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MODELING THE INFORMATION AND ANALYTICAL ENVIRONMENT FOR MANAGING ENTERPRISE BUSINESS PROCESSES

МОДЕЛЮВАННЯ ІНФОРМАЦІЙНО-АНАЛІТИЧНОГО СЕРЕДОВИЩА ДЛЯ УПРАВЛІННЯ БІЗНЕС-ПРОЦЕСАМИ ПІДПРИЄМСТВА

Summary. This article presents a conceptual model of an information-analytical environment aimed at enhancing the management of business processes within an enterprise. The research examines current approaches to business process management and information support, identifying their limitations in terms of integration, adaptability, and analytical capabilities. Based on this analysis, key requirements for an effective environment are defined, including data consolidation, analytical functionality, user interaction, and system security. The proposed methodology incorporates modern modeling tools such as BPMN, UML, and Data Flow diagrams to ensure structural clarity and scalability. A conditional case study illustrates the implementation of the model in a production-oriented enterprise, emphasizing improvements in process transparency, decision-making quality, and operational responsiveness. The article outlines the benefits of the approach compared to traditional systems and highlights directions for future development, including the use of intelligent technologies and adaptive system components.

Keywords: business process management, information-analytical environment, enterprise modeling, BPMN, UML, decision support systems, data integration, digital transformation, process optimization, adaptive systems.

Анотація. У статті представлено концептуальну модель інформаційно-аналітичного середовища, призначену для підвищення ефективності управління бізнес-процесами підприємства в умовах цифрової трансформації. Актуальність тематики зумовлена зростаючою потребою в адаптивних і комплексних управлінських рішеннях, здатних об'єднувати дані з різних джерел, забезпечувати аналітичну підтримку в режимі реального часу та сприяти прийняттю обґрунтованих рішень у динамічному бізнес-середовищі. Дослідження ґрунтується на аналізі сучасних підходів до управління бізнес-процесами та інформаційного забезпечення на підприємствах різних галузей, зокрема виявлено обмеження традиційних ERP-систем, недостатню інтегрованість IT-інфраструктури, фрагментарність обробки даних та низький рівень гнучкості при зміні зовнішніх умов. Модель, що пропонується, охоплює структурно-функціональні компоненти, зокрема підсистему збору, зберігання та обробки даних, аналітичний блок із вбудованими інструментами бізнес-аналітики, модуль користувацького інтерфейсу з можливістю персоналізації доступу, а також засоби забезпечення інформаційної безпеки. Взаємозв'язки між компонентами базуються на принципах модульності, масштабованості та сумісності з наявними корпоративними платформами. У статті подано методику побудови моделі із використанням сучасних засобів моделювання – BPMN для опису бізнес-процесів, UML для структурування взаємодій між компонентами системи, а також Data Flow Diagram для опису потоків інформації. Умовний кейс впровадження моделі на підприємстві харчової промисловості демонструє практичну реалізацію окремих компонентів моделі та позитивні зміни, що супроводжували її застосування. Зокрема, спостерігалося підвищення узгодженості між підрозділами, зниження часових витрат на виконання стандартних операцій, покращення оперативного контролю за ключовими показниками діяльності, а також підвищення точності аналітичних прогнозів. Запропонований підхід порівнюється з традиційними рішеннями, в яких переважає ізольоване функціонування систем без комплексної інтеграції. У висновках обґрунтовано універсальність моделі, її здатність до масштабування, адаптації та подальшого вдосконалення. Серед перспектив розвитку визначено використання інтелектуальних алгоритмів, засобів обробки неструктурованих даних, хмарних технологій, а також впровадження механізмів самонавчання для підвищення ефективності управлінських рішень і стійкості підприємства в умовах змінного середовища.

Ключові слова: управління бізнес-процесами, інформаційно-аналітичне середовище, моделювання підприємств, BPMN, UML, системи підтримки прийняття рішень, інтеграція даних, цифрова трансформація, оптимізація процесів, адаптивні системи.

Statement of the problem. Modern enterprises operate in a dynamic external environment, facing high competition and constant changes in market, technological, and regulatory conditions. In such conditions, effective business process management becomes a critical factor in ensuring stable development, competitiveness, and adaptability of the enterprise. One of the key tools for supporting management decisions is an information and analytical environment that allows you to quickly obtain, process, analyze, and visualize data on internal and external processes.

Despite the widespread implementation of information systems, most enterprises face problems

of information fragmentation, insufficient integration of data sources, limited analytical support for decision-making, and low flexibility in changing business processes. This necessitates the creation of a comprehensive model of an information and analytical environment that not only reflects the real business processes of the enterprise, but also ensures their effective management, optimization, and adaptation to changes.

Analysis of the latest research and publications. Modern scientific discourse is increasingly focusing on the problems of modeling business processes and creating information and analytical environments that can support flexible management of enterprises in the context of digital transformation. One of the basic approaches to modeling business processes is to use the BPMN notation, which provides a unified visualization of processes and supports their automated implementation. This approach is actively used to manage the dynamic capabilities of organizations, in particular in the context of digital entrepreneurship, as studied by Gunaris A. [1].

In parallel with the development of modeling tools, considerable attention is paid to business intelligence and information platforms that facilitate management decision-making. In particular, Stefanovich N. and Stefanovich D. [2] considered the possibilities of business intelligence in supply chains, emphasizing the role of integrated information systems in supporting operational and strategic tasks.

Of particular relevance is the problem of semantic compatibility when integrating different data sources. In this context, the research of Buchers Z., Lange K., and Beyan O. [3] demonstrates the prospects of using machine learning to ensure semantic interoperability in digital data spaces.

In turn, Gürcan F., Ayaz A., Menekshe Dalveren G.G. and Deravi M. [4] conducted an in-depth analysis of business intelligence strategies, trends and best practices based on machine learning and analysis of scientometric data over a twenty-year period.

At the domestic level, the relevant aspects of business process modeling in the context of improving the efficiency of enterprises are considered by Krutikov O. and Derzhypilskyi Y. [5], who emphasize the need to unify and standardize processes within the enterprise.

The research of Satyr L., Zadorozhna R., Novikova V. and Vasylenko O. [6] highlights the problems of processing large amounts of data (exabyte level) and integrating this data into business process models, focusing on visualization as a key element of the information systems interface.

From a technical point of view, the approach to the architecture of cloud environments presented by Mangler J. and Rinderle-Ma S. [7] is also important, as they proposed an architecture of a cloud process execution engine focused on the compatibility and scalability of system components.

In the context of industry specifics, Shkrabak I., Latysheva O., and Shevchenko N. [8] analyzed the management of material resources in mining and metallurgical companies on the basis of Performance Management, which demonstrates the potential of integrating information models into complex production processes.

The purpose of the article is to develop a conceptual approach to modeling an information and analytical environment for managing enterprise business processes, which ensures data integration, supports management decision-making, and improves the efficiency of organizational activities. In particular, the article aims to justify the structural and functional components of such an environment, define the requirements for its construction, and explore the possibilities of its application for adaptive business process management in the context of changes in the external and internal environment.

Presentation of the main research material. In today's environment of digital transformation, there is a growing need for a comprehensive approach to business process management that encompasses not only model building but also effective information and analytical support at all levels of decision-making. Due to the increasing complexity of organizational structures, the dynamism of the external environment, and the need for rapid adaptation to change, information technologies must ensure both transparency and flexibility of management processes. In this context, there is a need to analyze modern approaches to business process modeling and evaluate the effectiveness of existing information and analytical systems.

Among the leading methodologies for modeling business processes, the most widespread approach is based on the use of BPMN (Business Process Model and Notation), which is an international standard supported by the Object Management Group consortium. Its advantage is a unified graphical representation of processes that is understandable to both business users and technical specialists. Thanks to the support of automatic execution mechanisms, BPMN provides a direct link between the model and the software implementation of business logic. In addition, this notation is actively used in managing the dynamic capabilities of organizations, particularly in digital entrepreneurship and adaptive management systems [1]. Along with BPMN, other approaches are also used: UML activity diagrams, EPC models, declarative modeling, case management, etc., but their application is usually local and less standardized.

Information and analytical systems that support business process management occupy a key place in the structure of a modern enterprise. Business intelligence (BI) systems, enterprise information

systems (EIS), and business process management platforms (BPMS) enable the processing of large volumes of both structured and unstructured data, support the functioning of integrated workflows, and facilitate informed decision-making based on operational information. They allow the enterprise not only to assess the state of internal processes in real time, but also to predict development trends based on analytical indicators and key performance indicators [2]. However, despite the availability of modern information platforms, a significant number of companies face a number of systemic problems that significantly reduce the effectiveness of management decisions.

Among the main shortcomings inherent in modern approaches, it is worth highlighting the fragmentation of data and models stored in a large number of unrelated repositories. This complicates navigation, causes duplication of processes, and makes centralized management impossible. An additional problem is the lack of a unified semantic space, as a result of which processes that perform the same functions are described using different terms or forms, which significantly complicates their integration and analysis [3]. Technical incompatibility of information systems is also often observed, caused by the use of different standards, protocols, or data exchange formats, which leads to loss or distortion of information. A significant portion of solutions do not provide for the adaptability of models to changes in the external environment, which limits their suitability in dynamic conditions. The analytical component also remains underdeveloped: most BI systems are not capable of fully processing unstructured data, which constitutes a significant part of the enterprise's information space [4].

Table 1 presents a generalized comparison of the main types of models and information and analytical tools used in business process management, indicating their characteristics and limitations.

In light of these shortcomings, the development of requirements for a new generation of information and analytical environments must ensure integrated business process management that takes into account current challenges.

Such an environment should take into account the specifics of data sources and their semantics and maintain full compatibility with existing corporate systems. From a technical point of view, it is necessary to ensure an open architecture with support for interoperability standards such as BPMN 2.0, BPEL, XML, and REST API [7]. This will allow you to effectively combine different system components into a single information ecosystem. Support for scalability, modularity, and adaptability to change is critical, allowing you to quickly update business models without losing system integrity or performance.

Developing a conceptual model of an information and analytical environment for business process management requires a systematic approach that includes defining structural components, their interrelationships, reflecting the logic of the enterprise's functioning, and aligning with existing business models [8]. The model should not only illustrate the internal architecture of the environment, but also ensure its flexible updating in accordance with changes in operating conditions.

The key components of the conceptual model are structural blocks responsible for data storage, processing, and interpretation, business process logic management, user interaction, and information security.

The data component covers sources of structured and unstructured information, including corporate databases, external flows, transactional systems, as well as contextual data from social networks or IoT devices.

The analytics unit provides data processing based on business analytics algorithms, predictive modeling, machine learning, and visualization of key performance indicators.

The interface part of the model should ensure accessibility, personalization, and interactivity of user interaction, taking into account roles, access rights,

Table 1 – Key characteristics and limitations of current approaches to business process modeling and analytics

Means / model	Key features	Typical restrictions
BPMN 2.0	Standardized modeling, compatibility with BPMS, automated execution	Lack of semantic integration, duplication of processes
UML, EPC, declarative models	Local use, adaptation to industry specifics	Weak tool support, low unification
BI systems	Operational analytics, KPIs, dashboards, big data support	Insufficient work with unstructured data, limited semantic core
EIS, BPMS	Comprehensive integration, automation, flexible management	High complexity of implementation, incompatibility between platforms
Process repositories	Centralized storage, reuse of models	Mass duplication, unclear classification, lack of ontologies

Source: [5; 6]

and task specifics. The security component covers authentication, encryption, auditing, and access control mechanisms aimed at protecting critical information resources.

The relationships between these elements must be clearly defined at both the logical and informational levels. In particular, analytical modeling processes must be directly integrated with data sources, and the interface must reflect the status of business processes in real time with the possibility of rapid intervention. The system must support an event-driven architecture that allows it to respond to changes in the external or internal environment by automatically adapting the model components.

The model should also implement the logic for managing main and auxiliary processes, taking into account hierarchy, roles, execution scenarios, alternative development branches, and decision points. Processes are represented as data flows and events linked by conditional operators, gateways, cycles, and subprocess calls. It is important that such representation is unified, scalable, and easily transformable in case of changes in the business architecture.

Building a conceptual model requires a clearly defined methodology that involves a sequential execution of stages from analyzing the needs of the enterprise to formalizing and testing the model. First, the subject area is analyzed, and user requirements are collected and classified. Next, the logical structure of the environment is formed, taking into account the organizational model of the enterprise and its digital assets. This is followed by the modeling of data, business processes, and analytical flows using tools for describing structures and interactions, such as BPMN, UML, or DFD. The next steps include verifying the integrity of the model, simulating operating scenarios, and coordinating with the technical architecture of the platform being implemented.

Dynamism and adaptability within the modeling methodology involves the inclusion of mechanisms for automatic updating of process templates, the ability to reuse model fragments, and support for "what-if" scenarios to adapt to external changes. Such functions are especially important in an unpredictable market environment, where the speed of response to changes is a critical factor in competitiveness.

A summary of the key aspects of the conceptual model is presented in Table 2.

The conceptual model of the information and analytical environment is not only a technical description of the functioning of individual modules, but also a tool for strategic management of the enterprise, which ensures its flexibility, stability, and efficiency in a dynamic environment.

A hypothetical case of implementing a conceptual model of an information and analytical environment can be considered using the example of a medium-sized manufacturing enterprise in the food industry that specializes in the production and distribution of semi-finished products. The enterprise has complex logistics, several production workshops, an extensive network of suppliers, and a significant number of contractors, which makes the management of its business processes dependent on the quality and speed of information processing. Prior to the implementation of the model, the organization used traditional accounting systems without centralized process management and without full analytical support.

During the implementation of the conceptual model, an integrated data collection and storage component was first introduced, which combined disparate sources: production reports, CRM, financial tables, document flow, and external channels (in particular, orders from dealers and marketing analytics). This made it possible to create a unified data warehouse with a coordinated structure, which became the basis for further processes. As part of the analytical component, BI analytics modules were implemented with a focus on monitoring key operational indicators, analyzing seasonal demand, forecasting warehouse balances, and controlling supply efficiency. The interface part of the environment was adapted to three key roles: operations manager, financial analyst, and department head. This provided

Table 2 – Components of the conceptual model of the information and analytical environment

Component	Functional purpose	Features of implementation and interaction
Data	Collection, storage, integration of structured and unstructured data	Connection to internal databases, external APIs, IoT
Analytics	Data processing, modeling, forecasting, KPI formation	Use of ML, OLAP, BI dashboards
Interface	Information visualization, user interaction	Web access, role adaptation, interactivity
Safety	Data protection, access control, audit	Authentication, encryption, logging, access policies
Business processes	Formalization of the logic of enterprise functioning	BPMN scenarios, event logic, automation via BPMS
Adaptability	Supporting changes in the structure, behavior, and functions of the environment	Dynamic model updates, response to external events

Source: compiled by the author

personalized access to the information needed for decision-making. Digital security elements were also implemented: multi-level authentication, data transmission encryption protocols, and a user action logging system.

An assessment of changes in business process management, conducted several months after the system was launched, showed a significant reduction in order processing time, a decrease in logistics planning costs, and an improvement in procurement forecast accuracy. In addition, there was an increase in transparency between departments and a reduction in the number of errors in internal document flow. The company's management gained the ability to quickly monitor the effectiveness of key stages of business processes, which had previously been difficult due to the fragmentation of information flows.

Compared to traditional approaches, which were mainly based on disparate accounting or ERP systems without in-depth analytical support, the proposed model provides comprehensive integration and unification of business processes. The modular structure of the model facilitates its scaling to other departments or subsidiaries without significant changes in architecture. The adaptability of the system facilitates a quick response to changes in the market environment and flexible configuration of processes in accordance with new requirements.

Prospects for further development of the model are related to the introduction of intelligent agents for decision automation, expansion of unstructured data processing capabilities, and integration with cloud services to increase flexibility. In addition, an important direction is the formalization of business process ontology to improve interaction between different systems and create self-learning mechanisms, which will improve the quality of forecasting and adaptation to atypical scenarios.

Thus, the application of a conceptual model of the information and analytical environment has contributed to the optimization of business process management and laid the foundation for the further digital transformation of the enterprise in changing market conditions.

Conclusions. The development and implementation of a conceptual model of an information and analytical environment for managing business processes is an important step in improving the efficiency and adaptability of modern organizations. The proposed model provides comprehensive integration of diverse information resources, analytical tools, and security mechanisms, allowing for a holistic view of the current state and dynamics of business processes. Analysis of the model's implementation in a manufacturing enterprise demonstrates its ability to significantly optimize operational processes, improve the quality of management decisions, and ensure a flexible response to changes in the external environment.

Importantly, the conceptual model supports it as a universal tool for digital transformation. Prospects for development are linked to the introduction of intelligent technologies, the expansion of functionality for working with unstructured data, and the improvement of business process modeling methods. In general, further research and practical implementation will contribute to the formation of more sophisticated and adaptive information and analytical systems that will ensure the stability and competitiveness of enterprises in modern conditions.

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