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REQUIREMENTS MANAGEMENT MODEL FOR ANALYTICAL ACCOUNTING SYSTEMS BASED ON CLOUD INFRASTRUCTURE

МОДЕЛЬ КЕРУВАННЯ ВИМОГАМИ В АНАЛІТИЧНИХ СИСТЕМАХ ОБЛІКУ НА ОСНОВІ ХМАРНОЇ ІНФРАСТРУКТУРИ

Popereshnyak S.V.
c.ph.-m.s., as. prof.
ORCID: 0000-0002-0531-9809
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
Kyiv, Beresteyskyi Avenue, 37, 03056
Korniienko O. O.
postgraduate
ORCID: 0009-0006-9289-7995
Institute of Software Systems of the National Academy of Sciences of Ukraine,
Kyiv, Akademika Glushkova Avenue, 40, 03187
Viunnik Y.O.
postgraduate
ORCID: 0009-0002-3213-8058
Institute of Software Systems of the National Academy of Sciences of Ukraine,
Kyiv, Akademika Glushkova Avenue, 40, 03187

Abstact. *This paper proposes a requirements management model for analytical accounting systems based on cloud infrastructure, aimed at ensuring adaptability, scalability, and consistency between business requirements, analytical functionality, and infrastructure resources. The model represents requirements as formalized entities characterized by type, priority, life-cycle state, and traceability to analytical and architectural components. A key feature of the proposed approach is the explicit integration of requirements management with cloud service layers (IaaS, PaaS, SaaS), enabling dynamic adaptation through resource scaling and service reconfiguration without system downtime.*

The requirements management process is implemented as an iterative cycle that includes formalization, prioritization, traceability, and continuous adaptation based on feedback from system operation. An experimental validation was conducted using a prototype analytical accounting system deployed in a cloud environment. The results demonstrate a significant reduction in system adaptation time to changing business requirements, improved query response times, increased system availability, and more efficient utilization of computational resources compared to a baseline approach without structured requirements management.

The proposed model can serve as a conceptual foundation for the design and modernization of cloud-based analytical accounting systems, supporting more efficient system evolution and higher-quality managerial decision-making in dynamic business environments.

Key words: *requirements management, analytical accounting systems, cloud infrastructure, requirements traceability, cloud scalability, business requirements, analytical systems, adaptive systems*

Introduction.

Modern analytical accounting systems are key components of the information infrastructure of enterprises and organizations, providing support for managerial

decision-making based on the processing of large volumes of structured and semi-structured data. The conditions of digital transformation, continuous growth of data volumes, and the dynamic nature of the business environment necessitate ongoing refinement and revision of requirements for such systems.

At the same time, cloud infrastructure is increasingly adopted as the primary deployment environment for analytical accounting systems, as it offers scalability, resource elasticity, and reduced administrative costs. However, migrating systems to cloud environments complicates requirements management processes, since requirements must account for distributed architectures, dependencies on cloud service providers, and the need for continuous functional adaptation.

In traditional requirements management approaches, the primary focus is placed on the design phase, whereas in cloud-based environments the requirements life cycle becomes a continuous process. This creates the need to develop models that integrate requirements engineering with the characteristics of cloud architectures and analytical data processing.

Analysis of Recent Research and Publications.

Issues of requirements management in information systems are addressed in studies related to software engineering, information system architecture, and business analysis. Contemporary research emphasizes the need to reduce the gap between business requirements and the technical implementation of systems, especially in distributed and cloud-based environments.

A separate line of research focuses on the use of cloud infrastructure for building analytical systems, addressing scalability, reliability, and administrative efficiency. At the same time, in most studies requirements management is considered independently of the architectural characteristics of cloud platforms, which complicates the practical application of such approaches in accounting and analytical systems.

The integration of requirements management processes with analytical modules of accounting systems deployed in cloud environments, as well as the support for requirements traceability throughout the entire system life cycle, remains insufficiently explored. This determines the relevance of developing a generalized model oriented

toward analytical accounting systems operating on the basis of cloud infrastructure.

The purpose of this study is to develop a requirements management model for analytical accounting systems based on cloud infrastructure, which ensures adaptability to changing business requirements, scalability, and consistency between system development and operational processes.

Conceptual Model of Requirements Management

Analytical accounting systems operating on cloud infrastructure are characterized by complex multi-layer architectures, distributed data storage, and dynamic usage scenarios. Under such conditions, requirements management should be considered not as a one-time design activity, but as a continuous process integrated into the system life cycle.

The proposed requirements management model is based on representing requirements as a formalized set

$$R = \{r_1, r_2, \dots, r_n\},$$

where each requirement r_i is described by the tuple

$$r_i = \langle t_i, p_i, s_i, a_i \rangle,$$

where t_i denotes the requirement type (business, functional, non-functional, analytical), p_i is the priority, s_i represents the life-cycle state (proposed, agreed, implemented, validated), and a_i corresponds to the related architectural or analytical component of the system.

A key feature of the model is the tight coupling between requirements and cloud infrastructure, which enables consideration of constraints and capabilities at the IaaS, PaaS, and SaaS levels. Requirements define not only the functionality of the analytical accounting system but also influence the selection of data storage, processing, and scaling mechanisms. Thus, each requirement is traceable to a corresponding infrastructure resource or cloud service.

The requirements management process within the model is implemented as an iterative cycle that includes requirement formalization, prioritization, negotiation, and adaptation. Formalization ensures unambiguous interpretation of requirements by all stakeholders, while prioritization determines the order of implementation based on

business value and cloud infrastructure resource constraints.

An important component of the model is the traceability mechanism that establishes links between requirements, analytical modules, and accounting data. Let

$$A = \{a_1, a_2, \dots, a_m\}$$

be the set of analytical components of the system. Then, the mapping

$$f: R \to A$$

defines the correspondence between requirements and specific components, enabling the assessment of the impact of requirement changes on system architecture and analytical processing results.

Requirements adaptation in a cloud environment is achieved through dynamic reconfiguration of services and resources without interrupting system operation. This allows analytical accounting systems to respond promptly to changes in business processes, data volume growth, or new reporting requirements. Consequently, the model supports flexibility and scalability principles that are fundamental to cloud-based solutions.

The proposed approach ensures coordinated management of requirements, analytical functions, and infrastructure resources, contributing to improved productivity in the development of analytical accounting systems and enhanced quality of managerial decision-making. The model can be used as a conceptual foundation for the design and modernization of cloud-based information and analytical systems.

Requirements Management Model Diagram Description

To formalize the proposed approach to requirements management in analytical accounting systems operating in a cloud infrastructure environment, a generalized structural model has been developed. The model reflects the relationships between business requirements, functional components of the analytical system, and cloud infrastructure resources. It is designed to support the full requirements life cycle, from elicitation and prioritization to implementation, monitoring, and feedback-driven refinement. The overall scheme of the requirements management model is presented in Fig. 1. This model consists of three logically interconnected layers. The upper layer represents business requirements formed by stakeholders and structured as a

requirements catalog containing constraints, quality attributes, and service-level objectives. These requirements are processed by the requirements management subsystem, where formalization, prioritization, state control, and change management are performed to ensure consistency and readiness for implementation.

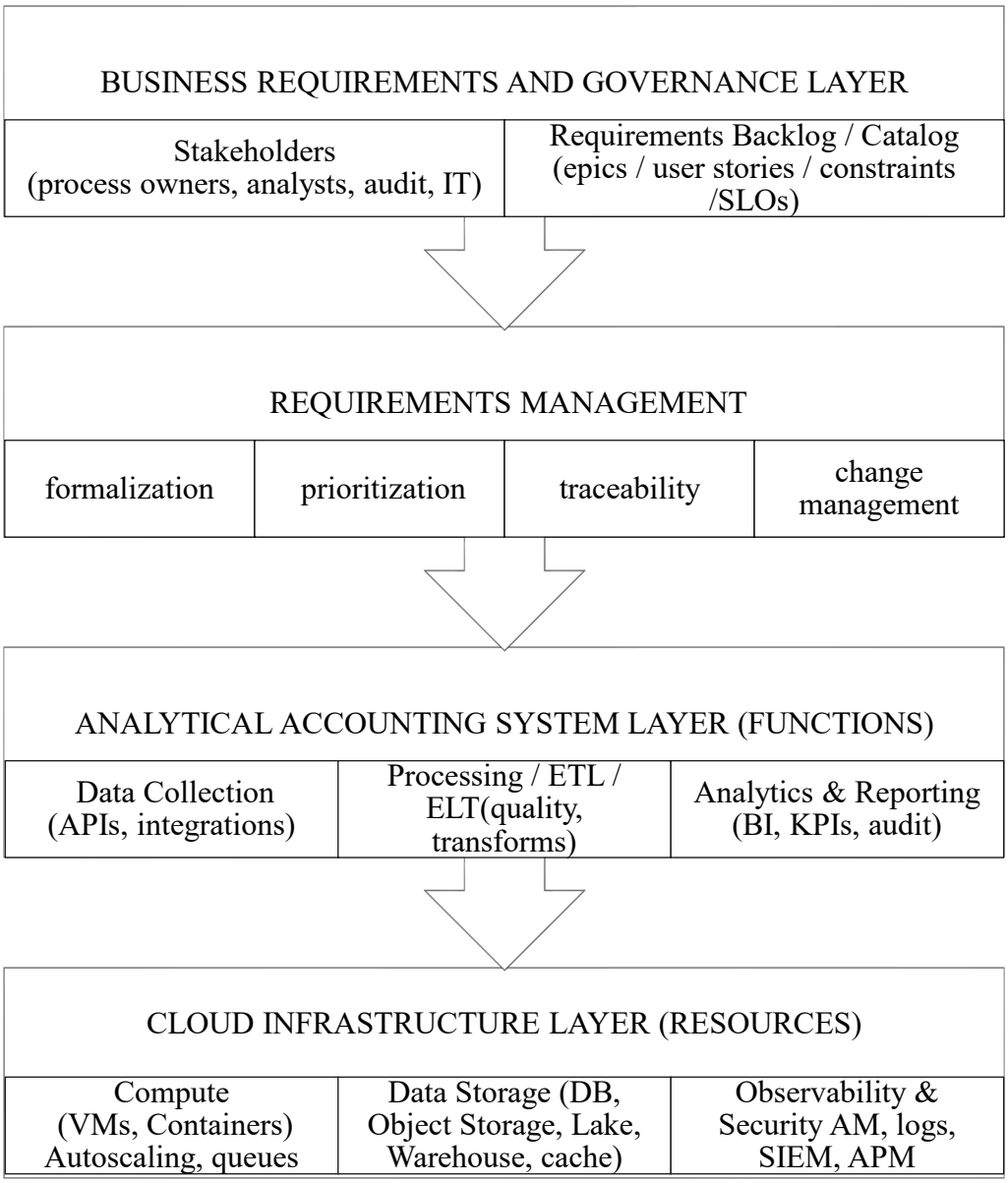

Figure 1 – Requirements Management Model for Cloud-Based Analytical Accounting Systems

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The central layer corresponds to the analytical accounting system, which includes data collection, processing, and analytical modules. At this level, business requirements are mapped to specific analytical functions, and traceability is maintained between requirements and system components. This mapping enables systematic

impact analysis when requirements evolve.

The lower layer represents the cloud infrastructure, encompassing compute resources, data storage services, scalability mechanisms, observability tools, and security controls. The linkage between the analytical layer and cloud infrastructure enables dynamic adaptation of the system through resource scaling, configuration changes, or workload redistribution without interrupting system operation.

Feedback loops shown in the model emphasize its iterative nature. Operational metrics, analytical results, and infrastructure constraints are continuously fed back into the requirements management process, enabling refinement and reprioritization of requirements. This approach ensures coordinated management of requirements, analytical functionality, and cloud resources, enhancing system adaptability, development productivity, and alignment with real operational conditions.

Experimental Validation and Application Example

The experimental validation of the proposed requirements management model for cloud-based analytical accounting systems was conducted using a prototype information and analytical system designed to support operational performance monitoring of a service-oriented enterprise. The system was applied to generate management analytics related to financial transactions, staff workload, and key performance indicators of business processes.

Application Example of the Model. As an application scenario, a change in business requirements for an analytical report was considered: reducing the acceptable generation time of a daily report from 10 minutes to 2 minutes and increasing the data refresh frequency from once per day to once per hour. Within the proposed model, these requirements were formalized at the requirements management level and automatically translated into decisions regarding the scaling of computational resources and the configuration of analytical services within the cloud infrastructure.

Figure 1 presents a generalized scheme of the experimental validation of the requirements management model for cloud-based analytical accounting systems. The starting point of the process is business requirements, which define the expected system behavior in terms of performance, availability, and analytical granularity.

The formalized requirements are passed to the requirements management module, where prioritization, traceability, and transformation into technical parameters of analytical components are performed. Subsequent execution takes place within the cloud infrastructure, which provides dynamic scaling and allocation of the required resources.

The results of analytical query execution are evaluated using predefined quality and performance metrics. Based on these measurements, a feedback loop is formed and used to adjust both requirements and system configurations. The overall logic of the experimental pipeline is illustrated in Fig. 2.

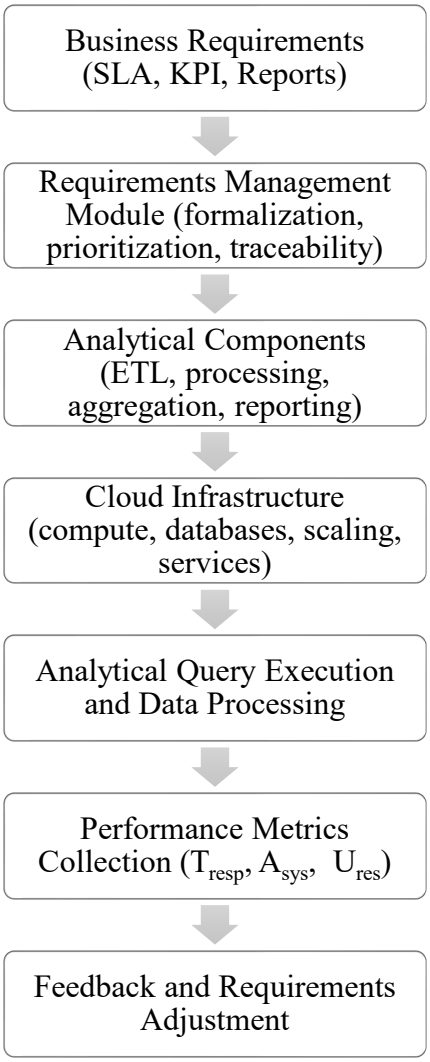

Figure 2 – Experimental validation scheme of the requirements management model

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The scheme illustrates how changes at the business requirements level affect the configuration of analytical modules and cloud infrastructure resources, while execution results are returned to the management system in the form of measurable indicators.

Evaluation Metrics. To quantitatively assess the effectiveness of the proposed model, the following metrics were used:

- T_{req} — average time required to implement changes in business requirements (hours);
- T_{resp} — average response time of analytical queries (seconds);
- A_{sys} — system availability (%);
- U_{res} — utilization rate of computational resources (%);
- Δ_{conf} — number of manual infrastructure configuration changes required after requirements modification.

The main experimental results are summarized in Table 1.

Table 1 – Comparison of analytical system performance indicators

Metric	Without requirements management model	With proposed model
T_{req}, h	6–8	1–2
T_{resp}, s	4,5	1,2
A_{sys}, %	96,8	99,2
U_{res}, %	85	65
Δ_{conf}	High	Minimal

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The obtained results demonstrate that the application of the proposed model significantly reduces system adaptation time to new business requirements and decreases infrastructure load through more efficient resource utilization.

Analysis of Experimental Results.

The reduction in analytical query response time and the increase in system availability confirm the effectiveness of integrating requirements management with cloud infrastructure scaling mechanisms. Particularly notable is the decrease in the

number of manual configuration changes, which indicates a higher level of automation in administration processes and a reduced risk of human error.

Thus, the experimental validation confirms that the proposed model is practically applicable to analytical accounting systems operating in dynamic environments and requiring rapid adaptation to evolving business requirements.

Conclusions

This paper presents a requirements management model for analytical accounting systems deployed on cloud infrastructure, aimed at ensuring adaptability, scalability, and consistency between business requirements, analytical functionality, and infrastructure resources. Unlike traditional approaches that treat requirements management as a one-time design activity, the proposed model considers it as a continuous, iterative process integrated throughout the system life cycle.

The model formalizes requirements as structured entities linked to analytical components and cloud services, enabling systematic traceability and impact analysis. By coupling requirements management with cloud infrastructure capabilities, the model supports dynamic adaptation through resource scaling and service reconfiguration without interrupting system operation. This approach aligns requirements engineering with the inherent flexibility of cloud-based architectures.

Experimental validation using a prototype analytical accounting system demonstrated a significant reduction in system adaptation time to changing business requirements, improved query response times, increased system availability, and more efficient utilization of computational resources. The reduction in manual infrastructure configuration changes further confirms the effectiveness of automating requirements-driven adaptation mechanisms.

The obtained results indicate that the proposed model is practically applicable to analytical accounting systems operating in dynamic business environments. It can serve as a conceptual foundation for the design and modernization of cloud-based information and analytical systems, supporting informed managerial decision-making and improving the overall efficiency of system development and operation.

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Анотація. *Сучасні аналітичні системи обліку відіграють ключову роль у підтримці управлінських рішень підприємств і організацій, забезпечуючи оброблення значних обсягів*

структурованих і напівструктурованих даних. Умови цифрової трансформації, зростання обсягів інформації та динамічність бізнес-середовища зумовлюють постійну зміну вимог до таких систем. Одночасно активне впровадження хмарної інфраструктури як базового середовища розгортання аналітичних систем підвищує вимоги до гнучкості, масштабованості та ефективності керування ресурсами, але водночас ускладнює процеси керування вимогами через розподілену архітектуру та залежність від хмарних сервісів.

Аналіз сучасних наукових публікацій показав, що більшість існуючих підходів до керування вимогами зосереджені переважно на етапі проєктування систем і недостатньо враховують безперервний характер життєвого циклу вимог у хмарному середовищі. Недостатньо опрацьованими залишаються питання інтеграції процесів керування вимогами з аналітичними модулями облікових систем та підтримки наскрізного трасування вимог упродовж усього життєвого циклу системи.

Метою дослідження є розроблення моделі керування вимогами в аналітичних системах обліку на основі хмарної інфраструктури, яка забезпечує адаптивність до змін бізнес-вимог, масштабованість та узгодженість між процесами розроблення й експлуатації системи. Запропонована модель ґрунтується на формалізованому представленні вимог як структурованої множини з визначеними атрибутами типу, пріоритету, стану життєвого циклу та відповідності аналітичним і архітектурним компонентам системи. Ключовою особливістю моделі є тісний зв'язок між вимогами та рівнями хмарної інфраструктури (IaaS, PaaS, SaaS), що дозволяє враховувати інфраструктурні обмеження й можливості під час реалізації аналітичної функціональності.

Процес керування вимогами реалізується у вигляді ітеративного циклу, який включає формалізацію, пріоритизацію, трасування та адаптацію вимог на основі зворотного зв'язку від експлуатаційних метрик. Запропонована структурна схема моделі відображає взаємозв'язки між бізнес-вимогами, аналітичними компонентами системи та ресурсами хмарної інфраструктури, забезпечуючи узгоджене керування функціональністю та ресурсами.

Експериментальну перевірку моделі проведено на прикладі прототипу аналітичної системи обліку операційних показників сервісного підприємства, розгорнутої у хмарному середовищі. Оцінювання ефективності виконувалося за метриками часу реалізації змін вимог, часу відповіді аналітичних запитів, доступності системи, рівня використання ресурсів та кількості ручних інфраструктурних змін. Результати експериментів показали істотне скорочення часу адаптації системи до нових бізнес-вимог, зменшення навантаження на інфраструктуру та підвищення стабільності роботи системи порівняно з підходом без формалізованого керування вимогами.

Отримані результати підтверджують практичну придатність запропонованої моделі для аналітичних систем обліку, що функціонують у динамічних умовах. Модель може бути використана як концептуальна основа для проєктування та модернізації хмарних інформаційно-аналітичних систем, сприяючи підвищенню ефективності розроблення та якості управлінських рішень.

Ключові слова: *управління вимогами, аналітичні облікові системи, хмарна інфраструктура, відстежуваність вимог, масштабованість хмари, бізнес-вимоги, аналітичні системи, адаптивні системи*

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