# СЕКЦІЯ КОМП'ЮТЕРНА ІНЖЕНЕРІЯ

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## CREATION OF A CLOUD IT ENVIRONMENT IN ORGANIZATIONS

***Abstract****. The rapid development of information technologies is driving the widespread adoption of cloud computing across various areas of organizational activity. The diversity of cloud services, their providers, and service models necessitates a well-grounded selection of optimal solutions that best meet the needs of a particular organization, taking into account economic, technical, functional, and security criteria [1]. Selecting an appropriate configuration of cloud services is a complex task, as it requires consideration of numerous variable parameters and potential risks. Traditional approaches based on expert assessments prove to be insufficiently effective under the complex and dynamic conditions of the market, which highlights the relevance of automated decision support systems in this domain.*

*One of the key stages in creating a cloud IT environment within organizations is the development of a decision support system that enables the structured analysis of available alternatives through mathematical models of multi-criteria analysis. The application of such methods makes it possible to formalize the process of comparing options, account for numerous parameters, and make well-founded management decisions. At the same time, the development of such systems is associated with a number of technical challenges, in particular ensuring the correct processing of input data, the optimal selection of evaluation methods, and the design of a flexible architecture capable of adapting to specific user requirements.*

***Keywords:*** *decision support systems (DSS), cloud services, IT environment.*

**Introduction**. The purpose of this work is to develop a decision support system for selecting cloud services for organizations, which provides a comprehensive multi-criteria evaluation of alternatives while considering current user requirements and market characteristics.

The main objective is to create an adaptive model of multi-criteria analysis that integrates the technical, economic, security, and organizational parameters of cloud services into a unified evaluation system. The model should support the adjustment of weighting coefficients, normalization of input data, computation of integral assessments, and ranking of alternatives. The general structure of the problem formulation is presented in Table 1.

The development involves building a universal model that allows working with different data sources, dynamically adapting criterion weights, and ensuring the accuracy of calculations in the presence of partial or incomplete data. Particular attention is paid to the creation of normalization mechanisms, since input parameters can have different ranges of values and different units of measurement.

The architecture of the decision support system for selecting cloud services is based on a modular multi-level structure that provides separation of functional responsibilities, scalability, and simplifying future support and system development. The main goal of building the architecture is to organise interaction between key components that implement the collection, processing, analysis, and visualisation of data necessary for making management decisions.

*Table 1 – Problem Statement Formalization*

| Component | Description |
|---|---|
| Input data | A set of cloud service parameters: technical, economic, security, legal, and service-related |
| Preprocessing | Conversion of input parameters to a normalized scale, standardization of units of measurement, and handling of missing values |
| Weight determination | Assignment of weight coefficients to each criterion according to their priority |
| Computational model | Application of a multi-criteria method for integrated evaluation (e.g., AHP, TOPSIS) |
| Result formation | Calculation of alternative rankings and generation of reports with summary indicators |
| Data output | Presentation of results to the user in tabular and graphical form |

**Literature Review**. The system should be designed for both automatic operation when complete data arrays are available from the API, and expert assessment mode in cases of partial or limited input data. This approach ensures the versatility of the model and its suitability for use in organisations with different levels of information availability [2].

In [3], the authors present the criteria necessary for making informed decisions for further system architecture design.

In [4], the requirements are analysed that enable the formation of a structured foundation for developing a decision support system architecture focused on integrating heterogeneous information sources, performing effective multi-criteria evaluation of alternatives, and supporting the current needs of users in the field of cloud computing.

The approach proposed in [5] ensures the versatility of the model and its applicability to organisations with varying levels of information availability.

The models developed in [6] provide a comprehensive conceptual framework for the further design of the decision support system architecture for selecting cloud services.

The architectural model constructed in [7] ensures complete separation of responsibilities between system components, enables effective information processing, guarantees flexibility and scalability, and forms a technical basis for further refinement of decision-making algorithms.

In [8], a logical structure is developed that fully supports the key functional processes of the system: storing criteria and their weights, recording service evaluations, producing the results of multi-criteria processing, maintaining the history of decision-making, and generating reports. The corresponding data structure enables effective and reliable system operation from both technical and applied perspectives.

The structural and conceptual models of the software system proposed in [9] provide a complete closed loop for input data processing, support all stages of calculations, produce results, and ensure their storage in accordance with requirements for reliability and scalability.

After analysing recent studies on the transition to a cloud model and the experiences of enterprises in its implementation, the following logical structure of the software system was proposed.

**Presentation of the main material**. The overall logical structure of the software system defines the main components that implement the system's key functions: data entry, business logic, data access, external integration, report generation, and access control. The structure of the primary software components is illustrated in Figure 1.

The User Interface component facilitates user interaction with the system. It handles the entry of criteria, configuration of weighting coefficients, initiation of data processing, viewing of recommendations, and generation of reports. The Authentication & Authorization component manages user authentication and access rights to the system's functional modules.

The central element is the Business Logic component, which encompasses the management of criteria, alternatives, evaluations, data processing, and the execution of decision-making algorithms.

Interaction with the database is performed through the Data Access component, which manages repositories of criteria, services, evaluations, decisions, and results. The External Data Integration component is responsible for acquiring up-to-date data from external providers. The final element is the Reporting component, which generates reports based on the calculated results.

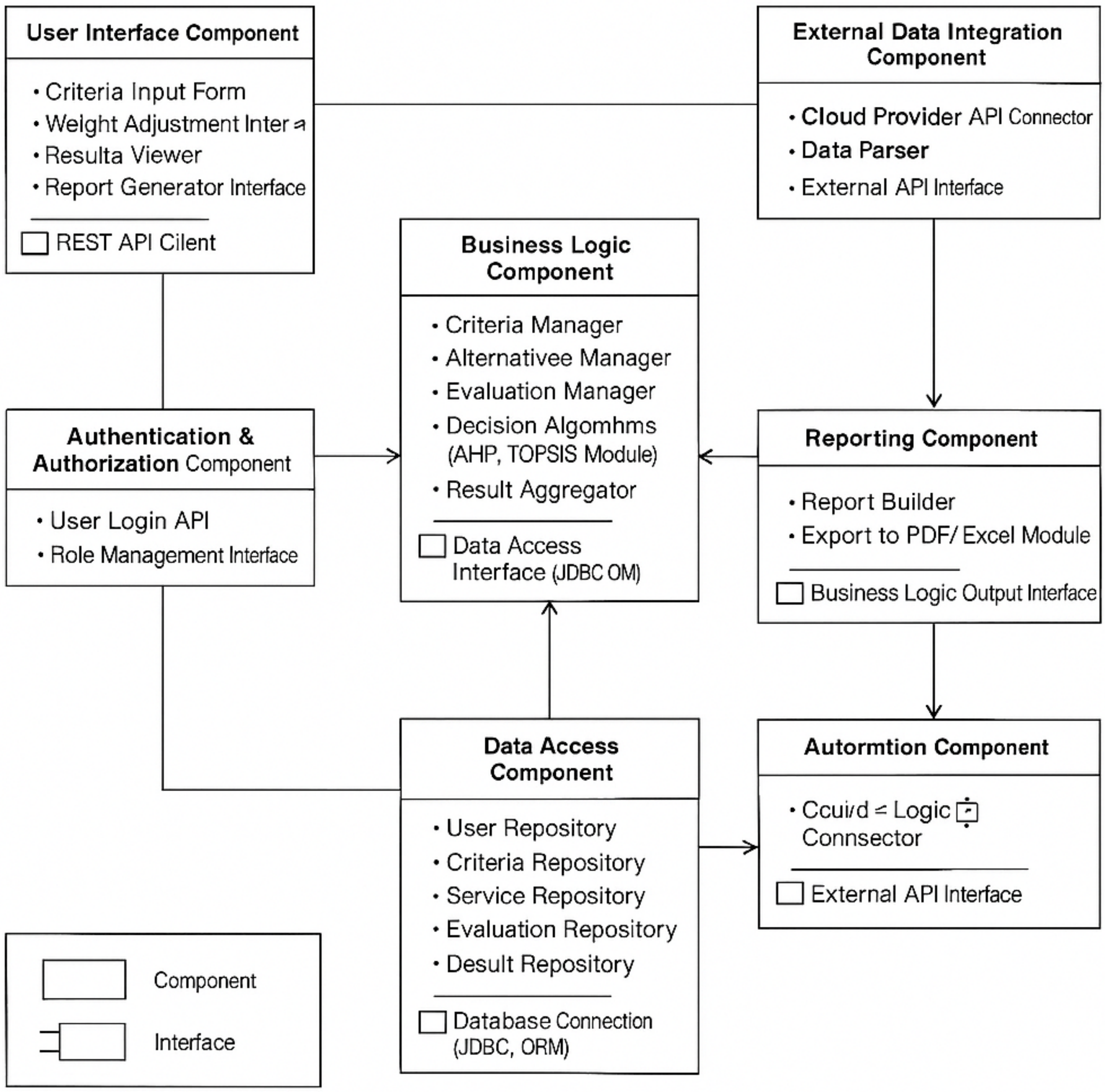


*Figure 1 – Component Diagram of the System Architecture*

The structural organisation of data in the decision support system for selecting cloud services is based on the construction of a logical data model that formalises the relationships between key information entities. The logical model represents the entire data lifecycle: from the initial input of criteria and assessments to the storage of analysis results and support for historical decision-making sessions.

The model identifies several core entities that form the backbone of the system. The User entity (USER) stores account information for registered users, including their ID, name, email address, secure password, and access role. Roles determine access to administrative functions or permission to edit criteria.

A central component of the system is the Criterion entity (CRITERION), which contains a description of each evaluation criterion, its weight, and unit of measurement. This ensures the flexibility of evaluation model formation for different categories of cloud services.

Each decision-making instance is formalised as a separate Decision Session (DECISION_SESSION), which allows for the complete history of analytical processes to be preserved. For each session, the weight coefficients of the criteria are additionally recorded in the SESSION_CRITERIA table, ensuring the preservation of variable weight configurations across different analyses.

To capture specific evaluations of criteria for alternative cloud services, the EVALUATION entity is used, which records the assessment values for each criterion within a given session. The results of the multi-criteria analysis are calculated and stored in the RESULT table, which contains the aggregated assessment of each alternative and its position in the ranked list.

The consolidated structure of the logical data model is illustrated in Figure 2.

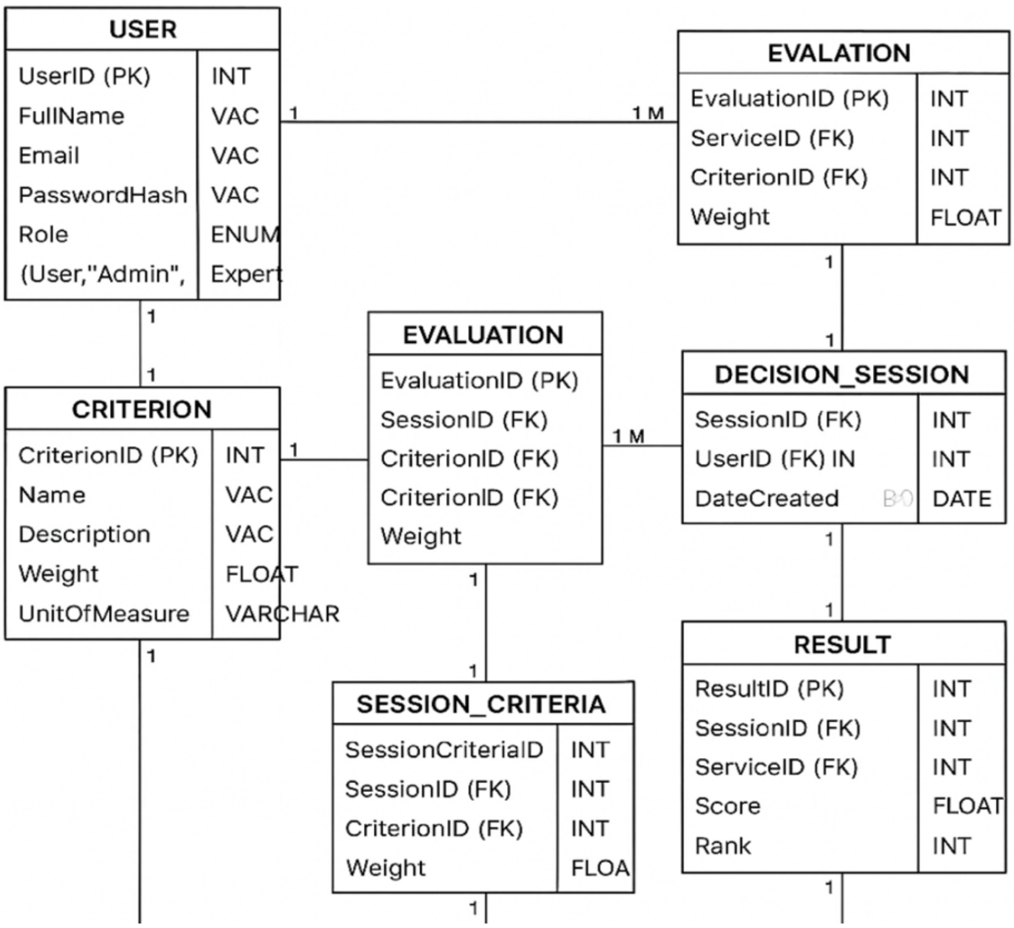


*Figure 2 – Logical ER Model of Decision Support System Data*

The design of the decision support system's operational algorithm is based on the sequential execution of stages, including input data collection, preliminary processing, multi-criteria evaluation, result aggregation, and the generation of output information for the user.

The correct functioning of the decision support system for selecting cloud services is ensured through the coordinated interaction of its components via defined data exchange protocols and internal communication interfaces. The formalisation of interaction mechanisms is crucial for ensuring system stability, scalability, integration compatibility, and information processing security.

The overall interaction logic between software system components is based on the principle of isolating logical modules that communicate through clearly defined interfaces. Standardised data exchange protocols are employed to guarantee compatibility when integrating external information sources and synchronising internal system modules. This defines the structure of the main information flows within the system.

Information is transmitted from the user to the system core through the user interface module. Data entered by the user is sent to the business logic component via REST API. The business logic component interacts with the data access subsystem using standardized database queries executed through the ORM layer.

Interaction with external data providers is handled through API connectors, which supply up-to-date parameters of alternative cloud services in JSON or XML formats. The data parsing module processes the received responses and converts them into the system's internal unified format.

Particular attention is given to the mechanisms for transferring intermediate results between the modules responsible for normalisation, calculation of integral assessments, and aggregation of results. For internal interactions, an object-oriented data transfer structure is used via serialized DTO (Data Transfer Object) structures, ensuring controlled data transfer without duplication. To ensure secure system operation, API access is restricted through an authentication module implementing the OAuth 2.0 protocol for managing user access sessions. Developing a decision support system for selecting cloud services requires the use of optimal programming tools that provide flexibility in implementing the architecture, support modern software development approaches, and enable effective integration with external systems. The choice of the development environment is determined by the need for stable operation, advanced debugging capabilities, integrated database support, and convenient use of libraries implementing multi-criteria analysis algorithms.

The integrated development environment PyCharm was selected as the primary development platform, offering full support for the Python programming language, which serves as the foundation for the entire system. PyCharm supports integration with version control systems, provides extensive code refactoring, debugging, and testing capabilities, and allows working with virtual environments, which is essential for isolating project dependencies. Using Python together with scientific computing and machine learning libraries provides a flexible toolkit for implementing decision-making algorithms.

To verify the performance of the developed decision support system for selecting cloud services, comprehensive testing of all major functional modules of the software was carried out. Testing was conducted in a controlled environment using real input data, closely approximating the conditions of practical use in an organizational setting.

The main objective of the testing was to validate the correctness of input parameter entry, normalisation data processing, execution of multi-criteria evaluation algorithms, ranking of alternatives, and report generation, as well as to assess the stability of the software under varying load conditions. The implementation of the decision support system for selecting cloud services involves a series of tasks related to deploying software modules, configuring the execution environment, ensuring component connectivity, and integrating with external data sources.

According to the proposed architectural model, the system is deployed in a distributed environment consisting of multiple interacting components: a client device, an application logic server, a database server, and external APIs of cloud service providers. A general diagram of the physical deployment model of the system is shown in Figure 3.

The client device serves as the primary point of access for users to the system. Interaction with the system is performed via a web browser or a specialised client application, both of which communicate with the application server over a secure HTTPS protocol.

The application server comprises a web server (implemented, for example, using Nginx, Apache, or Node.js), business logic modules, an authentication module, and an API controller. These components handle all user requests, manage the system's operational logic, and perform all algorithmic calculations related to criteria processing, normalisation, and ranking.

The database server is responsible for storing all essential information objects, including users, criteria, alternatives, decision sessions, evaluations, and final results. PostgreSQL or MySQL is employed as the database management system, supporting table collections grouped according to logical entities.

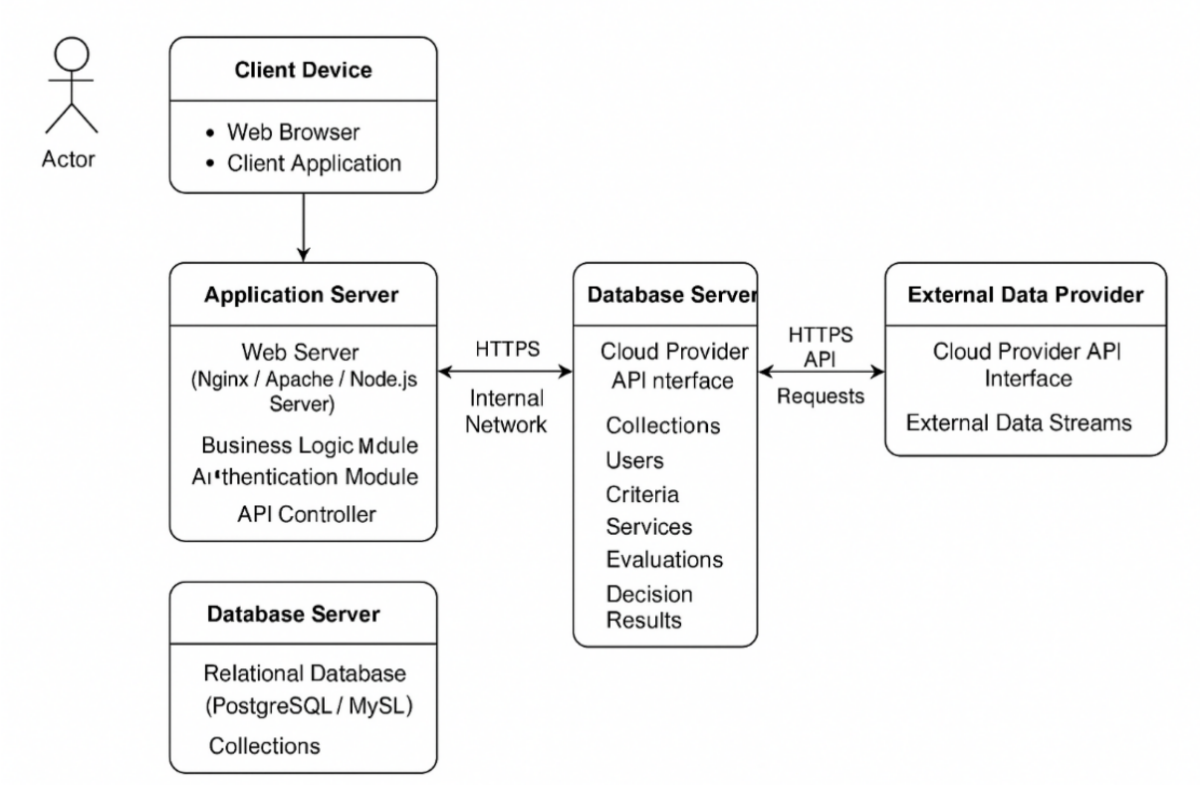


*Figure 3 – Deployment Diagram of the Decision Support System*

Integration with external data providers is conducted via secure HTTPS API channels, ensuring the timely updating of cloud service characteristics through the Cloud Provider API.

**Conclusions**. In the course of this work, a software system for decision support in selecting cloud services for organizational needs was developed, theoretically substantiated, and practically implemented. A comprehensive analysis of the subject area was conducted, taking into account current trends in cloud technology development and methods for multi-criteria evaluation of alternatives. Existing approaches to formalizing decision-making processes in the field of cloud computing were examined, existing solutions were classified, and their limitations were identified, highlighting the relevance of developing a custom adaptive model. UML diagrams of the subject area were created, and principles for organizing interactions among users, administrators, and external information sources were defined. The proposed model supports the processing of a wide range of criteria using various algorithmic methods of multi-criteria evaluation, such as AHP, TOPSIS, and ELECTRE.

The practical part of the work involved the development of software modules using Python in the PyCharm environment, employing the NumPy, Pandas, Scikit-learn, and SQLAlchemy libraries, as well as the PostgreSQL database system. Functional interaction between the client application, the application logic server, and the data storage was implemented via REST API with secure authentication. A graphical user interface was developed and tested, providing intuitive interaction with criteria, weighting coefficients, calculation of rating scores, and report generation. Functional testing confirmed the system's operability across the complete cycle of input data processing, computation of integral assessments, and presentation of results to the user. High calculation accuracy was achieved, with a maximum error not exceeding 0.05%. Additionally, an evaluation of the system's energy consumption under various operating modes demonstrated its energy efficiency and capability for long-term stable operation in both standalone and server environments.

The scalability analysis demonstrated that the developed system maintains linear performance stability even as the volume of processed data increases, ensuring effective operation in both small corporate and large inter-organizational infrastructures. The proposed system is adaptable to a wide range of usage scenarios, exhibiting flexibility in the configuration of algorithms and data processing parameters according to user requirements.

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## СТВОРЕННЯ ХМАРНОГО ІТ-СЕРЕДОВИЩА В ОРГАНІЗАЦІЯХ

***Анотація.*** *Сучасний розвиток інформаційних технологій зумовлює активне впровадження хмарних обчислень у різні сфери діяльності організацій. Різноманітність хмарних сервісів, їх провайдерів та сервісних моделей потребує обґрунтованого вибору оптимальних рішень, що максимально відповідають потребам конкретної організації з урахуванням економічних, технічних, функціональних і безпекових критеріїв [1]. Вибір відповідної конфігурації хмарних сервісів є складним завданням, оскільки потребує врахування значної кількості змінних параметрів та ризиків. Традиційні підходи, засновані на експертних оцінках, є недостатньо ефективними у складних динамічних умовах ринку, що обумовлює актуальність автоматизованих систем підтримки прийняття рішень у цій сфері.*

*Одним з етапів створення хмарного ІТ-середовища в організаціях є розробка системи підтримки прийняття рішень, яка дозволяє забезпечити структурований аналіз доступних альтернатив, використовуючи математичні моделі багатокритеріального аналізу. Застосування таких методів дає змогу формалізувати процес порівняння варіантів, враховувати численні параметри та приймати обґрунтовані управлінські рішення. Водночас розробка подібних систем супроводжується низкою технічних труднощів, зокрема, щодо забезпечення коректної обробки вхідних даних, оптимального вибору методів оцінювання та побудови гнучкої архітектури, здатної адаптуватися до специфічних вимог користувача.*

***Ключові слова****: системи підтримки прийняття рішень (СППР), хмарні сервіси, ІТ-середовище.*