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Architectural and methodological approaches to the design of corporate and web-oriented information systems with elements of intelligent data analysis

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Abstract. The relevance of the study is due to the digital transformation and the need to improve architectural and methodological approaches to the design of intelligent corporate and web-oriented information systems. The purpose of the study was to form a conceptual approach to the design of information systems using intelligent data analysis tools. The study was based on the theoretical analysis of scientific materials and the application of systemic, conceptual, project-oriented, domain-oriented and data-driven methodological approaches to substantiate the principles of designing adaptive information systems. The results obtained demonstrated the transition of modern information systems to multi-level modular and data-centric architectures that combine functional flexibility, scalability and intelligent analytical data processing. The integration of artificial intelligence algorithms provides the implementation of predictive analytics, information classification and detection of anomalies in the system's behaviour. The effectiveness of the platforms is assessed through a complex of time, resource and analytical metrics, in particular latency, throughput, central processing unit utilisation, memory consumption, error rate, mean absolute error, root mean squared error, mean absolute percentage error, precision, and recall. It is shown that the reliability of information systems is ensured by the use of fault-tolerant architectures, service component redundancy and self-tuning computing environments. The generalisation of the results confirmed the prospects for the development of adaptive cognitive-oriented data-centric information platforms of the new generation. The results can be used by scientists, developers, and software architects and organisations involved in the digital transformation of information systems in the design, optimisation and implementation of adaptive analytically oriented digital platforms

Keywords: machine learning; big data; data-driven; scalability; adaptive information platforms; domain-oriented design

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INTRODUCTION

The relevance of the study is determined by the intensive digital transformation of society and the business environment, which necessitates the creation of more complex and functionally rich information systems. The growth of structured and unstructured data requires a transition from traditional transactional platforms to intelligent digital environments capable of providing automated analytical processing of information and decision-making support. In these conditions, the development of coordinated architectural and methodological approaches to the design of corporate and web-oriented information systems is used.

In the scientific discourse, information systems research is increasingly focused on issues of architectural optimisation of digital platforms and the integration of intelligent data processing methods into applied information environments. In the work of H. Khudov *et al.* (2025), an analysis of architectural models of information technologies for image processing in complex technical systems was carried out, where it was shown that the efficiency of the functioning of the information platform is determined by the structural organisation of data processing channels and the choice of algorithmic procedures for transforming information flows. The authors proved that multi-level data representation provides increased accuracy of signal processing and improves the stability of monitoring systems. In the study of V. Obukhov & V. Tovbych (2025), the emphasis is placed on the application of intelligent technologies in the processes of architectural design of information systems. The authors emphasised that the use of algorithmic methods of design support makes it possible to formalise the adoption of architectural decisions and reduce the subjectivity of engineering analysis. The results obtained showed that the integration of artificial intelligence methods into design processes contributes to increasing the adaptability of architectural models and optimising the structural complexity of software platforms.

Another perspective is revealed by J. Luo *et al.* (2022), who studied the application of data warehouse technologies and methods of intelligent information analysis in corporate information systems. The authors showed that the combination of the concepts of data warehouse and data mining provides effective support for analytical processing of large volumes of information, in particular in the tasks of business process management and forecasting system behaviour. The authors emphasised that the use of structured analytical environments increases the efficiency of decision-making and contributes to the formation of integrated digital platforms. The work of T. Rak & R. Żyła (2022) demonstrated the possibilities of using data mining to detect hidden dependencies in the output streams of web systems. The authors showed that the use of analytical procedures allows identifying structural and behavioural patterns of the functioning of the information environment, which is important for the tasks of optimising the processing of user requests and improving the quality-of-service interaction. The issue of architectural analysis of corporate information systems based on an application programming interface (API) gateway logs is considered in the study of C.R. Pinheiro *et al.* (2024). The authors proposed the use of a lightweight ontological model for interpreting architectural patterns of service interaction, which provides the possibility of formalised analysis of the structure of the corporate platform and monitoring its functional behaviour. The results obtained demonstrated the promising nature of combining semantic modelling and telemetric analysis of system events.

Another area of research is presented in the work of M. Muslih *et al.* (2024), where a web-based information system for assessing professional suitability of users was developed using the architectural principles of the Enterprise Architecture Framework. The authors proved that the use of structured methodological approaches to the design of digital platforms contributes to increasing the coherence of business processes, technological infrastructure and analytical services of the information system. The work of J. Vinueza-Martinez *et al.* (2024) investigated modern trends in the development of geographic information systems built on the basis of the web geographic information system (GIS) architecture. The authors conducted a bibliometric analysis of scientific publications and showed that the development of web-based geospatial platforms is characterised by increasing attention to the integration of spatial analytics, cloud computing and service-oriented models of geodata processing. The results of the study confirmed that modern GIS platforms are transforming into multifunctional analytical environments capable of supporting the monitoring of territorial processes and making management decisions based on spatiotemporal data. At the same time, the study by L. Abdulrahman *et al.* (2022) presents an overview of modern approaches to the design of web-based regional information systems, in particular in the field of tourism management. The authors emphasised that the effectiveness of such platforms is determined by the comprehensive integration of functional services, analytical modules and user interfaces within a single digital architecture.

Previous studies mainly focused on the analysis of individual aspects of information systems design, in particular architectural models of corporate and web-oriented platforms or the application of data mining methods in specific application tasks. At the same time, the issues of system integration of architectural, methodological and analytical components within a single conceptual model of information systems design remain insufficiently addressed. In particular, there is a gap in substantiating the choice of architectural solutions in relation to data processing methods, assessing platform effectiveness and demonstrating possible scenarios for the practical implementation of intelligent modules in corporate and web-oriented environments. The aim of the study was to develop a conceptual approach to the design of corporate and web-oriented information systems with the integration of data mining elements. To achieve this goal, the following tasks were solved: to analyse modern architectural and methodological approaches to the design of information systems, taking into account the possibilities of integrating analytical modules; to substantiate the conceptual model of the information platform and determine approaches to assessing the impact of the proposed solutions on the scalability, adaptability, and performance of the system.

MATERIALS AND METHODS

The study was of a theoretical and survey nature, with project-oriented and analytical approaches. The time frame of the study covered the period from September 2024 to February 2026. The materials of the study were scientific articles and reviews on the architecture of information systems and digital transformation, as well as materials from international conferences on distributed computing and big data (Adamov, 2018; Zhang, 2025). To analyse the architecture of web-oriented platforms, the following standards and technical documents were used: OpenAPI Specification 3.1.0, Request for Comments (RFC) 7231 (HyperText Transfer Protocol (HTTP) semantics), RFC 3986 (Uniform Resource Identifier (URI) syntax), W3C Web API Best Practices recommendations, JavaScript Object Notation (JSON) Schema specifications, as well as OAuth 2.0 security standards for describing API integration. The system analysis method was used to consider the information system as a complex multi-level object. Within the framework of this approach, the logical structuring of the digital platform, the definition of functional subsystems and the analysis of the relationships between the infrastructure, service, data-centric and analytical components of the architecture were carried out. System analysis made it possible to form a generalised concept of the functioning of modern information ecosystems and to determine the principles of structural integrity of the software platform.

The conceptual modelling method was used to formalise the architectural principles of building an information system and describe the general logic of its functioning. Within the framework of the study, a theoretical structural representation of the digital platform was carried out in the form of a generalised multi-level model, which included infrastructure, service, data-centric, analytical and application components. Special attention was paid to the analysis of the principles of organising interaction between the functional levels of the system and determining the general place of intellectual and analytical components in the structure of the information platform. The project-oriented method was used to study the theoretical aspects of the life cycle of an information system as an engineering-controlled process of creating software platforms. Within the framework of this approach, the general principles of organising the stages of information systems design were considered, including the formation of requirements for functionality, conceptual architectural design, implementation of software modules, testing of software logic, system implementation and subsequent support of the digital platform. Methodologically, the study was based on a generalised analysis of modern approaches to the modular organisation of software, the principles of weak component coupling and iterative logic of information systems development without performing applied experimental procedures.

The domain-oriented design method was used to ensure semantic consistency of the software architecture with the subject area of the system's functioning. Within the framework of the study, a business domain model was formed, in which the platform architecture was organised around key business objects. Data processing service modules and information repository storage mechanisms were defined, which allowed reducing the cognitive complexity of the architecture and ensuring the possibility of reusing business logic during system modernisation. Data-driven methodology was used to justify architectural solutions based on the analysis of the operational characteristics of the information platform. Based on the analysed data, a model of adaptive configuration management of the software environment was formed, which provided for automated optimisation of system parameters depending on changes in load and user behavioural characteristics.

The algorithmic component of the study was based on a theoretical analysis of the possibilities of applying data mining methods without performing empirical computational experiments. The study considered the conceptual principles of the functioning of forecasting models based on time series analysis and statistical learning, which allowed extrapolating the behavioural characteristics of information systems in hypothetical scenarios of the development. For the tasks of classification and segmentation of information objects, the methodological features of the application of clustering algorithms, discriminant analysis and deep learning methods were analysed from the standpoint of the functional purpose in the structure of the information platform. The study used the method of comparative analysis of architectural models of corporate information systems. The analysis was carried out according to key technical criteria, in particular, scalability, modularity, complexity of support, independence of components and the level of fault tolerance, which made it possible to generalise the features of monolithic, service-oriented and microservice architectures. An architectural analysis of web-oriented systems was conducted, in particular, the principles of frontend/backend decomposition, API-oriented interaction, and the Representational State Transfer (REST) approach were investigated. A structural and functional analysis of data integration and processing was also used, which covered the concepts of Data warehouse, Extract, Transform, Load, Extract, Load, Transform, and visualisation tools. In addition, an analysis of event-oriented interaction of components in distributed information systems was carried out to assess the mechanisms of coordination and data transfer between services. A historical and evolutionary analysis was also applied, which was used to trace the stages of development of information system architectures and approaches to the design – from monolithic systems to service-oriented and microservice architectures, as well as to analyse the transformation of data integration methods and the organisation of component interaction in modern digital platforms.

The analysis of the reliability of the information system was carried out from the standpoint of the concept of fault-tolerant architectural environments at the level of theoretical modelling of possible scenarios of the platform's operation. The principles of service component redundancy, automated recovery of programme processes, and isolation of critical infrastructure nodes as mechanisms for increasing the stability of a digital system were considered. The study of the adaptability of the information platform was based on the concept of self-tuning computing environments, in which the parameters of the software infrastructure could change in accordance with variations in the operational load or behavioural characteristics of users based on the analysis of telemetric data in theoretically simulated conditions. An integral assessment of the effectiveness of the information system architecture was carried out at the level of conceptual synthesis of individual groups of indicators without conducting numerical experiments. The combined performance index was considered as a generalised theoretical construct that reflected the balance between speed, resource efficiency, accuracy of analytical models, and platform stability. Thus, the set of applied materials and methods made it possible to form a holistic theoretical and analytical substantiation of the principles of designing modern adaptive information systems, providing a systematic analysis of architectural models, methodological approaches, and concepts for integrating intelligent analytics into digital platforms.

RESULTS

Conceptual principles for building corporate and web-based information systems

The 2016-2026 stage of information technology development is characterised by a systemic transformation of approaches to designing information platforms, which is due to the transition to digitally-oriented data and process management models. The evolution of corporate and web-based information systems is directly related to the concept of digital transformation, which involves the integration of computing, communication and analytical components into a single technological ecosystem. Within this paradigm, the information system is considered not only as a tool for automating operational activities, but also as an intelligent decision-making support platform capable of adapting to changes in the external and internal environment. The evolutionary development of information systems architecture went through several conceptual stages, ranging from monolithic software complexes to distributed service-oriented platforms. Classic monolithic solutions were characterised by a high level of internal connectivity of components and limited scalability, which made it difficult to modernise the system in the face of growing data volumes. Further development led to the formation of the Service-Oriented Architecture paradigm, which involves the decomposition of functionality into independent service modules with standardised interaction interfaces. This approach provides the possibility of reusing services, increases the level of integration compatibility and simplifies software maintenance processes. The next logical step was the concept of Microservices architecture, which considers the system as a set of autonomous microcomponents, each of which implements a separate business function and can be deployed independently of other modules (Efe, 2024; Molodets & Bulana, 2024).

The digital transformation of information systems is largely determined by the exponential growth in the volume of structured and unstructured data, which creates new requirements for methods of the processing and analysis. In this context, the concept of big data is used, which encompasses technologies for storing, processing and analytical modelling of very large amounts of information (Adamov, 2018). The main characteristics of modern information platforms are horizontal scalability, fault tolerance, high-speed streaming data processing and support for multi-user access. Structurally, modern corporate systems are increasingly built on the basis of cloud-oriented infrastructure, which ensures elastic use of computing resources and optimisation of the cost of operating the technological platform. A priority in the development of information systems is the integration of artificial intelligence (AI) methods, which transforms traditional information platforms into cognitive-oriented knowledge processing environments. Intelligent data analysis is used to identify hidden patterns, predict user behavioural characteristics, automate classification of information objects and support management decision-making. In corporate and web-based systems, machine learning algorithms can be incorporated as separate analytical services or as embedded business logic components, depending on the chosen architectural strategy (Emadi, 2023). The conceptual structure of a modern information platform, which demonstrates the relationship between the functional, data-centric, and intelligent components of the system, is given in Table 1.

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Table 1. Conceptual levels of a modern information system

System level	Main purpose	Key technological elements
Infrastructure level	Provision of computing resources	Cloud services, containerisation, virtualisation
Service level	Implementation of business functions	API gateways, microservices, message queues
Data-driven level	Information storage and processing	Data warehouses, streaming analytics
Intellectual and analytical level	Cognitive information processing	Machine learning models, predictive analytics
Application level	User interaction	Web interfaces, mobile clients

Source: compiled by the author based on J. Emadi (2023), A. Efe (2024)

Table 1 reflects a stratified model of an information system, in which each level performs an autonomous but functionally related role in forming a holistic digital platform. This structuring corresponds to the principle of division of responsibilities and reduces architectural complexity, ensuring manageability, scalability and technological flexibility of the system. Conceptually, it is important that the intellectual and analytical component is presented as a separate level, which indicates the transition from transactional systems to cognitively oriented decision support platforms. Taken together, the model demonstrates the logic of sequential transformation of resources into applied value, forming the basis for building adaptive and scalable corporate ecosystems. Web-oriented information systems are characterised by a high level of client accessibility and platform independence. The use of multi-component architecture allows for the interaction of user interfaces with server logic through standardised programme interfaces. In this context, web platforms act as universal environments for integrating corporate resources, analytical services and external information sources. The use of intelligent algorithms in the web environment creates the prerequisites for the formation of adaptive interfaces, personalised recommendation mechanisms and automated monitoring of system behaviour. Thus, the conceptual principles of building modern information systems are based on a synergistic combination of architectural modularity, data-centric information flow management and artificial intelligence technologies, which ensures the transition from traditional automated platforms to intelligent digital ecosystems. A promising direction of development is the further formalisation of methods for integrating analytical models into the software-architectural contour of the system in order to increase its adaptability and operational efficiency.

Architectural models for designing modern information systems

Corporate information systems are designed as complex multi-tiered platforms, the architecture of which is aimed at ensuring functional isolation of components, high availability of services and the possibility of independent scaling of individual modules. The traditional client-server model evolved towards multi-tiered structures that involve the separation of presentation, business-logical and data-centric subsystems. Such decomposition allows reducing inter-component dependence, increasing the level of data processing security and ensuring flexibility in software modernisation without the need for complete system reconstruction. The transition from monolithic software solutions to service-oriented architectural models is associated with the development of the concept of Service-Oriented Architecture, which involves building a system as a set of loosely coupled services with standardised interaction protocols. Within this paradigm, the functional modules of the system encapsulate business logic and expose it through universal communication interfaces. A further development of this architectural idea was the Microservices architecture model, characterised by maximum autonomy of software components, the possibility of an independent service life cycle, and high horizontal scalability of the platform (Bondarchuk *et al.*, 2024).

A multi-tiered corporate system usually includes infrastructure, service, logical, and presentation layers. The infrastructure layer provides a physical or virtual environment for executing programme code, including storage resources, network communication, and computing power. The service layer implements the functionality of business processes through a set of interacting services, while the data layer is responsible for the consistency of information resources and transaction management. The presentation layer provides user interaction with the system through client interfaces. Comparative characteristics of architectural models of corporate systems are presented in Table 2.

The comparative matrix reflects the evolution of architectures from centralised to decentralised models, in which complexity is managed through decomposition and autonomisation of components. It demonstrates the transition from a tightly integrated structure to network interaction of independent services, which increases the flexibility and adaptability of the system. At the same time, the complexity does not disappear, but moves to the plane of coordination of distributed processes, data consistency management and infrastructure monitoring. Therefore, the choice of architecture is determined by the balance between scalability and organisational capacity to ensure effective management of the distributed environment. Conceptually, the interaction of corporate platform components can be represented as a hierarchical structure of data flows and service calls. Information requests from client applications arrive at API gateways, after which these requests are routed to the corresponding business services, which process the data and form the result of the operation (Fig. 1).

Table 2. Comparative characteristics of architectural models of corporate systems

Criterion	Monolithic architecture	Service-oriented architecture	Microservice architecture
Scalability	Limited	Moderate	High
Modularity	Low	Medium	High
Difficulty of support	High as the system grows	Medium	Optimised
Component independence	Minimum	Partial	Maximum
Fault tolerance	Lower	Medium	High

Source: compiled by the authors based on J. Essien (2023), S.K. Jangam (2023)

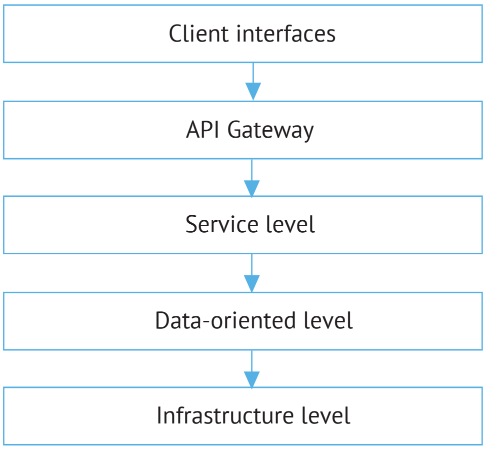

Figure 1. Hierarchical architectural model of query processing in a multi-level information system
Source: compiled by the authors based on H. Kozub & Yu. Kozub (2022), S.K. Jangam (2023), A. Matani *et al.* (2024)

The presented scheme reflects the logic of sequential transformation of information queries within a multi-tier architecture, where each tier acts as a functional intermediary between user interaction and underlying computing resources. Such a structural organisation provides centralised management of access to services and allows separating business operation processing mechanisms from infrastructure execution mechanisms. Conceptually, this model emphasises the principles of sequential abstraction and decomposition of the system, which contributes to the manageability of complex software platforms. It also creates the prerequisites for independent modernisation of individual layers of the system and integration of additional functional modules, in particular analytical or intelligent components, without violating the overall architectural integrity. Integration of corporate information resources is carried out through the use of standardised data exchange protocols, which allows for interaction between the organisation's internal subsystems and external information services. The use of event-driven interaction of components becomes important, which minimises synchronous system blocking and increases its performance in high-load environments.

Web-oriented information systems form a separate class of software platforms based on the principle of platform-independent user interaction with server logic via network data transfer protocols. The key architectural characteristic of such systems is a clear decomposition of frontend and backend components, which ensures the independence of user interface development from internal business logic. The frontend subsystem is responsible for implementing the presentation layer, forming dynamic interfaces, and ensuring interactive user interaction with the system. For this purpose, modern client frameworks are used that support a component-oriented development model and reactive interface state updating. The backend layer implements business process processing algorithms, database management, and integration with external services (Tekane, 2025).

Interaction between the client and server parts of the system is carried out mainly through API-oriented communication mechanisms based on the use of standard data exchange interfaces. The most common technological approach is the use of Representational State Transfer, which provides a unified model for accessing system resources via HTTP. The REST architecture involves the use of stateless requests, resource identification via URIs, and standardised operation methods. Cloud infrastructure plays a key role in ensuring the scalability of web-oriented platforms. The use of the Cloud computing concept allows for elastic scaling of computing resources, automatic load balancing, and data redundancy (Liu *et al.*, 2023). Modern systems often use containerisation of software components, which provides a unified execution environment regardless of the physical infrastructure.

The integration of data intelligence modules into the overall architecture of the information system is based on the principle of multi-level analytical processing of information flows. Analytical components can be implemented as standalone services or as embedded algorithmic business logic modules, depending on the performance, security, and complexity requirements of machine learning models. Streaming and batch data processing form two fundamental paradigms of the analytical computing model. Batch processing is used to analyse large historical data sets and train predictive models, while streaming processing is focused on real time and involves incremental updating of analysis results. In this context, the concept of big data is actively used, which provides a technological basis for working with high-dimensional information flows. Integration of Machine learning algorithms into application services is carried out through the creation of specialised analytical microservices or through embedding predictive models directly into the business logic of the system (Muvva, 2025). This approach allows for the implementation of adaptive process optimisation functions, automated information classification, and detection of anomalous user behaviour patterns. A typical scheme for integrating analytical components can be represented as a sequence of technological levels (Fig. 2).

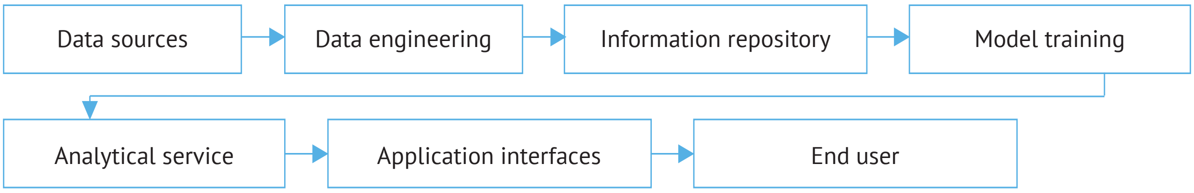

Figure 2. Integration scheme of analytical components

Source: compiled by the authors based on S. Muvva (2025)

The above structure demonstrates the shift of the architectural logic of information systems towards close integration of operational and analytical processes. Analytical components are built into the general information processing cycle, turning data not only into a storage resource, but into an active tool for supporting the functioning of the system. As a result, analytics becomes a component of application services and directly affects the formation of management or functional decisions. In such an architecture, data is the central element that combines infrastructure processing mechanisms with the applied logic of the system. This creates the prerequisites for the formation of adaptive information platforms that are able not only to respond to user requests, but also to predict behavioural patterns, optimise business processes and increase the efficiency of the entire digital ecosystem. Thus, the architectural integration of intelligent analytics transforms the information system into a cognitive-oriented platform capable of supporting automated decision-making in a dynamic digital environment. Further development of such systems is associated with the improvement of distributed model learning methods and optimisation of computational costs when operating intelligent services.

Methodological approaches to information systems design

The project-oriented methodology for designing information systems is based on the concept of a managed software product life cycle, which involves formalised management of all stages of creation, implementation, and operation of a digital platform. In modern software engineering, the system life cycle is considered as a continuous process that includes the stages of requirements analysis, architectural design, implementation of functional components, testing, deployment and further modernisation of the system. This approach provides the ability to adapt the information platform to changes in the technological environment and business requirements of the organisation. A key element of the project-oriented paradigm is the use of iterative software development models, which involve the gradual refinement of the functional specification of the system through a series of consecutive design and testing cycles. Among modern methodological approaches, flexible development methods based on the principles of adaptive project management are widespread. In this context, the Agile software development methodology ensures a high speed of response of the development team to changing customer requirements and promotes continuous improvement of the software product through short iterative cycles (Kundisch *et al.*, 2022).

Information system life cycle management can be formalised through a multi-level model of quality control and functional compliance of the system with user requirements (Table 3). In the structural dimension, the life cycle includes strategic architecture planning, technical implementation, operational monitoring and post-operational support of the software platform. The use of the principles of continuous integration and automated testing of software code is becoming increasingly important, which minimises the risks of critical system errors.

Table 3. Generalised structure of the information system life cycle

Life cycle stage	Main tasks	Resulting artifacts
Requirements analysis	Formalisation of functional needs	Requirements specification
Architectural design	Defining the structural model of the system	Architectural design
Implementation	Software development of components	Executable code
Testing	Function verification	Testing reports
Deployment	System deployment	Working platform
Support	Optimisation and modernisation	System update

Source: compiled by the authors based on D. Kundisch *et al.* (2022), N. Renaldo *et al.* (2022)

The presented structure reflects the system logic of organising the process of creating an information system, within which each stage forms the basis for the next level of technological implementation. It demonstrates the sequential transformation of the initial conceptual requirements into a functional software product through a system of interconnected engineering procedures. This approach emphasises that the effectiveness of development is determined not only by technical solutions, but also by the quality of management of the design, control, and improvement processes of the system. In general, the table indicates a transition from a linear understanding of the life cycle to a cyclical and adaptive model of software platform development. This provides the possibility of continuous improvement of the system architecture, integration of new functional components and maintenance of stability of work in a changing technological environment. Iterative software development methodologies involve the use of incremental increase in system functionality, which makes it possible to reduce the complexity of managing large projects. The development process is divided into a series of short cycles, within which planning, implementation, evaluation of results and correction of architectural solutions are carried out. This model minimises technological risks and ensures more stable integration of software modules into complex information environments.

Domain-driven design of information systems is based on the principle of structural correspondence of the software architecture to the subject area of the system's functioning. The main idea of this approach is the maximum coordination of the business logic of the software product with the conceptual model of the organisational environment in which the system is operated. Within the framework of this methodology, the software system is considered as a formalised model of business processes that reflects the structural and functional characteristics of the subject area. The concept of Domain-driven design involves the hierarchical organisation of the software code in accordance with the business domains of the organisation (Zhang, 2025). The architectural structure of the system is formed around key business objects that determine the logic of information processing and interaction between functional modules (Hackenbeck *et al.*, 2025). Within the framework of this methodology, the concepts of domain core, aggregates, domain services and data repositories are distinguished. Aligning the software architecture with the subject area reduces the cognitive complexity of the software and increases the level of scalability of the system. An important aspect is the formation of a universal business logic model that can be reused when upgrading the information platform or integrating new functional components. The interaction of the elements of a domain-oriented architecture can be represented in the form of a diagram (Fig. 3).

Figure 3. Interaction of elements of domain-oriented architecture
Source: compiled by the authors based on C. Hackenbeck *et al.* (2025)

The presented scheme reflects the conceptual translation of real business processes into the software architecture of the system, where the domain model plays a central role as an intellectual framework of applied logic. Such a structural organisation demonstrates that the software system is formed not around technical components, but around the substantive elements of the subject area, which provides a more natural reflection of organisational processes in the software environment. In general, this model emphasises the importance of semantic consistency between the conceptual description of the organisation's activities and the software implementation of the information platform. This creates the prerequisites for increasing the clarity of the system architecture, simplifies its evolutionary development, and ensures the stability of business logic when expanding or modifying functional components.

The data-driven architectural strategy for designing information systems involves the use of analytical methods of information processing to form optimal parameters of the software platform. This approach is based on the concept of decision-making based on empirical data, which allows minimising the subjective factor when choosing technological solutions. Within the framework of this paradigm, data mining methods are actively used, which ensure the detection of hidden patterns in large amounts of information. Analytical results can be used to optimise the structure of databases, balance the load between service nodes, and predict the behavioural characteristics of system users (Hensel *et al.*, 2022). Using analytics to optimise the functional components of the information platform involves constant monitoring of the system's operational metrics, including bandwidth, query processing latency, service error rate, and the efficiency of computing resources. Based on the collected telemetric data, automated correction of the configuration parameters of the software environment is carried out, which forms the basis of the concept of self-tuning information systems. A typical structure of data-driven architectural management can be represented as a sequence of analytical operations (Fig. 4).

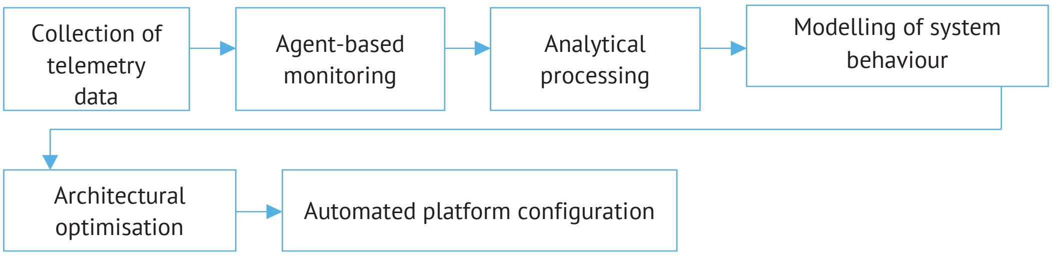

Figure 4. Typical structure of data-driven architectural management
Source: compiled by the author based on K. Kayabay *et al.* (2022)

The presented scheme reflects the transition to an architectural model in which the design and optimisation of the information system are carried out on the basis of continuous analysis of operational data. In such logic, the results of monitoring the functioning of the platform become the basis for correcting configuration parameters, improving the structural organisation of components and increasing the efficiency of resource use. In general, the model demonstrates the formation of an adaptive information infrastructure capable of self-regulation and evolutionary improvement in accordance with changes in load, user behaviour and technological conditions of the system's operation. Thus, methodological approaches to the design of information systems form an integrated system of engineering and analytical management of the life cycle of software platforms, combining the principles of iterative development, domain decomposition and empirically based architectural decision-making. Further development of design methodologies is associated with the implementation of autonomous intelligent mechanisms for optimising software systems.

Practical aspects of implementing information systems with intelligent analytics

The practical implementation of information systems with integrated analytical modules involves the formation of a comprehensive technological platform that combines infrastructure, service and cognitive components of information processing. In modern conditions of digital transformation, corporate information systems are considered as multifunctional knowledge management environments that can provide not only the automation of operational processes, but also support intelligent decision-making based on the analysis of large volumes of data. The basis for building such platforms is the concept of integrated architecture, which ensures the interaction of data sources, analytical algorithms and application services through standardised software interfaces. The conceptual model of a corporate information platform can be represented as a multi-level structure that includes the data collection level, the level of the storage and pre-processing, the analytical level of knowledge modelling and the level of applied interpretation of results. At the infrastructure level, information flows from internal corporate systems, external web sources, and sensor or transactional subsystems are accumulated. For effective management of large amounts of information, the data warehouse concept is used, which provides structured storage of historical data and support for highly complex analytical queries. Distributed information processing technologies can be used in parallel, in particular ecosystems based on the principles of big data (Ismail *et al.*, 2024).

The service level of the platform includes analytical modules that implement algorithmic processing of information flows and the formation of predictive models of system behaviour. In this context, Machine learning methods are used to automate the processes of detecting patterns in high-dimensional data. The practical architecture of such platforms is often based on the concept of microservice interaction of analytical components, where each algorithmic module functions as an autonomous knowledge processing service. An example of a web-based information system with an analytical module can be implemented as an integrated user data management platform that provides personalisation of services and prediction of user behavioural characteristics. Such systems use the technology of intelligent analysis of web activity, which allows forming dynamic user profiles based on the history of interaction with the digital environment. The interface part of the platform implements mechanisms for visualising analytical results, which helps to increase the interpretability of machine learning models and support management decision-making (Hossain *et al.*, 2024). A typical functional structure of an information system with intelligent analytics can be formalised in the form of a multilayer architecture of component interaction (Table 4).

Table 4. Functional levels of the analytical information platform

Platform level	Functional purpose	Key technological solutions
Data sources	Accumulation of information flows	API integration, streaming brokers
Data processing	Preliminary information transformation	Extract, Transform, Load/Extract, Load, Transform processes
Analytical level	Intelligent modelling	ML models, statistical analytics
Service level	Application business logic	Microservices, RESTful services
Presentation of results	Analytics visualisation	Dashboard systems

Source: compiled by the authors based on Q. Hossain *et al.* (2024)

The table below summarises the logic of the functioning of analytically oriented information platforms, demonstrating the transition from traditional transactional systems to architectures in which analytical data processing is integrated directly into operational processes. In such a model, information flows undergo a sequential transformation – from primary accumulation to intelligent interpretation and applied use of results, which forms a single data management loop. The synthesis of the presented levels indicates the formation of a holistic data-centric architecture in which analytical algorithms become an integral element of the platform's service logic, ensuring automation of decision-making, personalisation of digital services and increased adaptability of corporate information systems to changes in the information environment.

The implementation of intelligent data analysis functions involves the use of different types of algorithmic models depending on the information processing task. Forecasting behavioural characteristics is carried out by building temporal or stochastic models that allow extrapolating future values of the studied parameters based on historical observations. In this context, predictive analytics methods are used, based on the mathematical apparatus of statistical learning and neuroevolutionary modelling. The use of time series analysis algorithms for processing dynamic information flows is important. The tasks of classification and segmentation of information data are solved through the use of structural learning methods, which provide grouping of information objects according to the degree of similarity of the characteristics. For this, clustering, discriminant analysis and deep learning algorithms can be used, which allows the formation of multidimensional data distribution models. Personalised recommendation mechanisms are based on the analysis of user behaviour history and involve the use of the principles of collaborative filtering or content-oriented interaction modelling (Arafat *et al.*, 2025).

Detection of anomalies in information systems is a critically important functional task, as it allows ensuring cybersecurity and stable functioning of digital platforms. In this aspect, statistical process control methods and machine learning algorithms are used to identify deviations from the normal operating mode of the system. The practical implementation of such mechanisms may include the use of Anomaly detection models, which are capable of automatically recording atypical patterns of user behaviour or system processes (Usmani *et al.*, 2024). Thus, the practical implementation of information systems with intelligent analytics forms the technological basis for creating adaptive digital platforms of a new generation that combine the capabilities of distributed data processing, predictive modelling and automated support for making management decisions. The further development of such systems will be determined by the improvement of model training algorithms and increasing the interpretability of intelligent services.

Evaluating the effectiveness of architectural solutions for information systems

Evaluating the effectiveness of architectural solutions for information systems is a complex multidimensional task that involves analysing the technological, functional, and analytical characteristics of the software platform. In modern software engineering, system efficiency is considered an integral property of the architecture, which reflects the ability of the information platform to provide stable data processing at minimal computational costs and a high level of accuracy of analytical results. Methodologically, the effectiveness assessment is based on the principles of quantitative performance metrics, statistical validation of models, and analysis of system reliability under variable load conditions.

Information systems performance metrics form the basis of the technical assessment of architectural solutions and allow determining the optimal parameters of the software platform's functioning. Key performance indicators include request processing time, system throughput, network interaction latency, and the efficiency of computing resources. In the context of distributed platforms, the concept of Cloud computing performance metrics is of particular importance, which is used to assess the scalability of cloud services, the level of resource availability and the variability of the system's response time when the number of user requests increases. The scalability of an information system is determined by the ability of the architecture to support the growth of the computing load without critical deterioration in performance. Modern digital platforms use the principle of horizontal scaling, which involves adding new computing nodes to a distributed cluster environment. In this context, Distributed computing technologies are actively used, which provide parallel processing of information flows and load balancing between service components of the system (Hackenbeck *et al.*, 2025). The main performance metrics of information systems are presented in Table 5.

Table 5. Key metrics for information systems performance

Metrics group	Indicator	Measurement description
Time characteristics	Latency	Average system response time
	Throughput	Number of requests processed per unit of time
Resource characteristics	Central processing unit utilisation	Central processing unit resource loading
	Memory consumption	Random access memory usage
Reliability	Error rate	Frequency of system errors
Scalability	Scalability coefficient	Performance dynamics with increasing load

Source: compiled by the authors based on M.S. Sultana & S. Akter (2023), P.R. Nangi *et al.* (2024)

The presented Table 5 systematises approaches to quantitative assessment of the functioning of information platforms, demonstrating that the effectiveness of architectural solutions is formed not by separate technical indicators, but by the coordinated set. The combination of time, resource, and reliability characteristics reflects the multidimensional nature of the performance of distributed systems, in which the stability of query processing, the efficiency of the use of computing resources and resistance to load growth are interconnected. In this context, metrics serve as tools for empirical verification of architectural solutions, allowing to assess how much the selected technological model provides a balance between speed, economy of infrastructure use and reliability of system operation in conditions of scaling and dynamic load changes.

Assessing the accuracy of analytical models is a critically important aspect of the functioning of information systems with integrated intelligent components. Verification of predictive and classification algorithms is carried out by comparing model results with empirical observations. In this context, machine learning methods based on the mathematical apparatus of statistical inference are used. A significant role is played by the use of Supervised learning approaches, which involve training models based on pre-labelled data (Kumar *et al.*, 2022). Standard forecast error metrics are used to quantitatively assess the quality of analytical models (Table 6). Among these forecast error metrics, the most common are the mean absolute error, the mean square error, and the relative forecast error. These indicators allow formalising the level of modelling accuracy and providing an objective comparison of alternative algorithmic solutions.

Table 6. Metrics for assessing the accuracy of analytical models

Metrics	Mathematical content	Scope of application
MAE	Mean absolute deviation	Robust forecast estimate
RMSE	Root-mean-square forecast error	Sensitivity to large deviations
MAPE	Relative forecast error	Normalised accuracy estimate
Precision	True positive classification rate	Binary classification
Recall	Object detection completeness	Detection tasks

Notes: MAE – mean absolute error; RMSE – root mean squared error; MAPE – mean absolute percentage error
Source: compiled by the authors based on R.C. Khamari *et al.* (2025)

The presented system of metrics reflects the desire to formalise the assessment of the quality of intelligent models by combining statistical and classification criteria. The use of different types of errors allows for multidimensional verification of predictive algorithms, since individual indicators are sensitive to different characteristics of data distribution and the structure of modelling errors. In general, such a composition of metrics forms a universal toolkit for validating analytical systems, which can be used both for forecasting tasks and for tasks of structural classification of information objects, ensuring a balance between the model's resistance to outliers, prediction accuracy and completeness of detection of relevant patterns. The analysis of the reliability of an information system involves studying the stability of the software platform's functioning in conditions of component failures or external destructive influences. The reliability of the architecture is determined by the probability of failure-free operation of the system during a given time interval. In modern digital environments, considerable attention is paid to the concept of Fault-tolerant system, which involves the implementation of mechanisms for redundancy, automatic restoration of services and isolation of erroneous processes. The adaptability of the information platform characterises the ability of the system to change the parameters of its functioning in accordance with variations in the external environment or user behaviour. In this aspect, the principles of self-tuning computing environments are applied, which can automatically optimise the configuration of the software infrastructure based on telemetric data. The overall integrated efficiency of the information system architecture can be assessed through a combined performance index that aggregates the time, resource and analytical characteristics of the platform. The formation of such an index allows for a comparative analysis of alternative architectural models and to justify the choice of a technological strategy for the development of the information system.

DISCUSSION

The analysis of scientific publications indicates the active development of the concept of integrating analytics into the architecture of information systems, which is consistent with the results of the study on the formation of data-centric adaptive digital platforms. Thus, in the work of M.C. Solano & J.C. Cruz (2024), a systematic review of the integration of analytical components into corporate information systems was carried out, where it was shown that the implementation of analytics increases operational efficiency, supports decision-making and promotes the digital transformation of enterprises. The conclusions obtained by the authors correlate with the results of the study on the feasibility of architectural integration of intelligent data analysis into the service contour of the platform. At the same time, the specified work details the structural organisation of multi-level architectural models to a lesser extent, which explains the differences in the level of conceptual formalisation. The study of A. Almoqry & N. ALSohybe (2025) considered the architectural aspects of the digital transformation of information systems in the field of education, where the importance of integrated data management platforms and flexible architectural models was highlighted. The authors' results confirmed the prospects of using adaptive information environments, but the emphasis is mainly on the organisational and institutional conditions for the implementation of digital technologies. Compared to the current study, which focuses on theoretical modelling of the architectural logic of the system and the integration of analytical algorithms into the technological contour of the platform, the work of A. Almoqry & N. ALSohybe demonstrates a more applied and managerial focus, which causes a partial difference in the results. In turn, the publication of V.-H. Capacho-Alfonso *et al*. (2025) is devoted to a bibliometric analysis of the development of enterprise architecture in the context of smart cities, healthcare and new technologies. The authors established the growth of research related to the use of artificial intelligence and architectural innovations in digital ecosystems. The obtained trends are generally consistent with the current conclusion about the dominance of cognitively oriented data processing platforms. At the same time, the differences are that the bibliometric approach captures only structural trends in the development of the industry, while the conducted research is conceptual and methodological in nature and is aimed at forming a model of architectural integration of analytical components.

The impact of generative artificial intelligence on the activities of information systems architects in Agile environments is studied in the work of S.J. Kooy *et al*. (2025). The authors showed that the use of generative models can support design processes, but emphasise the need for quality control of generated architectural solutions and human expert verification support. The conclusions obtained are consistent with the results of the conducted research on the feasibility of integrating intelligent analytics into the technological contour of information platforms. The study by J. Weller & R. Dumitrescu (2025) proposed a decision-driven analytics approach for designing information systems in a smart manufacturing environment. The authors pointed out the importance of integrating analytical models directly into the architecture of business processes, which correlates with the current conclusion about the formation of data-centric platforms, in which analytics acts as a functional component of the operational loop. The differences between the results lie in the level of detail: the aforementioned study is focused on the engineering of use-case scenarios for industrial systems, while the analysis focuses on a generalised theoretical and methodological description of the architectural logic of information ecosystems. At the same time, the publication by N.R. Busch & A. Zalewski (2025) is devoted to a review of methods for evaluating enterprise architecture. The authors noted that the effectiveness of architectural models is determined by the balance between system complexity, scalability, reliability, and manageability of the software life cycle. These results directly confirmed the conclusions obtained regarding the multidimensional assessment of the performance of information platforms.

Interrelated aspects of the development of data-driven digital environments, in particular the technological optimisation of big data processing and the organisational and architectural impact of analytics on the innovative potential of information systems were demonstrated by the works of V. Winata (2022) and S. Pathak *et al*. (2025). Taken together, these studies confirm the general scientific position on the growing importance of artificial intelligence in managing information flows and supporting the adaptive functioning of digital platforms. At the same time, the conducted study expands this direction by conceptually and methodologically generalising the principles of integrating intelligent analytics into the architecture of information systems, which makes it possible to consider analytical modules as a structural component of a digital platform, and not only as a tool for technological optimisation. The study by B. Adhytia *et al*. (2022) demonstrated that enterprise architecture is a key factor in realising the value of big data analytics in organisational systems. The authors emphasised that the effectiveness of analytical platforms depends on the consistency of the infrastructure, service, and information layers of the architecture.

These findings support the results obtained regarding the multi-level stratified model of the information system. At the same time, the current work extends existing approaches by including the intellectual-analytical layer as a separate functional layer of the architecture, which is less detailed in the aforementioned studies. The study by A. Erica *et al.* (2024) shows that the use of data analytics in management systems contributes to improving the quality of management decision-making through structured interpretation of information flows. The authors stressed the role of integrated analytics in supporting management-oriented information systems, which is consistent with the current conclusion about the need to embed analytical modules into the operational contour of the platform.

The use of artificial intelligence to create adaptive learning environments in digital educational platforms is investigated in the publication by I. Gligorea *et al.* (2023). The authors proved that adaptive learning mechanisms increase the personalisation of digital interaction and improve the efficiency of information services. The results obtained partially correlate with the current conclusion about the adaptability of information systems as a key characteristic of modern digital platforms. The difference lies in the industry specificity: the conducted study is of a universal nature and is aimed at generalising the architectural principles of corporate and web-oriented information systems, while the mentioned work focuses on educational systems. In turn, the work of H.C. Ling & H.S. Chiang (2022) investigated the effectiveness of adaptive recommendation systems in the educational web environment. The authors showed that personalised recommendation algorithms have a positive effect on user productivity indicators by dynamically taking into account behavioural patterns of interaction with the system. The results obtained are consistent with the obtained conceptual conclusion about the importance of adaptability of information platforms.

In the publication of A. Gaurav *et al.* (2023), the authors considered the application of machine learning to detect malicious software in the infrastructures of the Internet of Things of corporate information systems. The authors confirmed the effectiveness of intelligent algorithms in the tasks of cyber protection of digital platforms, which correlates with the current theoretical position on the importance of integrating analytical mechanisms to ensure the stability of information systems. At the same time, the study by A. Gaurav *et al.* (2023) has a highly specialised technical focus, while the conducted study considered more general architectural and methodological principles of applying intelligent analytics in information platforms.

A comparison of the results obtained showed that most studies confirm the importance of integrating analytical and intelligent components into the architecture of information systems, in particular in the context of adaptability of digital platforms, personalised data processing and the use of machine learning methods to improve functional efficiency. A general trend of transition from local algorithmic solutions to a systemic architectural vision of information ecosystems, which corresponds to the concept of data-centric and cognitive-oriented platforms, was identified. The differences between the results of other authors and the presented study are mainly due to the level of generalisation – in the analysed works, the emphasis was on empirical experiments or highly specialised applied problems, while in this study, a conceptual and methodological synthesis of architectural approaches to the design of information systems was carried out. Thus, the results obtained are consistent with modern scientific trends in the development of digital platforms, but expand these trends due to the integrated theoretical substantiation of the principles of designing adaptive information systems.

CONCLUSIONS

The analysis found that modern information platforms are developing in the direction of transition from monolithic architectures to multi-level modular models that provide scalability, functional isolation of components and technological flexibility of systems. Information systems are increasingly integrating analytical components into the overall architectural contour, transforming from automation tools into intelligent decision-making support environments. The use of big data and artificial intelligence algorithms ensures the processing of complex information flows, the identification of patterns and the prediction of user behaviour. The design of information platforms is based on an iterative software development life cycle, which includes requirements analysis, architectural modelling, implementation, testing, and modernisation of the system. Domain-oriented design promotes semantic consistency of the software architecture with the subject area of the system, reduces software complexity and increases scalability. The data-driven approach makes it possible to use operational and telemetric data to optimise the platform configuration and load balancing between services.

The practical implementation of intelligent information systems involves a multi-level data processing structure that covers the collection, storage, analytical processing, modelling, and visualisation of information. The effectiveness of the architecture is assessed comprehensively using time, resource, and reliability characteristics. Scalability is ensured by horizontal expansion of the computing infrastructure and the use of the metrics latency, throughput, central processing unit utilisation, memory consumption, error rate and scalability factor. The quality of analytical models is assessed using the metrics MAE, RMSE, MAPE, precision and recall. The reliability of information systems is ensured by fault-tolerant architectural solutions, service redundancy, automatic process recovery and the use of self-tuning computing environments. The results obtained confirm the prospects for the development of adaptive cognitive-oriented information systems that combine architectural modularity, intelligent analytics and effective management of digital resources. The limitations of the study are its predominantly theoretical and analytical nature without conducting empirical experimental evaluation of the proposed models in real information environments. Prospects for further research are related to the practical validation of conceptual approaches by modelling architectural solutions of information systems and assessing the effectiveness under real load conditions.

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Архітектурні та методологічні підходи до проєктування корпоративних і веборієнтованих інформаційних систем з елементами інтелектуального аналізу даних

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Анотація. Актуальність дослідження зумовлена цифровою трансформацією та необхідністю удосконалення архітектурних і методологічних підходів до проєктування інтелектуальних корпоративних і веборієнтованих інформаційних систем. Метою дослідження було сформувати концептуальний підхід до проєктування інформаційних систем із застосуванням інструментів інтелектуального аналізу даних. Дослідження ґрунтувалося на теоретичному аналізі наукових матеріалів та застосуванні системного, концептуального, проєктно-орієнтованого, доменно-орієнтованого та даноорієнтованого методологічних підходів для обґрунтування принципів проєктування адаптивних інформаційних систем. Отримані результати засвідчили перехід сучасних інформаційних систем до багаторівневих модульних та даноцентричних архітектур, які поєднують функціональну гнучкість, масштабованість та інтелектуальну аналітичну обробку даних. Інтеграція алгоритмів штучного інтелекту забезпечує реалізацію прогнозної аналітики, класифікації інформації та виявлення аномалій у поведінці системи. Ефективність платформ оцінюється через комплекс часових, ресурсних та аналітичних метрик, зокрема затримкою, пропускною здатністю, рівнем використання центрального процесора, споживанням оперативної пам'яті, частотою помилок, середньою абсолютною похибкою, середньоквадратичною похибкою, середньою абсолютною відсотковою похибкою, точністю та повнотою. Показано, що надійність інформаційних систем забезпечується використанням відмовостійких архітектур, резервуванням сервісних компонентів та самонастроюваними обчислювальними середовищами. Узагальнення результатів підтвердило перспективність розвитку адаптивних когнітивно-орієнтованих даноцентричних інформаційних платформ нового покоління. Результати можуть бути використані науковцями, розробниками та архітекторами програмного забезпечення та організаціями, що займаються цифровою трансформацією інформаційних систем, при проєктуванні, оптимізації та впровадженні адаптивних аналітично орієнтованих цифрових платформ

Ключові слова: машинне навчання; великі дані; даноорієнтований підхід; масштабованість; адаптивні інформаційні платформи; доменно-орієнтоване проєктування