Cloud Migration: Identifying the Sources of Potential Technical Challenges and Issues

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***Abstract*—Digital Transformation is emerging as a crucial factor for successful adaptation to the modern digital world for all possible economic and social entities. In recent years, cloud migration, cloud services and computing solutions adoption have been popular enablers for the Digital Transformation. During the Digital Transformation process, organizations and institutions face various technical challenges and implementation problems. This article explores the issues related to cloud migration and existing cloud service models. It investigates the advantages and disadvantages of the most popular cloud services offered by leading service providers, summarizes the main challenges in cloud migration processes, and how organizations can overcome them. Results help organizations understand the sources of potential technical challenges and implementation problems affecting cloud adoption and address these issues at an early stage of the initiative in order to reduce the threat of failure, avoid potential pitfalls and achieve desired cloud capabilities and business benefits.**

***Keywords*—Digital transformation; cloud; cloud migration; cloud models; PaaS; SaaS; IaaS; challenges**

I. Introduction

The topic of the research presented here is related to a field that until recently was considered evolving and nascent and currently occupies a central place in scientific analyses and practical developments. This is the area known as Digital Transformation, which is emerging as an important factor for successful adaptation to the modern digital world for all possible economic and social entities – countries, cities, industries, companies and people.

In fact, Digital Transformation began in the last century with the introduction of personal computers, the automation of industry, and the global expansion and establishment of the WWW as a means of communication and information exchange worldwide. As analogue systems were replaced by digital ones, the Internet became an integral part of personal and professional life.

The onset of this information age has given a strong impetus to worldwide globalisation, which is reaching hitherto unknown proportions.

The present study is part of a larger scientific research of the approaches to Digital Transformation of organizations and companies working in the field of the intangible sphere, such as, for example, service-oriented companies that provide online payment solutions, software or consulting services, educational and health organizations, as well as local or state government bodies, etc. The objective of the research is to identify typical implementation challenges and problems in the introduction of modern digital technologies. As a further matter, it aims to propose and experiment with solutions to overcome implementation problems faced by various organizations and institutions undergoing Digital Transformation.

According to Gartner [1], more than 85% of organizations will embrace a cloud-first principle by 2025. Since cloud migration and the adoption of cloud services and computing solutions are certainly enablers for Digital Transformation, the research should first address the challenges in this area and the approaches to optimize this multi-stage process.

This article presents the initial stages of this large-scale scientific research, which consists of exploring what cloud migration is and which cloud service models exist in cloud computing adoption. Furthermore, the paper investigates the advantages and disadvantages of the most popular cloud services offered by leading service providers and summarize the main challenges in cloud migration processes and how they can be optimized. The analysis performed allows us to understand the sources of potential technical challenges and implementation problems affecting cloud adoption, and to address these issues at an early stage of the initiative in order to reduce the threat of failure. The study serves to inform future efforts in implementing cloud innovation to avoid potential pitfalls and achieve desired cloud capabilities and business benefits.

The rest of the paper is organized as follows. Section II presents the benefits of cloud migration and discusses the advantages and disadvantages of the main types of cloud service models. Section III presents an overview of some of the most popular cloud computing platforms offered by the leading cloud service providers and discusses their advantages and disadvantages. Section IV summarises the migration challenges corresponding to different aspects and suggests potential approaches to how organizations and institutions can overcome or mitigate them. The Conclusion in Section V summarizes the contribution and limitations of this paper and plans for future work in the field is summarized in Section VI.

II. Cloud Migration. Cloud Computing Service Models

Cloud migration refers to the process of moving digital assets, including data, applications, workloads and IT processes, from on-premises or legacy infrastructure to a cloud-based environment or so-called cloud computing environment. This transition involves transferring computing resources, such as servers, storage, databases, networks and software applications, to a cloud service provider's

infrastructure. The ultimate goal of cloud migration is to achieve greater scalability, flexibility, and cost-efficiency and enhanced performance while leveraging the benefits of cloud computing [2].

The significance of cloud migration in modern IT infrastructure stems from the transformative impact it can have on businesses, operations, and technological landscapes. The key reasons that drive industries to adopt cloud technologies are well known (see Fig. 1), but below the reasons why cloud migration is vital in today's IT environment are discussed in more detail.

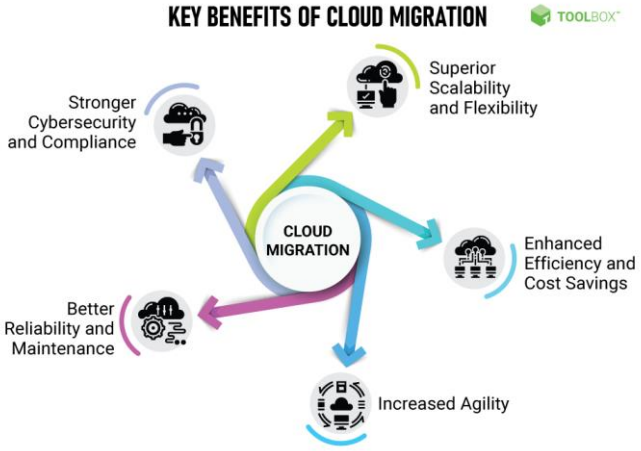

Fig. 1. Key benefits of cloud migration [3].

Cloud platforms offer elastic *scalability* [4], enabling businesses to easily scale resources up or down based on demand. This flexibility allows organizations to adapt to changes swiftly and efficiently without significant hardware investments or infrastructure reconfigurations.

Migration to the cloud often leads to cost savings [5] by moving from capital-intensive models (purchasing and maintaining physical hardware) to operational costs (pay-as-you-go or subscription-based models). This allows businesses to align costs with actual usage and optimize their IT spending.

Cloud migration fosters agility and innovation [6] by providing a platform for rapid development, testing, and deployment of new applications and features. Development teams can benefit from cloud-native services and tools, enabling faster time-to-market and a competitive edge.

Cloud infrastructure allows for worldwide accessibility to data and applications. Geographically distributed teams and users can access resources from any location, promoting collaboration and facilitating a globally connected workforce.

Cloud service providers invest heavily in security measures, often surpassing what many organizations can afford or manage independently. They offer advanced security features, compliance certifications, and regular updates to mitigate security risks and ensure compliance with industry-specific regulations [4].

Cloud providers offer robust disaster recovery and backup solutions, ensuring data integrity and availability in case of unforeseen events or system failures. Cloud-based disaster recovery strategies contribute to enhanced business continuity and reduced downtime.

Cloud platforms provide powerful analytics and machine learning capabilities, enabling organizations to derive actionable insights from their data through data analysis [6]. This data-driven approach can inform strategic decision-making and drive business growth.

Consolidating workloads in the cloud often leads to increased resource utilization and energy efficiency, contributing to a reduced overall carbon footprint compared to traditional on-premise data centers by environmentally sustainable solutions [7].

Migrating to the cloud allows companies to use centralized cloud services hosted by a vendor or cloud provider and delivered by the Internet. Cloud providers offer different cloud computing service models, each serving specific purposes and meeting different requirements. These service models are often called "as a service" or "aaS" models [8]. The three main types of service models are (see Fig. 2) software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS).

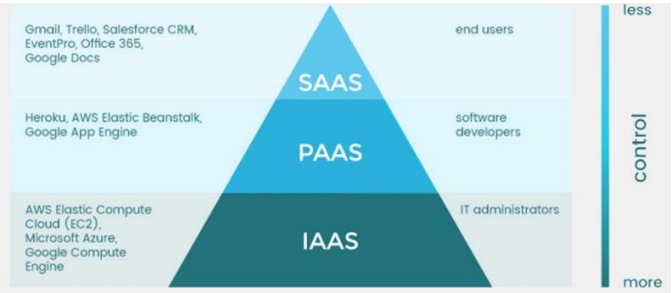

Fig. 2. Main types of cloud computing service models [9].

Infrastructure as a Service (IaaS) offers virtualized computing resources over the Internet, including virtual machines, storage, networking, and other infrastructure components. Users can manage and control the entire infrastructure by installing and configuring operating systems, applications and databases. IaaS provides a highly flexible and customizable environment commonly used by IT administrators and developers to build test and manage their applications and services [10]. Examples of IaaS providers include Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform (GCP), and IBM Cloud.

Platform as a Service (PaaS) provides a platform and environment for developers to create, deploy, and manage applications without worrying about the underlying infrastructure [11]. It offers development tools, frameworks, runtime environments, databases, and other services needed to develop applications [9]. Developers focus on coding and application logic, while the PaaS provider looks after the infrastructure management. Examples of PaaS are Microsoft Azure App Service, Google App Engine, and AWS Elastic Beanstalk.

Software as a Service (SaaS) delivers software applications over the Internet on a subscription basis. Users access these

applications through web browsers without download or install anything locally [12]. The service provider manages all aspects of the application, including maintenance, security, updates and infrastructure. Examples of SaaS applications include email services (e.g., Gmail), customer relationship management (CRM) systems (e.g., Salesforce), and collaboration tools (e.g., Microsoft 365).

In practice, organisations often use a combination of these service models to meet their specific requirements, known as 'hybrid' or 'multi-cloud' approaches. This allows them to avoid disadvantages and leverage the strengths and advantages of each service model (see Table I) to create a customised solution that best suits their business needs.

TABLE I. CLOUD COMPUTING SERVICE MODEL (DIS)ADVANTAGES

Service Model	Advantages	Disadvantages
IaaS	Full control and customization of the infrastructure. Scalability and flexibility to meet changing needs. Pay-as-you-go pricing model that optimizes cost efficiency. Rapid provisioning and scaling of resources	Requires expertise in infrastructure management. Security, updates and maintenance are the responsibility of the user. Potential complexity in managing different infrastructure components
PaaS	Optimized application development and deployment. Automatic scaling depending on application demand. Built-in development tools and frameworks. Cost and time effective for development teams	Limited control over basic infrastructure. Dependence on the PaaS provider for updates and maintenance. Some constraints on the choice of development tools and frameworks
SaaS	No user installation or maintenance is required. Accessibility from any device with an internet connection. Regular automatic updates and patches. Scalability depending on user needs	Limited customization and control options compared to on-premises solutions. Dependence on the service provider for availability and security

In recent years, there has been a trend towards the formation of new "aaS" in the cloud, which are referred to under the general term Everything as a Service (XaaS). It is a broad term encompassing different service models where different types of resources and capabilities are provided over the Internet as a service. XaaS essentially extends the "as a service" concept beyond traditional cloud computing service models (SaaS, PaaS, IaaS) to include a wide range of offerings related to technology, software, infrastructure and even non-technology areas [13], as follows:

- Function as a Service (FaaS): FaaS is a serverless computing model that allows developers to execute code in response to events without managing servers. This is an example of XaaS in the context of application execution.
- Database as a Service (DBaaS): DBaaS provides database management and hosting in the cloud, allowing users to access and manage databases without the need to manage infrastructure.
- Security as a Service (SecaaS): This includes a set of security-related services, including threat detection, identity and access management, and security monitoring, provided in the cloud.
- Communication as a Service (CaaS): CaaS includes cloud-based communication services such as voice over IP (VoIP), video conferencing and messaging platforms.
- Monitoring as a Service (MaaS): MaaS provides application, infrastructure and network performance monitoring and monitoring services.
- Storage as a Service (StaaS): StaaS provides cloud-based storage solutions, including file storage, object storage, and backup services.
- IoT as a Service (IoTaaS): IoTaaS offers cloud-based services to manage and analyze data from Internet of Things (IoT) connected devices.
- Analytics as a Service (AaaS): AaaS provides cloud-based data analytics and processing capabilities, enabling organizations to make data-driven decisions to improve the efficiency of various aspects of the business, such as sales, demand forecasting, and sourcing.
- AI as a Service (AIaaS): AIaaS provides AI and machine learning services in the cloud, enabling organizations to leverage AI capabilities without the need for extensive AI expertise.
- Integration Platform as a Service (iPaaS): iPaaS is a cloud-based platform that facilitates integration between different applications, systems and data within an organization. iPaaS solutions enable seamless communication, data sharing, and workflow automation between disparate systems, both cloud and on-premises [14]. They play a critical role in simplifying the integration process, increasing business agility, and supporting digital transformation initiatives.

XaaS is a flexible and evolving concept, and new service models continue to emerge as technology evolves. It allows organizations to access and leverage a wide range of resources and capabilities without the need to make extensive investments in infrastructure or manage it, making it a key enabler of digital transformation and innovation across industries. According to research by Deloitte [15], companies adopting XaaS are increasingly aiming for agility and innovation rather than efficiency and cost reduction.

III. DISCUSSION: LEADING CLOUD SERVICE PLATFORMS - ADVANTAGES AND DISADVANTAGES OF POPULAR OPTIONS

Several leading cloud service providers have been dominating the cloud computing market over the past few years. Below is an overview of some of the most popular cloud computing platforms offered by the global players. Each of these options has its own set of features, addressing different needs and preferences. Still, they also share some common

limitations that should be considered when deciding on the right cloud provider.

A. Amazon Web Services (AWS)

AWS offers a broad range of cloud services, including computing, storage, databases, machine learning, IoT, and more, providing flexibility for various use cases.

Not only does Amazon provide data centers in numerous regions worldwide, allowing for low-latency access to resources from different parts of the world [16], but also a wide range of security features and compliance certifications [17], making it suitable for industries with strict security requirements.

A variety of reliable storage solutions, including Amazon S3, Amazon EBS, Amazon Glacier, and others, offer scalable, durable, and highly affordable storage options for different use cases [17].

Furthermore, Amazon web services boast high performance and reliability [16], with strong achievement in terms of uptime and service availability, backed by Service Level Agreements (SLAs) to ensure reliability.

Due to the ability to scale resources up or down depending on demand, businesses can quickly adapt to changing requirements without upfront capital investment. Combined with that scalability and flexibility, the pay-as-you-go pricing model, which allows users to pay only for services they use, can help organizations manage and optimize costs effectively.

Also worth mentioning are the AWS's large and active user community, extensive documentation, and multiple third-party integrations in case customers need support and resources.

However, AWS has some weaknesses that should be mentioned. To start with, data transfer costs can add up and become a significant expense, especially for large volumes of data moved between regions or outside the AWS network. A further limitation of AWS is the lack of 24/7 support for all plans – only higher-level plans include around-the-clock access to customer support. Moreover, due to the huge customer base, custom support can be limited, and enterprises may experience delays in getting specialized help in critical situations. Finally, organizations that have invested in AWS may face challenges if they decide to migrate to another cloud provider due to potential vendor lock-in and the need for significant adjustments to existing systems and processes.

B. Microsoft Azure

Azure integrates seamlessly with Microsoft tools and products, making it an attractive choice for organizations already using Microsoft technologies such as Windows Server, Active Directory or SQL Server. Moreover, demonstrating a strong enterprise focus, the Microsoft cloud is also well suited for large enterprises, with a range of enterprise-class services, including Azure AD, Windows Virtual Desktop, and more.

Additionally, it provides solid support for hybrid cloud solutions [18], allowing organizations to easily connect on-premises data centers to the cloud.

Azure PaaS offerings could be considered fully comprehensive. It delivers a robust application development environment, including services such as Azure App Service and Azure Functions. Besides, it provides a rich set of developer tools and frameworks that support efficient application implementation and deployment.

Furthermore, Artificial intelligence (AI) and data analytics capabilities of Azure encompass advanced AI and machine learning (ML) services, such as Azure Machine Learning and Azure Cognitive Services, making it the preferred choice for AI-driven applications and data analytics.

Another significant service is the Azure Active Directory (Azure AD) with its robust identity and access management capabilities [18], enabling secure access to Azure services and other integrated applications.

Although the public cloud computing platform has many advantages, it also has a fair share of disadvantages, e.g. its complexity. The rich portfolio of services and features can be overwhelming for new users. Installing and initially configuring Azure services can get complex, especially when configuring networks, security, and permissions. Azure has a significant global presence. Even so, it has a slightly less global reach, compared to AWS in some parts of the world. Likewise, compared to AWS, Azure may have fewer third-party integrations and a more limited selection of third-party tools available in its ecosystem. Its cloud services possess limited platform portability because they are designed to run primarily within the Azure ecosystem, which can create challenges if an organization decides to move to another cloud service provider.

C. Google Cloud Platform (GCP)

GCP data analytics, ML and AI capabilities with services such as BigQuery, TensorFlow and Google AI Platform make it the preferred choice for organizations requiring advanced data processing and analytics.

A significant advantage of the platform is its powerful big data solutions such as BigQuery, Dataflow and Dataprep that enable organizations to efficiently process and analyze large data sets and gain valuable insights.

On the other hand, as a pioneer in containerization and Kubernetes, Google provides a robust Kubernetes Engine with its Cloud Platform. Accordingly, GCP [19] excellently suits companies focused on containerized applications and microservices.

As might be expected, GCP integrates seamlessly with Google Workspace (formerly G Suite), providing a complete environment for collaboration, productivity and cloud applications.

In addition, GCP has a massive global network infrastructure with strategically distributed data centers, which provides low-latency access to resources from different regions. Being designed for scalability and high performance, this infrastructure also allows businesses to scale resources quickly based on demand, ensuring optimal performance even as traffic spikes.

Due to its robust security features and regulatory compliance certifications, the platform ensures data privacy and meets various industry-specific regulatory requirements.

As for pricing, Google offers a pay-as-you-go pricing model that provides cost efficiencies and flexibility for businesses, especially those looking to manage and optimize costs.

Some disadvantages of GCP compared to AWS and Azure mentioned worth are the smaller market share and the limited global presence as it has fewer data center regions, which can impact latency and availability for some users. Despite being strong in certain areas, such as data analytics and machine learning, GCP may have a less diverse service portfolio than competitors such as AWS and Azure. Moreover, one may find the maturity of some services insufficient, especially of some relatively newer ones, in comparison with their AWS or Azure counterparts, which may result in occasional limitations or evolving features. A further weakness of Google cloud is its relatively limited focus on enterprises, although it is expanding its enterprise offerings. In the past GCP have been more focused on start-ups and developers, which may affect its attractiveness to larger enterprises. As for documentation and support [20], the platform's documentation is comprehensive, but support and specialized resources may not be as available as with larger cloud providers.

D. Alibaba Cloud

Alibaba Cloud has a significant presence in Asia and China, making it an excellent choice for businesses targeting this region.

This Cloud provides specialized solutions with a focus on e-commerce and retail enterprises, including artificial intelligence services for customer insights.

It is indisputable that Alibaba has diverse service offerings. The Cloud delivers a wide range of services, including computing, storage, database, big data, artificial intelligence, machine learning and IoT to meet a variety of business needs.

The company is also known for its cost-effectiveness and competitive pricing [21] compared to other major cloud providers, making it attractive to cost-conscious organizations.

Finally, Alibaba Cloud offers advanced distributed computing capabilities that enable high-performance computing, data processing and analytics at scale.

Alibaba Cloud was founded in 2009, only three years after AWS. Even so, it is a relatively new player in the cloud market and is characterised with some limitations. In the first place is its limited global reach. Although expanding, Alibaba Cloud has fewer data center regions outside of Asia [21], which impacts global availability. Secondly, English language support and documentation may not be as extensive as other providers. Furthermore, compared to other major cloud providers such as AWS, Azure and GCP, Alibaba Cloud's ecosystem may be less mature, with fewer third-party integrations and a smaller developer community. What can also affect its appeal to larger companies is its initially limited focus on enterprises, since Alibaba was more focused on start-ups and SMEs in the past. Another significant disadvantage concerns the compliance with international regulations and data protection and privacy that businesses outside China may have, especially given that Alibaba Cloud is a Chinese company. Finally, regarding the quality of customer support, some users report inconsistencies, having experienced problems with delays and getting timely help.

E. IBM Cloud

IBM Cloud has a strong focus on hybrid and multi-cloud services. It emphasizes hybrid and multi-cloud solutions [22] and is therefore an appropriate choice for organizations with complex infrastructure needs. Offering comprehensive support and consulting services, IBM helps organizations optimize their cloud infrastructure and ensure a successful transition to the cloud. As a matter of fact, IBM's Integration with Red Hat has strengthened the company's position in hybrid clouds with services such as IBM Cloud Paks and OpenShift.

Not only does the cloud offer a variety of enterprise-class services, including blockchain, artificial intelligence and IoT [22], but it simultaneously provides robust security features and regulatory compliance capabilities to ensure data security and privacy as well as compliance with numerous industry regulations and standards. The advanced AI and data analytics services [22], including IBM Watson, enable organizations to draw correct conclusions and make informed business decisions.

Furthermore, IBM Cloud has a global network of data centres, allowing companies to deploy resources worldwide and optimise performance by delivering resources closer to users.

However, IBM Cloud also possesses some shortcomings. It targets a niche market to meet more specific enterprise requirements and may not be as widely deployed as AWS, Azure or GCP. As a result, the cloud has a smaller market share compared to the major [23], which can lead to a smaller community, fewer third-party integrations and a narrower set of tools and services. In addition, some IBM services may be relatively newer or less mature than their AWS or Azure counterparts, which may result in evolving features or limitations. Finally, organizations that have invested in IBM technologies may face challenges if they decide to migrate to another cloud provider due to potential vendor lock-in and the need for significant adjustments to existing systems and processes.

F. Oracle Cloud

Oracle Cloud is known for its strong database solutions, making it an attractive choice for businesses relying heavily on Oracle databases.

It addresses the needs of enterprises with services such as Oracle Cloud Infrastructure, Oracle Autonomous Database and applications such as Oracle E-Business Suite. Oracle Cloud has an enterprise focus and provides a comprehensive suite of enterprise solutions, including databases, applications, computing, storage, analytics and more [24], suitable for large enterprises and businesses with complex needs.

Oracle Cloud integrates seamlessly with Oracle software and applications, providing a complete and optimized environment for organizations already using Oracle products.

Moreover, Oracle places a strong emphasis on security and regulatory compliance and offers a number of security features and certifications to ensure data protection and meet industry-specific regulatory requirements.

In addition, it has the capability to integrate with on-premises data centers, supporting a hybrid cloud model [25] for organizations that need a combination of cloud and on-premises solutions.

Still, some limitations should be pointed out regarding the cloud computing services offered by Oracle. Oracle Cloud's main strength lies in its niche market ─ database offerings. But it could be a weakness, as well, that may not allow it to meet all cloud computing needs. Oracle has a smaller number of data centres than the major cloud providers and, hence, a limited global reach. Besides, organizations that have invested heavily in Oracle technologies may face challenges if they decide to migrate to another cloud provider due to the potential vendor lock-in and the need for significant adjustments to existing systems and processes.

According to global data and business analytics platform Statista, the top three cloud providers by market distribution in 2023 are AWS, Azure and Google Cloud, followed at a significant distance by IBM and Oracle (see Fig. 3).

Fig. 3. Cloud market [26].

It is important to note that the evolution of cloud computing is extremely dynamic and these providers continue to improve and expand their services continuously. In addition, the specific needs and preferences of the individual organizations will determine which cloud provider is most suitable for them [26]. Therefore, a thorough evaluation and consideration of the advantages and disadvantages are critical when choosing a cloud service provider.

Beyond the provider-specific drawbacks mentioned above, there are some common ones that all cloud platforms share. When choosing to move to the cloud, organizations have to be aware of those limitations which could threaten their initiative, as for example – the steep learning curve. Because of the vast array of offered services and features, cloud platforms can be intimidating for users, especially for newbies or users unfamiliar with cloud computing concepts. Not only can this affect the ease of adoption and effective use of the platform, but it can also lead to extra training costs and unpredicted deployment delays.

A further consideration is the pricing complexity of the cloud services. Cloud providers offer different options for their customers in terms of pricing, but the most common models are reserved instances – purchased for a preliminary determined period, spot instances, where customers can bid for unused capacity, and the pay-as-you-go model, which charges customers based on the actual usage of resources. Even though the reserved instance option can lead to more significant cost savings, it has one major drawback – loss of flexibility [27]. On the other hand, the pay-as-you-go pricing model is flexible enough, but a more detailed examination of the granularity of the billing units proves drastic differences between the providers [27]. With the spot pricing, customers can get a significant discount, compared to the on-demand model, but there is always a risk of suddenly losing the purchased instances if the spot goes beyond your bid. Consequently, understanding and estimating costs can get very complex due to the multiple services delivered, the different pricing models and the various associated factors, such as compute resources, storage, data transfer, location, etc. [19].

Altogether, based on all above stated weaknesses of the different cloud service platforms offered, the following summarized technical problems and issues can be identified in the process of cloud migration and its further use:

- Resistance to deployment and employee leaving due to need for training to work with the cloud platform;
- Additional costs or respectfully incorrect forecasting of costs, caused by various factors - misunderstanding of pricing options; need for data transfer not planned in the initial budget; need for experienced experts for installation and configuration of cloud services; need for costs to implement missing third-party integrations; increased number of necessary services to satisfy business needs;
- Latency and delayed performance because of insufficient number of data center regions;
- Delay and temporary interruption of business activity, due to lack of expertise or timely customer support;
- Difficulties and need for additional costs for changes in existing systems and processes when migrating to another cloud service provider.
- Difficulties in performing daily operations caused by insufficient maturity of some services and their evolving.

IV. Results: Cloud Migration Challenges and Mitigation Approaches

Migrating existing on-premise applications to the cloud presents several key challenges that can be avoided through careful planning, appropriate strategies and effective implementation. Some of the key challenges, obstacles and difficulties that organizations face when transferring their infrastructure, applications, and data to cloud-based environments are related to a range of aspects concerning the migration process, such as data security and compliance, data transfer and latency, application compatibility, performance optimization, integration complexity, cost management, skill and knowledge gap, and downtime and business continuity.

Table II presents cloud migration challenges corresponding to the listed aspects and suggests potential approaches how to overcome or mitigate them.

TABLE II. Cloud Migration Challenges and Mitigation Opportunities

Integration aspect	Challenge	Mitigation
Data security and compliance:	Often on-premise applications handle sensitive data; hence, ensuring data security and regulatory compliance during migration is a serious concern.	Employ encryption, access controls, and compliance management tools to maintain data security. Conduct thorough compliance audits to ensure adherence to relevant regulatory requirements.
Data Transfer and Latency:	Transferring large volumes of data from on-premises systems to the cloud can be time-consuming and may cause latency issues.	Use data compression techniques, network optimization, and implement phased data transfer strategies to reduce the time and latency associated with data transfer [6].
Application compatibility:	Compatibility issues may arise when moving applications designed for on-premise environments to the cloud due to differences in infrastructure and configurations.	Conduct a comprehensive application assessment to identify compatibility issues. Modify or refactor the application as needed to ensure compatibility with the target cloud environment.
Performance optimization:	Ensuring optimal performance of applications in the cloud compared to on-premise can be challenging, affecting user experience.	Optimize applications for cloud infrastructure by utilizing auto-scaling, load balancing, and performance monitoring tools. Conduct performance testing to identify bottlenecks and optimize accordingly.
Integration complexity:	Integrating on-premise applications with cloud services and other applications can be complex, leading to data silos and inefficiencies.	Employ robust integration solutions and frameworks to facilitate seamless communication between on-premise and cloud-based components. Utilize APIs and middleware to bridge the integration gaps.
Cost management:	Cloud migration costs, including subscription fees and data transfer charges, can escalate and exceed the initial estimates.	Conduct a thorough cost analysis before migration, utilize cost management tools to monitor and control spending, and consider rightsizing resources based on usage patterns to optimize costs.
Skill and Knowledge Gap:	Migrating to the cloud often requires specialized skills and knowledge that may be lacking within the existing on-premises team.	Provide training and upskilling opportunities for the team or consider hiring cloud migration experts and consultants to bridge the skills gap and ensure a smooth migration process.
Downtime and Business Continuity:	Minimizing downtime during migration is critical to maintaining business continuity, which can be challenging during transition.	Implement a phased migration approach, perform thorough testing, and have a rollback plan in place to mitigate downtime and ensure uninterrupted business operations.

Addressing these challenges requires a holistic approach, involving thorough planning, stakeholder engagement, risk assessment, and leveraging appropriate technologies and methodologies to achieve a successful and smooth migration of on-premise applications to the cloud.

V. Conclusion

In summary, cloud migration is a strategic move that offers organizations the ability to align their IT infrastructure with business goals, enhance operational efficiency, optimize costs, and remain competitive in an ever-evolving technological landscape. By leveraging cloud capabilities, businesses can drive innovation, improve agility, and focus on their core competencies while harnessing the power of modern cloud computing.

The study presented in the paper is part of a wider scientific research with a very extensive goal to study and experiment with approaches, practices, problems and tools related to digital transformation initiatives in different spheres of the intangible domain.

This article draws on core challenges associated with cloud migration. By applying the proposed approaches for overcoming and mitigation, organizations and institutions can address these challenges at an early stage of the initiative and reduce the threat of failure. In this way, the study presented here can inform the future efforts of organizations and institutions in implementing cloud innovation to avoid potential pitfalls and achieve desired cloud capabilities and business benefits.

This study has some limitations as well. It is aimed at organizations and companies working in the intangible sphere, and all the challenges of cloud migration are brought out from this perspective. Therefore, additional research is needed to show whether all the proposed guidelines for overcoming or mitigating them can help avoid potential pitfalls and achieve desired cloud capabilities and business benefits in enterprises operating in the material sphere (e.g. production).

VI. Future Work

The results achieved here, related to the identification of the main sources of problems during the implementation of leading cloud service platforms, will allow throughout the subsequent stages of the research to systematize possible

problems and implementation obstacles that may arise when moving data, applications, and other business elements in the process of cloud migration. As a result, best practices, recommendations, and solutions to overcome them will be proposed and experimented. Empirical evidence will be derived through experiments affecting individual stages at which business operations of specific business entities from the intangible sphere migrate to the cloud. Appropriate cloud services and a relevant cloud service provider will be selected for the investigation.

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