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ISSUES AND PROSPECTS OF INTEGRATING RELATIONAL DATABASES WITH CLOUD TECHNOLOGIES

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ABSTRACT

The integration of relational databases into cloud computing environments is characterized by the rapid growth of data volumes, the need to ensure flexibility, scalability and high performance of information management systems. Given that cloud technologies allow organizations to quickly adapt infrastructure to changing loads, integrate transactional and analytical processes, increase the efficiency of business processes and minimize operating costs; integration of RDBMS with cloud services is becoming a key factor in ensuring sustainability, security and competitiveness of organizations. The purpose of this article is to systematically analyze the current challenges of integrating relational databases into cloud computing environments and to identify promising areas for their development, considering technological and organizational aspects. The study applies to a set of methods that provides a systematic and reasonable assessment of the integration of relational databases into cloud environments. The forecasting method was used to outline the market prospects and growth dynamics of corporate data in the cloud; methods of synthesis, systematization and generalization were used to classify architectural models, analyze technical, economic and security aspects and identify key development trends; and a comparative analysis of cases of leading cloud RDBMS providers allowed to assess the effectiveness of real implementation; which provides a holistic view of the problem and forms a methodological basis for a reasonable choice of integration models. According to the report, the amount of enterprise data being stored in the cloud is increasing in tandem with the steady growth of the global cloud computing market. This demonstrates the importance of cloud solutions for strategic planning and the speed at which businesses are digitizing. Cloud-native, hybrid, multi-cloud, and microservice models that offer cost-effectiveness, technical agility, and security are all options for relational database integration into the cloud. AI-driven management, serverless architectures, and containerization all boost productivity by enabling real-time data flow optimization. It is suggested that a successful integration approach for RDBs into the cloud can be established based on adaptability (flexibility), autonomy, and interoperability, ensuring strategic flexibility of organizations. Leveraging data fabric, data mesh, and autonomous AI-driven solutions, classic management logic is transformed from one of reactive administration to one of proactive load prediction. This multi-dimensional strategy drives digital transformation efficiency and forms the competitive capabilities of today's enterprises.

I. INTRODUCTION

In the information-led and digitized world of the day, all kinds of organizations – commercial, public sector, and education providers – are faced with a burgeoning scale of data needing to be managed efficiently, effectively, and securely. The total size of global data storage is predicted to reach over 200 zettabytes by the end of 2025, according to Cybersecurity Ventures [1] – this includes data that is stored on private and public IT infrastructures, utility infrastructures, private and public cloud data centers, personal computing devices – personal computers (PCs), laptops, tablets, and smartphones – and Internet of Things (IoT) devices. This requires relational database management systems to be extended to work with cloud environments to enable elasticity, operational analytics, and business process continuity. Cloud offerings like DBaaS also empower businesses to save on operational expenses and boost efficiency without compromising on SLAs even as they bridge traditional transactional systems with real-time analytics and machine learning, as seen in Oracle Autonomous Database, Amazon Aurora Serverless, and Google Cloud Spanner [2], [3].

Furthermore, data security in the cloud, access control, GDPR and ISO 27001 compliance, and vendor lock-in risk need to be managed and impose further architectural and organizational restrictions [4]. The purpose of this research article is to perform a comprehensive review of techniques for processing and integrating relational databases in cloud computing platforms and determine feasible research directions for both technological and organizational aspects. The novelty of this study lies in the fact that we present a general comparison among architectural styles such as cloud-native, hybrid, multi-cloud, and API/microservices; the top DBaaS providers (Amazon RDS/Aurora, Azure SQL Database, Google Cloud SQL/Spanner, and Oracle Autonomous Database); as well as emerging trends like AI-powered database management, serverless approach, containerization, and data fabric and data mesh paradigms.

II. LITERATURE REVIEW

II.1 THEORETICAL BACKGROUND TO CLOUD COMPUTING AND INTEGRATION WITH RELATIONAL DATABASES

II.1.1 Development of Cloud Technologies (IAAS, PAAS, SAAS, DBAAS) in Data Management

The evolution of cloud computing has witnessed a series of expansions in the range and size of data center services, leading toward scalable, distributed data game platforms for data center infrastructure and computing resource delivery. According to [5] reviewed the nature of IaaS, PaaS, and SaaS-based cloud service models, which have become the basis for building modern infrastructure and application solutions. Opinions of the authors to have flexibility regarding resources and virtualization in the first place gave rise to the "as-a-service" model, which finally culminates in efficient management of a database in distributed systems. In [6] narrate the transition from traditional data centers to cloud formation using the Microsoft SQL Server case study. They concluded that DBaaS is a key mid-layer between traditional on-premises solutions and the advanced cloud databases and allows users to take advantage of automated management, service reliability, and lower operational expenses.

The security issues of DBaaS have already been discussed widely by [7], [8], who also argue that outsourcing the managing of databases to a third-party cloud service provider compromises the confidentiality of data, user authentication, and access control. Later on, through the transition to this web-scale model, governed by the as-a-service logic, it came to be more about a general transformation of the IT landscape – as firm on-premises architectures gave way to malleable and elastic cloud systems, where data was emerging as the essential material of the digital economy, as indicated by [9]. The evolution of relational databases to a new type of computing platform is made possible by that of cloud computing techniques, which result in the enhancement of the performance, scalability, and information flow management.

II.1.2 Characteristics of Relational Databases in Traditional Architectures

Relational databases are the cornerstone of data management that is structured, complete, and secure in traditional architectures when it comes to computing. Relational databases have long been a staple for structured, complete, and controlled data processing in classical computing environments. According to [10], the primary concept of these systems is the storage of data in tables and relations, which allows one to easily search, group, and summarize data with SQL. According to [11] states that a database schema is a blueprint or an outline that represents the organization of data in the form of the database design of the fields, tables, views, etc., of the database.

In fact, the ACID properties (atomicity, consistency, isolation, and durability) constitute the backbone of dependable transactional systems, which uphold this integrity [12]. Indexes and integrity constraints also improve the performance and correctness of queries, and the SQL standard supports complex analytical queries and procedures. Indeed, classical relational systems [13] are known to have scale-up constraints, which become more critical with increasingly massive data sizes and numbers of concurrent transactions. This pushes for mixing approaches, for moving relational structures to the cloud, where horizontal scaling and more flexible load balancing can be supported.

II.1.3 Principles of Compatibility of Relational Structures with Cloud Architecture

The porting of relational databases to cloud platforms must follow certain architectural paradigms to be compatible, dependable, and efficient. Because cloud software development should be guided by the principles of modularity, scalability, fault tolerance, and distributedness, as [14] state, this results in the attribute set for relational systems in the cloud. Following hybrid cloud models, by [4] states that a seamless integration of private and public clouds is a must for ensuring access to critical data without impeding productivity.

So, Muppala, and other new modern SQL platforms that seem to be heading in the direction of cloud-predicated architectures that are designed for distributed computing, query caching, and dynamic scaling. The interaction of distributed systems and cloud computing is considered by [15] as the foundation of the data architectures in the future, with centralized control being replaced with decomposed services. The concept of multi-cloud resilience [16] validates this statement, including the integration of distributed ledgers (DLT) and synchronization protocols across platforms to maintain data continuity and consistency.

According to [17] develops the principles of cloud-native database under the separation of relational structure from application through microservice style and containerization; this enables automatic scaling and adaptive load balancing, which allows relational databases to be active players in the cloud environment.

II.1.4 Comparison with NoSQL and NewSQL Systems: Advantages, Disadvantages, Compromise Approaches

Relational systems vis-à-vis NoSQL and NewSQL databases comparison demonstrates that the scientific community established a goal to balance data structure and scalability. In [18] Traditional SQL systems provide stability and transactional accuracy, and LazyBox noSQL offers high performance and flexibility of the data structure, especially for large unstructured volumes. According to [19] characterize the NewSQL systems as a middle ground that retains transactional consistency of traditional relational databases while providing scalability of NoSQL by utilizing multi-model architectures and query optimization.

In turn, by [20] verify through empirical tests that SQL solutions hold consistent performance in the most demanding business applications, while in rapidly changing web-based applications, NoSQL solutions exceed themselves and are seemingly more suitable. In [21] observe contrasting behaviors between relational and NoSQL databases when processing data in parallel. SQL is more effective in maintaining transaction integrity, while NoSQL is more scalable than Type with the number of threads. Hence, the end state of cloud database integration is not leaving the relational model behind in search of some new variety of non-relational schema design but letting (transparent) hybrids of relational and non-relational models to take the dance of consistency, availability, and performance to new scales.

III. METHODS

In the process of studying the integration of relational databases into cloud environments, a set of scientific analysis methods was applied:

- the synthesis method combined the results of analytical reviews, implementation cases, and market reports to form a holistic view of modern architectural approaches and technological trends in the field of DBaaS, serverless infrastructures, containerization, and AI-driven management;
- the forecasting method was used to assess the dynamics of the global cloud computing market and the share of corporate data in the cloud, which provided the basis for formulating the prospects for the development of integration architectures in the long term;
- a comparative analysis of cases of leading corporations (Oracle Autonomous Database, AWS Aurora, Google Cloud Spanner, IBM Data Fabric, Netflix Data Mesh) was used to assess the practical effectiveness of implementing cloud relational systems, which allowed comparing the declared performance indicators, resource savings, reduction of service time and SLA compliance with real implementations.
- the systematization method allowed us to classify integration models (cloud-native, hybrid, multi-cloud, microservice and API-first approaches), compare their technical, economic and security characteristics and create a generalized comparison matrix for further analysis;
- the generalization method made it possible to identify key patterns in the development of relational database integration, in particular the trend towards the creation of unified analytical environments (Data Fabric) and decentralized models of data management (Data Mesh), as well as the transition from manual administration to autonomous management based on machine learning.

IV. RESULTS

In the current context of digital transformation and rapid development of information technology, cloud computing is becoming a fundamental component of the strategic development of organizations in all sectors of the economy. The implementation of cloud solutions allows enterprises to ensure high flexibility of IT infrastructure, operational scalability of resources and integration of analytical platforms for making informed management decisions in real time. One of the key indicators of the development of cloud technologies is the dynamics of the global cloud computing market and the share of corporate data stored in the cloud. Thus, the analysis of the dynamics of the global cloud computing market for the period 2024–2034 shows a steady trend of exponential growth.

Thus, in 2024, the market volume was estimated at USD 912.77 billion, while by 2034 it is projected to reach USD 7473.31 billion (Figure 1). This indicates a more than eightfold increase in the market over the course of one decade, reflecting the active digitalization of the economy, the spread of remote work, the large-scale implementation of SaaS solutions, and the transition of corporate and government organizations to cloud services. The high compound annual growth rate (CAGR) during 2026–2034, particularly in the projection period, shows that cloud platforms have a strategic importance in ensuring business stability and competitiveness of the enterprises.

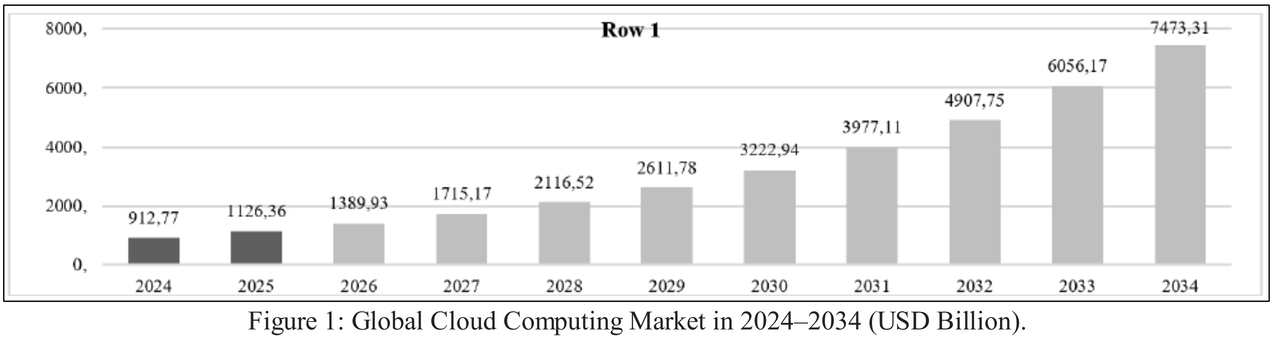

Figure 1: Global Cloud Computing Market in 2024–2034 (USD Billion).
Source: [22].

Note: data for 2026–2034 are forecasted.

Additionally, the analysis of the share of corporate data stored in the cloud shows a steady increase from 30% in 2015 to 68.66% in 2025 (Figure 2). The growth of this indicator reflects the technological adaptation of organizations and changes in data management practices and corporate IT strategy. In particular, there is an active implementation of cloud solutions to ensure the continuity of business processes, increase the flexibility of IT infrastructure and integrate analytical platforms for real-time decision-making.

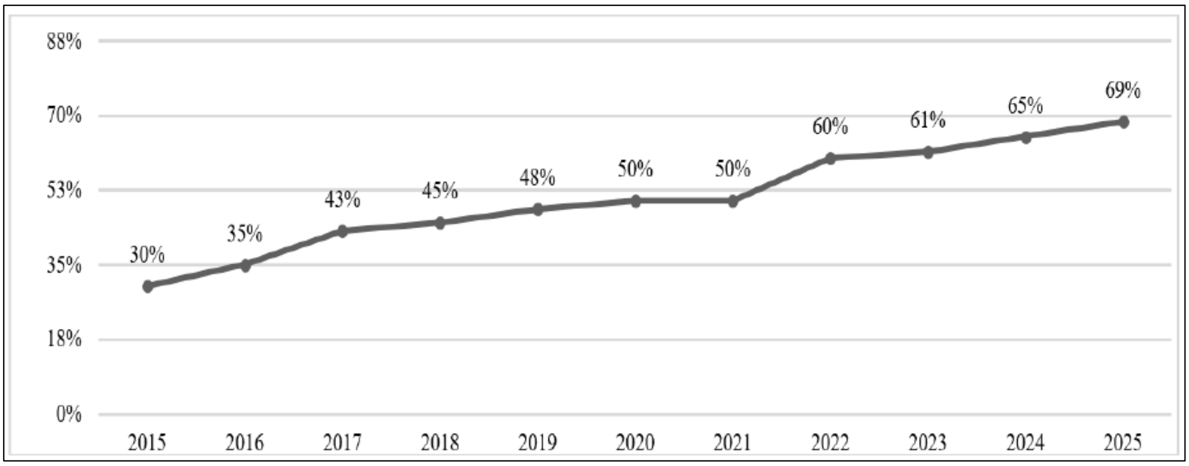

Figure 2: Share of Corporate Data Stopped in the Cloud Over Time.
Source: [23].

Note: data for 2023–2025 are forecasted.

Taking into account these trends, it becomes obvious that a systematic approach to the selection of architectural models for integrating relational databases in cloud environments is needed. Architectural models of integration include:

I. Full migration of relational databases to the cloud involves the use of "cloud-native" relational services that natively implement distributed storage, replication, transaction management and automatic scaling mechanisms. Analytical estimates of the market indicate a rapid growth in demand for cloud-native database solutions: according to market reports, the cloud-native database market is showing double-digit CAGR and was already estimated at billions of dollars in 2024, reflecting the intensification of migration projects and investments in DbaaS [24]. Technically, cloud-native Relational Database Management System (RDBMS) is characterized by horizontal scalability (sharding/partitioning), multi-site replication with consistency at the level of configurable SLAs, automatic disaster recovery, and integration with cloud provider services (monitoring, encryption keys, IAM). The typical business motive is to reduce TCO through operational automation and speed up time-to-market of analytical and transactional applications. In practice, large organizations (e.g., Capital One) have proven the ability to fully migrate with careful security and regulatory compliance planning [25].

II. The hybrid model remains the most common in sectors with strict regulatory requirements (banking, public sector, healthcare). It combines on-premise transactional systems for critical data with cloud services for analytics, backup, and peak loads. IDC and other analysts report a significant share of enterprises choosing "multi-vector" modernization strategies – about 60% of respondents reported the need for infrastructure transformation in 2024, which reinforces the role of hybrid architectures as an evolutionary step [26]. From a technology perspective, hybrid solutions require data synchronization (logical replication, Change Data Capture), aligned security policies, and network connectivity (VPN, Direct Connect/ExpressRoute). The benefit is control of critical data, but also the ability to take advantage of cloud elasticity for analytics or DR; the downside is operational complexity and a need for synchronized configuration management.

III. Multi-cloud strategies are used to reduce vendor-lock-in risk, optimize cost, distribute workloads, and increase resilience. Large corporations implement multi-cloud patterns as part of their resilience strategy (distribution of critical services between AWS, Azure, GCP). Examples in industry (BMW, Schneider Electric, Uber) demonstrate the practical application of multi-cloud systems for managing configurations, secrets, and traffic between platforms. Multicloud poses the challenge of data consistency and complex transaction management mechanisms in a distributed environment [27].

IV. Architectural practices of microservices and API-first approach allow flexible integration of relational storages as separate service components, which makes it possible to combine different types of databases (SQL, NewSQL, NoSQL) in accordance with the requirements of individual services, with clearly defined access contracts (REST/gRPC). This approach reduces system connectivity and simplifies module evolution, but transactional integrity requirements may dictate the use of orchestration schemes or two-phase protocols in scenarios where ACID is a critical requirement.

V. The tools and functionalities of the leading cloud RDBMS platforms vary depending on the architectural suitability, scaling mechanisms, consistency and security guarantees, namely:

- Amazon RDS/Aurora – provides multi-mode implementations (MySQL-/PostgreSQL-compatible) with automatic replication, "read replica", the ability to scale vertically and limited horizontal scaling (Aurora Serverless, Global Database). The solution is often used to transform large transactional workloads in the cloud; AWS maintains leadership in the cloud infrastructure market, which enhances the ecosystem attractiveness of RDS [28].
- Microsoft Azure SQL Database – offers both "managed instance" and serverless options, deep integration with the Microsoft ecosystem (Active Directory, Power BI) and tools for migration from on-premise SQL Server. Azure is often chosen by enterprises with a high dependence on the Microsoft stack; the platform offers advanced security and management tools [29].

- Google Cloud SQL/Cloud Spanner – Cloud SQL provides managed instances of PostgreSQL/MySQL; Cloud Spanner is an example of a globally distributed, strongly-consistent relational DBMS that combines a SQL interface with horizontal scalability. Spanner shows that relational models can be scaled globally while maintaining strong consistency guarantees [30]. Instead, Spotify, working with Google Cloud, has automated thousands of data pipelines and significantly improved the efficiency of analytics processing (claimed around 300% efficiency improvement in certain computing scenarios), which emphasizes the role of cloud-based relational and analytics services in handling highly demanding workloads. Although Spotify uses a wide stack of tools (including non-relational technologies), the case study demonstrates how cloud RDBMS/analytics services are integrated into the overall data architecture [31].
- Oracle Cloud Infrastructure (Autonomous Database) is an enterprise-SQL-workloads-oriented platform with automated operational functions (self-tuning, automatic patching), which is attractive for organizations with deep use of the Oracle stack. OCI is designed for conservative enterprise transitions to the cloud, where the completeness of SQL functionality and optimization for business applications is important [32]. In particular, companies such as Cisco Systems and Siemens AG use OCI for centralized corporate data management. According to the WiseGuyReports [32] report, Oracle retains about 12% of the DBaaS market and demonstrates steady growth in the enterprise segment due to the trust in its SQL core and high SLAs (up to 99.995% uptime) [33].

Thus, the integration of relational databases into cloud environments is accompanied by a complex combination of technical, organizational, and regulatory challenges that determine the architectural parameters of systems, as well as strategic aspects of data management. While leading DBaaS vendors are actively improving migration, synchronization and automatic scaling tools, issues of transaction consistency, secure storage and latency minimization remain key to the performance and credibility of cloud solutions. In addition, economic and compliance requirements are becoming increasingly important, directly affecting the total cost of ownership, the risks of vendor lock-in, and the need to develop competencies to operate complex hybrid environments. In the context of this study, it is advisable to systematize the main problem areas (Table 1) that form the outlines of the modern integration paradigm of relational database management systems (DBMS) in cloud ecosystems.

Table 1: The main challenges of integrating relational databases in cloud environments.

Integration model	Technical challenges	Security aspects	Economic challenges
Cloud-native RDBMS	- High requirements for transaction consistency in distributed environments (especially in multi-region configurations); - Latency between regions affects OLTP workload; - Automatic scaling can cause short-term delays when the data volume increases; - Limited compatibility of SQL engines (PostgreSQL, MySQL, Oracle) with cloud API specifications.	- End-to-end data encryption in motion and in storage (TLS, AES-256); - Access control through IAM (AWS IAM, Azure AD) with the need for centralized role management; - Compliance requirements (GDPR, SOC 2, ISO 27001, PCI DSS) require customization of audits and logs.	- The cost of ownership (TCO) increases with high transaction volumes and backups; - Vendor lock-in - the complexity of migration between providers (AWS → Azure); - The need for specialized personnel (DevOps, Cloud DBA).
Hybrid integration (on-premise + cloud)	- Delays in synchronization between local and cloud databases; - The need for Change Data Capture and logical replication mechanisms; - Incompatibility of SQL engines in different environments (versions, parameters, triggers); - Limitation of network bandwidth with large data volumes.	- Separation of responsibilities between internal IT teams and providers in terms of encryption, backup and disaster recovery. - Increased risks of security policy inconsistency.	- High cost of maintaining a dual infrastructure. - Difficulties in assessing ROI in case of partial migration. - The need for coordination between DevOps and ITIL teams.
Multi-cloud integration	- Distributed transactions between providers have different consistency mechanisms; - Lack of a single standard for cross-cloud SQL interoperability; - Network delays and complexity of request routing.	- Difficulty in centralized security monitoring between multiple environments. - Increased risks of leakage due to different metadata storage policies. - Requirement for integrated SIEM/Zero Trust Frameworks.	- High operational costs for SLA synchronization between providers. - Blurring of responsibility for security incidents. - The need for Cloud Governance Frameworks (FinOps, ITSM).
Integration through APIs / microservices	- High costs for API orchestration and cross-service consistency; - The need to manage distributed transactions (Saga, 2PC); - Compatibility of database schemas between microservices in different environments.	- Protection of endpoint APIs (OAuth 2.0, JWT). - Monitoring authentication and logging on the scale of hundreds of services. - GDPR compliance during cross-service transfer of personal data.	- High costs of DevOps automation (CI/CD pipelines, observability). - The need for distributed monitoring (Prometheus, OpenTelemetry). - Lack of personnel with experience in microservice RDBMS architectures.

Source: Authors, (2026).

Combined, the suggests that a relational database should be a first-class citizen in the cloud, and its implementation should encompass a continuum from technical feasibility to economic viability, as well as information security. Transactional consistency in distributed environments and vertical scaling limitations are examples of technical constraints that are being addressed by distributed SQL engines, microservice orchestration, and containerization. At the same time, security and regulatory matters are more conservative, while a need exists to comply with international data protection laws (GDPR, ISO/IEC 270-01).

At the same time, financial issues (such as the costs of multi-cloud system management and a dearth of qualified personnel) impact the need for strategic migration planning and the use of cloud governance measures. Therefore, it is really a technically enabled, legally balanced, and financially sustainable multi-dimensional approach that is becoming the yardstick for the success of integration processes in contemporary cloud-based environments.

In view of this, the development prospects in this area are determined by two main vectors: technological evolution (automation, serverless, containerization, AI-driven management) and management and methodological shift towards distributed and semantically consistent models (Data Fabric, Data Mesh); which increase the efficiency of data storage and processing, as well as transform the management logic of the business – from reactive administration to proactive anticipation of needs and loads. The key areas of innovative development of relational databases in cloud environments, including integration with ML platforms, containerization, serverless architectures, automated management and the formation of new data paradigms (Data Fabric, Data Mesh) are systematized in Table 2.

Table 2: Prospects for the development of relational database integration in cloud environments.

Development direction	Content and technological features	Implementation examples and case studies
Integration with Big Data and Machine Learning platforms	Relational DBMSs in the cloud are increasigly combined with analytical environments (Databricks, Snowflake, Vertex AI) to create a unified Data Fabric. This ensures data consolidation, reduction of ETL costs, and building predictive models without duplicating data.	Oracle Autonomous Database + Databricks: integration via *Delta Sharing* for two-way data exchange between OLTP and ML modules without ETL [2]. SAP Datasphere + Databricks: creating a single layer of access to corporate data without replication [34].
Containerization and database orchestration (Docker, Kubernetes)	Containerization allows to standardize the deployment of RDBMS in multi-cloud environments, reducing vendor lock-in and increasing portability. Kubernetes clustering provides automatic scaling, fault tolerance, and CI/CD integration.	Google Cloud SQL on GKE: an example of a hybrid architecture where the database is scaled through the Kubernetes Engine with automatic failover support [35]. AWS Aurora in containers: using Amazon Aurora with containers for rapid deployment of microservices in AWS ECS/Fargate [36].
Serverless models (Serverless SQL, Cloud Spanner, Aurora Serverless)	Serverless architectures eliminate the need for manual scaling, providing automatic resource management, per-query billing, and minimizing downtime. They are becoming the core of the modern DBaaS approach.	Aurora Serverless v2: provides instant scaling at peak loads and reduces costs by 40% [3]. Cloud Spanner: a globally distributed SQL DBMS with high consistency, used by *Spotify* for streaming analytics across millions of users [37].
AI-driven Database Management	The use of machine learning to independently tune queries, predict load, and automatically update indexes. This minimizes the human factor and increases SLA.	Oracle Autonomous Database: The implementation of Oracle Autonomous Data Warehouse at *Rosendin* reduced the administration burden, simplified data management, improved productivity, and identified $300 thousand in labor cost savings based on an analysis that took only 10 hours [38]. DPA (Digital Procurement Agency): DPA replaced a complex multi-system architecture (MySQL + MongoDB Atlas) at with a single Autonomus Database on Oracle Cloud Infrastructure. This resulted in a 15% acceleration in time-to-production, increased productivity, significant ease of management, and a reduction in operating costs by about 10% [39].
Development of Data Fabric and Data Mesh approaches	Data Fabric offers a single view of metadata management for heterogeneous data sources, whereas Data Mesh is predicted on a decentralized domain ownership model. This is the future pattern for work in large organizations with diverse databases.	IBM Data Fabric Platform: combines relational and non-relational sources in a single metamodel, supports DataOps functions [40]. Netflix Data Mesh Implementation: Netflix implements Data Mesh to synchronize dozens of SQL clusters with real-time streaming data [41].

Source: Authors, (2026).

The evolution of relational database access in the cloud exemplifies the transformation from disjointed storage models toward intelligent, cohesive system models where data is a first-class organizational asset. Integration solutions are evolving to the new dynamic architectures such as Data Fabric or Data Mesh to align these solutions no longer only on the technology level but on the level of data management concepts (from collection to analytics). Simultaneously, the progress in AI-based techniques for managing databases suggests a gradual shift of the emphasis from administrating towards self-administrating, where ML algorithms have a crucial role to play in autonomously optimizing queries, balancing loads, and maintaining SLAs.

Containerization and database orchestration are leading to a new multi-cloud portability model that facilitates vendor lock-in and offers potential for data-level integration with CI/CD. Simultaneously, serverless architectures are also being adapted as a key element in the Database-as-a-Service (DBaaS) model, offering the benefits of cost-efficiency, elasticity, and continuous data access. The integration of relational DBMSs with popular Big Data platforms and ML enables synergy between transactional systems and analytical services, thus realizing a single analytical space – Unified Data Fabric. From a methodological point of view, the choice of a model for integrating relational databases in cloud environments should be based on a systematic combination of the organization's goals, type of data processed, level of digital maturity, and architectural requirements.

For this purpose, it is advisable to apply a methodological approach based on a matrix of compliance with strategic goals and technological parameters of integration, which provides for: (1) Identification of business goals (real-time analytics, scalability, continuity of service); (2) Assessment of the type and amount of data, which determines the feasibility of using a relational, hybrid or polystructured architecture; (3) Selection of an integration model (Big Data Integration, Serverless DB, Data Fabric, AI-driven DBM, etc.), taking into account security, latency, regulatory compliance requirements; and (4) Development of an integration flow map and definition of metadata management mechanisms.

Thus, the optimal integration model should strike a balance between adaptability, autonomy, and interoperability. Organizations with an analytics-oriented business model should implement Data Fabric with ML integration for end-to-end analytics, while businesses that focus on rapid scaling of services can use Serverless SQL or containerized RDBMS solutions. For companies seeking digital transformation of management processes, the most promising direction is the implementation of AI-driven Autonomous Databases that minimize the human factor and ensure a high level of operational efficiency.

V. DISCUSSION

The obtained results confirm the key theoretical positions highlighted in previous studies [5],[6],[9] regarding the gradual transition from centralized database management systems to decentralized cloud services operating on the as-a-service model. Similar to the findings of [6], the study conducted by found that DBaaS approaches do provide automation of administration and increase the efficiency of operations, but at the same time increase the risks associated with data privacy and vendor lock-in. This is in line with the warnings of [7], [8], who emphasize that even in modern models with end-to-end encryption and centralized IAM control, issues of authentication and compliance with security standards (GDPR, ISO 27001) remain open. In addition, the problem of scalability of relational systems in cloud environments is a controversial aspect, which is confirmed by the results of this study.

According to pointed out the structural limitations of SQL architectures under heavy load more than a decade ago, and current analytical data demonstrates that although modern cloud-native RDBMSs overcome these limitations through containerization and microservices [15], [17], [42], issues of latency and distributed transaction consistency persist. This indicates that the cloud evolution of SQL has not eliminated the fundamental challenges but only moved them to the plane of architectural balancing between consistency and availability, which is in line with the CAP model, which is being actively developed by modern NewSQL researchers [19], [21]. Comparison of our results with the works of [18], [20] confirms that relational systems continue to demonstrate higher transactional stability in critical business scenarios, while NoSQL solutions remain more efficient for unstructured data flows.

We have expanded upon the research of these authors by demonstrating that the most effective compromise between the stability of SQL and the flexibility of NoSQL is hybrid integration through APIs, microservices, or multi-cloud platforms. This confirms the idea of [19] of the possibility to build up polyglot persistence, the coexistence of different types of databases in a single cloud infrastructure. Our findings have also been aligned with the strategies of [14], [16], who advocate the importance of modular design and fault tolerance in cloud design. Notably, evidence-based studies advocate that for multi-cloud solutions, unified security frameworks (Zero Trust, SIEM) and centralized procedures for managing financial and operational risk (FinOps, ITSM) are becoming increasingly critical. This aligns with [16] multi-cloud resilience framework and further reiterates the importance of transitioning into proactive data infrastructure management approaches.

VI. CONCLUSIONS

Considering that business is becoming increasingly digital and the volume of enterprise data is growing quickly, there is a need to adopt a new model for managing information resources. The results prove that the expanding global cloud computing market and increasing corporate data in the cloud push the need for technology reform and IT infrastructure strategy. This delivers business-minded, analytically driven services and resources to agencies. The paper shows that stencils for relational database integration, e.g., cloud-native, hybrid, or multi-cloud, including microservice-API-based implementation, represent a tradeoff among technical flexibility, security levels, and costs. Cloud-native solutions enable high scalability and automation of transaction processing, although hybrid and multi-cloud solutions sacrifice control over sensitive data in exchange for the elasticity of cloud solutions. Coupling with microservices/APIs provides systemic IT connectivity-reduction value and enables an incremental corporate IT infrastructure evolution.

From a practical point of view, the review of these high-end platforms (Amazon RDS/Aurora, Microsoft Azure SQL, Google Cloud SQL/Spanner and Oracle Autonomous Database) shows that the relational database as a service implementation is largely influenced by the configuration of its horizontal and vertical scalability model, consistency, security, availability guarantees and integration with analytic and ML services. In this regard, the complex nature of the process integration calls for a multi-facet assessment covering technical feasibility, regulatory compliance, and financial viability. The convergence of serverless computing paradigms with containerization, AI-powered orchestration, Data Fabric and Data Mesh enables smart data ecosystems where the movement of data itself is continuously augmented. This creates an ideal autonomy-integration equilibrium in data processing.

A systematic choice from the integration models is visible when considering business objectives, type of data, security requirements, and compliance requirements. Using a mapping between strategic goals and the technology-based facets of the integration, companies can determine the most strategic approaches, minimize risks associated with vendor lock-in, enhance analytical processing capabilities, and have ongoing access to operational data. Hence, the future opportunities for integration of relational database in cloud computing are influenced by both progress of technology and management and methodological trends for distributed, semantically coherent data models.

VII. AUTHOR'S CONTRIBUTION

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