried out at all stages of the LC. The final stage of verification is acceptance control, the results of which should confirm the conformity of the finished product with the established requirements.

7. Packing and storage should contribute to the preservation of quality in the areas of production and handling (part of the life cycle from the shipment by the manufacturer to receipt by a specific consumer), during loading and unloading, transportation,

8. Storage in warehouses.

9. Distribution and sale consist in the purchase of goods by wholesale organizations with the aim of selling goods to stores and selling goods to retail customers. At this stage, the personnel of the organization of the service industry becomes the subject of quality management. At the same time, the provision of the service continues, in particular, customer service is provided. The main task of service providers is to ensure the quality of service and high service culture.

10. At the stage of operation (use and consumption), a consumer of products is connected to the management. On how well he will use (exploit) products, in particular, will depend on its service life.

11. Maintenance and after-sales activities - technical assistance in maintenance (installation, assembly, personnel training), preventive and warranty repairs, supply of components.

12. At the disposal stage, it is necessary to prevent the harmful effects of the used products on the environment.

The recycling phase does not end the activity of the organization. By this date, and practically even earlier, the organization begins to study the estimated needs, clarify current needs and, after marketing, starts designing new products[19].

This is how a new phase of quality activity arises - from the marketing stage to the recycling stage, forming the "Quality loop".

The following life cycle stages can be used for services:

- providing information on services offered to the consumer;
- order acceptance;
- execution of the order;
- quality control of order execution;
- the issuance of the order to the consumer.

The Deming model (PDCA cycle) describes the quality management activities implemented at each stage of the PLC (quality loop). It identifies four areas of activity through which the quality system influences the process of forming the quality of products and services.

PDCA is an abbreviation of the words: plan, do, check, action. The PDCA cycle consists of consecutive phases:

- Plan (setting goals and objectives, determining ways to achieve goals).
- Doing (education and training, work on a limited scale or conducting an experiment).
- Check (definition and evaluation of the results of the work performed).
- Actions (implementation of changes on a large scale in case of a successful experiment).

If all employees of the organization consistently apply the PDCA cycle and do not forget that it is never interrupted, improvement will become an integral part of their work. The organization will learn to better understand itself and be prepared for that. To respond to new customer wishes.

5. The results of the implementation of ontologically-oriented technologies in the management of digital production

In the conditions of digital transformation, economics and enterprise management should focus on finding compatible solutions, approaches and concepts, based on a common declarative presentation of directions and information and communication technologies. Such technologies are the technologies of "ontology engineering" [20].

Digitalization and active use of cloud technologies in modern production, the formation of customer access systems at all stages of production and production makes it necessary to integrate the enterprise into an active information environment in which there are other enterprises that interact with each other in the supplier-buyer system, "Customer-performer" or are competitors.

The concept Industry 4.0 in this regard involves the integration of vertical and horizontal value chains. Namely, the production contour is the integration of vertical processes throughout the organization (from product design and material supply of components to the production process itself, including logistics and maintenance).

Commercial contour — horizontal integration goes beyond internal operations and covers suppliers, consumers, and all key partners in the value chain, and is achieved through the use of real-time intelligent monitoring and control devices[21]. Creating an ontologically-oriented information support provides a comprehensive platform solution in which data on operational processes, process efficiency, quality management and operational planning, optimized for various platforms, are available in real time in an integrated network. In this case, solutions can be worked out using block (modular) technologies. Thus, an interaction platform between information carriers with specific protocols for such interactions can be created through ontological blocks (OB).

SGML terminology (ISO 8879) is used to describe the requirements for the product structure. In accordance with the requirements of ISO 8879, the database structure is described by a declaration (update) of a set of information objects, their attributes, relationships, and hierarchy[19]. The set of these declarations in terms of SGML is a description of the logical structure of the document - DTD (Document Type Definition). The database of any OB block is a set of data whose logical structure corresponds to a certain DTD.

In order to unify data formats, the way they are presented in the OB is defined by ISO 8879 (representation of textual information). ISO 10744 (multimedia information presentation).

To describe the subject areas of the production structure of a system, the main ontology agent has the following formal description: ONT_LC = (Oob, lm (R), Fob) where Oob is the set of concepts of the subject domain defined by ontological blocks,; - a lot of fuzzy (weighted) relations between onto-

logical blocks; Fob - a description of the ontology "process" process (interaction of ontological blocks).

The architecture of the module-ontological solutions (OB-block) consists of the following key elements (fig.2):

- A set of scripts and sample libraries of basic data (ONTOLOGIC)
- Data exchange infrastructure with applications (SAP NetWeaver XI)
- Access portal (SAP NetWeaver Portal)
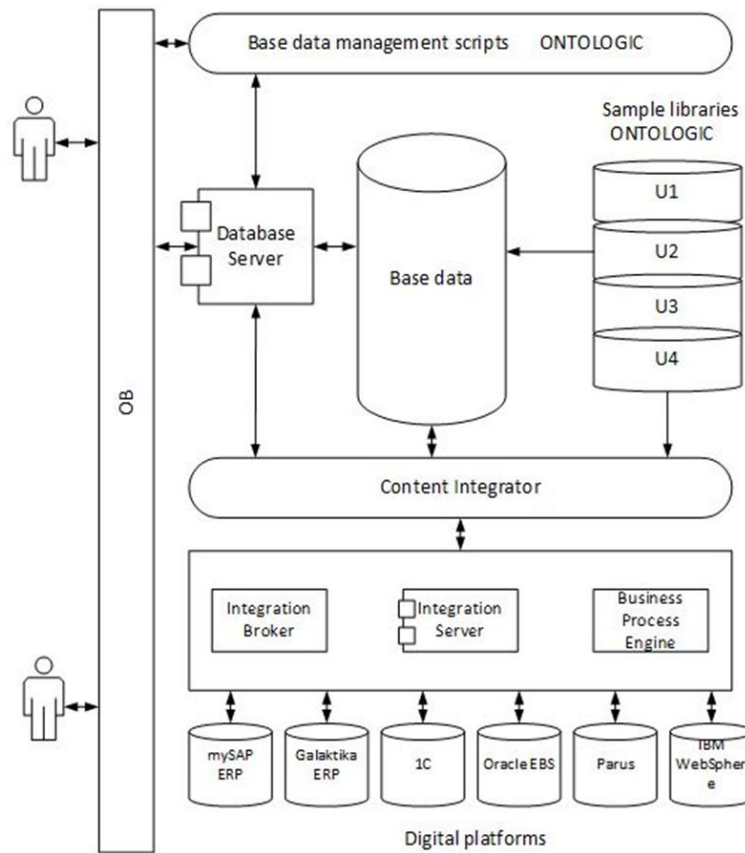- Data base server (SAP Master Data Server)
- Content integrator

Figure 2. Architecture of the ontological unit.

6. Conclusion

Due to the introduction of ontology and their formalization in an SMS based on knowledge, it is also possible to realize the level of integration of enterprises into a complex of integrated distributed systems business process management.

Wherein organizations will use the same basic ontology for interaction. Ontologies define a kind of protocol for the integration of information systems, and offer a "common language" for communication between various organizations. Such integration can be realized thanks to the information support of external business processes of enterprises.

The process of describing external business processes is a key step in building an SMS, since, based on a formal description of business processes, a prototype multi-agent system is built.

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