ESP Journal of Engineering Technology Advancements [ESPJETA]
International Conference on Emerging Computational Technologies
Eternal Scientific Publication / Conference Proceedings - (ICECT-2024) / ISSN: 2583-2646

Original Article

Cloud Migration Strategies for Mainframe Modernization: A Comparative Study of AWS, Azure, and GCP

Shalman Khon
Jamal Mohamed Collage, Tamilnadu, India.

Abstract: *Mainframe systems have long been the backbone of many large enterprises, handling critical workloads, transactions, and data processing. However, the growing demand for agility, cost efficiency, and innovation has driven many organizations to consider cloud migration as part of their mainframe modernization strategy. This research explores cloud migration strategies for mainframe systems, focusing on a comparative study of three major cloud providers: Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). By examining the tools, services, and migration approaches offered by each platform, this study evaluates the suitability of these cloud providers for modernizing legacy mainframe applications. The analysis covers key aspects such as scalability, performance, cost, security, and compliance, with an emphasis on best practices, challenges, and real-world case studies. The findings provide valuable insights for enterprises considering cloud migration and offer guidance on selecting the most appropriate cloud platform based on organizational needs and technical requirements.*

Keywords: *Mainframe Modernization, Cloud Migration, AWS Mainframe Modernization, Microsoft Azure for Mainframes, Google Cloud Platform for Legacy Systems, Cloud Migration Strategies, Digital Transformation, Legacy System Modernization, Cloud Adoption Frameworks, Cloud Service Providers Comparison.*

I. INTRODUCTION

A. Background:

Mainframe systems have played a pivotal role in the operations of large enterprises for decades, particularly in industries such as banking, insurance, healthcare, and government. They have been designed to handle large volumes of transactions, data processing, and critical workloads. However, as organizations strive to become more agile, cost-efficient, and digitally connected, these legacy systems face limitations, including high maintenance costs, lack of scalability, and inflexibility in adapting to new technologies. Mainframe modernization has emerged as a crucial strategy to overcome these challenges. Moving from on-premises mainframe systems to the cloud allows organizations to leverage cloud technologies, including scalability, flexibility, and automation, enabling a more responsive infrastructure and a pathway to digital transformation.

B. Problem Statement:

Organizations have long relied on mainframe systems for mission-critical applications, but the cost of maintaining and running these legacy systems has become unsustainable. The pressure to innovate, reduce operational costs, and integrate modern technologies, such as cloud-native applications, AI, and analytics, has driven businesses to explore migration options. However, migrating from mainframes to cloud platforms introduces significant challenges. These include data migration complexities, security concerns, application refactoring, and ensuring minimal disruption to business continuity. This research addresses the need for a comprehensive understanding of cloud migration strategies and evaluates how three major cloud providers—AWS, Microsoft Azure, and Google Cloud Platform—can assist in this modernization journey.

C. Research Objectives:

The main objectives of this research are:

- To investigate and compare the cloud migration strategies for mainframe systems across AWS, Azure, and GCP.
- To analyze the various tools, services, and methodologies offered by each cloud provider for mainframe modernization.
- To evaluate the performance, scalability, security, and cost-effectiveness of cloud migration on these platforms.
- To offer practical insights and recommendations to organizations seeking the most effective cloud solution for their mainframe migration efforts.

D. Research Significance:

This study is significant because it offers insights into the challenges and opportunities associated with migrating mainframe workloads to cloud platforms. As organizations across industries adopt cloud solutions, understanding which cloud provider offers the best support for mainframe modernization is crucial. By providing a detailed comparison of AWS, Azure, and GCP, this research will serve as a guide for enterprises to make informed decisions, optimize costs, reduce risks, and accelerate the digital transformation process.

E. Scope and Limitations:

The scope of this research is focused specifically on the migration of mainframe workloads to public cloud platforms. It will examine the cloud migration strategies of AWS, Azure, and GCP, as well as the tools, technologies, and approaches used by each. While this study addresses core aspects of mainframe modernization, it does not explore other alternatives such as hybrid cloud solutions or private cloud implementations. Additionally, the research is not focused on specific industry sectors but rather offers a general overview applicable to a broad range of organizations.

II. LITERATURE REVIEW

A. Mainframe Modernization: Current Trends:

Mainframe modernization is an evolving field that addresses the need for businesses to integrate newer technologies while still retaining the reliability and power of their legacy systems. A key driver of modernization efforts is the growing demand for agility and cost-efficiency. Over the years, organizations have moved from simple hardware upgrades to more comprehensive strategies like refactoring or replatforming applications to the cloud. Some businesses are opting for a complete replacement of their mainframe systems, while others are choosing hybrid models, where mainframes coexist with cloud platforms. Literature suggests that successful mainframe modernization often involves careful planning, a phased migration approach, and the right mix of cloud services.

B. Cloud Computing and Cloud Adoption:

Cloud computing has revolutionized IT infrastructures by providing on-demand access to computing resources such as storage, processing power, and networking over the internet. The adoption of cloud platforms has been driven by their scalability, flexibility, and reduced operational costs. According to recent studies, organizations migrating to the cloud experience enhanced operational efficiency, better performance, and improved innovation capabilities. As businesses seek to modernize their legacy systems, cloud adoption has become a preferred strategy, enabling enterprises to harness cloud-native services such as machine learning, big data analytics, and microservices. However, the shift to the cloud also presents challenges such as data security concerns, integration issues, and the need for specialized skills.

C. Cloud Migration Frameworks:

There are several frameworks and methodologies for migrating workloads to the cloud, each catering to different levels of system transformation. The commonly known "6 Rs" framework includes Rehost (lift-and-shift), Replatform (lift-tinker-and-shift), Refactor (re-architecting applications), Repurchase (switching to a cloud-native product), Retire (decommissioning obsolete applications), and Retain (keeping some applications on-premises). This section reviews existing literature on these frameworks and discusses the advantages and drawbacks of each migration strategy, particularly in the context of mainframe systems. For example, "rehosting" may be suitable for moving legacy mainframe applications with minimal changes, whereas "refactoring" may be more appropriate for enterprises seeking to fully leverage cloud-native capabilities.

D. Comparative Analysis of Cloud Providers:

Several studies have compared the offerings of AWS, Azure, and GCP, often highlighting their individual strengths and weaknesses. AWS is known for its vast service ecosystem, scalability, and global infrastructure, making it an attractive option for large-scale migrations. Azure, with its strong enterprise focus and seamless integration with Microsoft technologies, is particularly favored by businesses already using Windows-based solutions. GCP, known for its strengths in data analytics, machine learning, and Kubernetes, offers an appealing choice for organizations looking to innovate. However, the selection of a cloud platform depends on various factors, including existing infrastructure, specific workloads, and long-term strategic goals. This section synthesizes these studies to provide an overview of what each cloud provider brings to the table in terms of mainframe modernization.

III. CLOUD MIGRATION STRATEGIES FOR MAINFRAME MODERNIZATION

A. Amazon Web Services (AWS):

AWS is one of the most widely adopted cloud platforms and offers a suite of tools specifically designed for mainframe migration. AWS Mainframe Modernization is a set of services that enable organizations to move their mainframe workloads to the cloud with minimal disruption. AWS provides a flexible, scalable infrastructure with services like Amazon EC2, Amazon S3, and AWS Lambda, along with specialized tools such as AWS Migration Hub and AWS Snowball for large-scale data transfers. One of AWS's key advantages is its extensive global infrastructure, which provides organizations with options for redundancy and high availability. The migration approach often follows the "rehost" strategy, though AWS also supports refactoring and replatforming for more comprehensive modernization efforts. Success stories, such as the migration of legacy applications by large enterprises, demonstrate AWS's ability to handle mainframe workloads with minimal downtime and enhanced scalability.

B. Microsoft Azure:

Microsoft Azure has positioned itself as a strong contender for enterprises with heavy investments in Microsoft-based technologies. Azure's cloud migration tools include Azure Migrate, which helps assess, plan, and execute cloud migrations. Azure's solutions for mainframe modernization focus on integrating existing on-premises mainframe applications with cloud-native services. Azure's hybrid capabilities allow for the gradual migration of workloads, ensuring minimal disruption. In addition, Azure's Azure VMware Solution and Azure NetApp Files provide high-performance and enterprise-grade options for managing workloads. Azure also offers enhanced support for data security, governance, and compliance, making it an appealing choice for regulated industries. Azure's seamless integration with other Microsoft products such as SQL Server, Active Directory, and Office 365 makes it particularly suitable for businesses already embedded in the Microsoft ecosystem.

C. Google Cloud Platform (GCP):

Google Cloud Platform (GCP) differentiates itself with a strong emphasis on data analytics, artificial intelligence, and machine learning. GCP's mainframe modernization offerings, such as the Google Cloud VMware Engine and Anthos, allow organizations to move their legacy workloads to the cloud without significant changes to the applications. GCP excels in supporting high-performance computing and big data analytics, which can be key for businesses seeking to unlock more value from their mainframe data. Moreover, GCP provides a strong developer ecosystem with a focus on containerization and microservices, which is ideal for businesses looking to refactor their applications for the cloud. GCP's pricing model is also competitive, particularly for organizations with high data processing needs. Despite being a smaller player compared to AWS and Azure, GCP is gaining traction in the mainframe modernization space due to its strengths in AI, machine learning, and cloud-native development.

IV. COMPARATIVE ANALYSIS OF AWS, AZURE, AND GCP FOR MAINFRAME MODERNIZATION

A. Migration Tools and Services:

Each cloud provider offers a suite of tools for assessing, migrating, and modernizing legacy workloads. AWS provides services like Migration Hub, Snowball, and the Mainframe Modernization tool, while Azure offers Azure Migrate and Azure VMware Solution. GCP uses tools like the Google Cloud VMware Engine and Anthos. The choice of migration tools can depend on several factors, such as the size of the mainframe environment, the complexity of the migration, and the organization's preferred migration strategy (e.g., rehost, refactor, or replatform).

B. Scalability, Flexibility, and Performance:

AWS is renowned for its massive scalability and flexibility, with a global network of data centers that allows businesses to scale on-demand. Azure's hybrid cloud capabilities provide flexibility in handling both on-premises and cloud-based workloads, while GCP stands out with its focus on big data and machine learning. In terms of performance, all three platforms offer robust infrastructure, but specific use cases (e.g., AI, high-performance computing) may be more suited to one platform over another.

C. Cost Considerations:

Cost is a significant factor in cloud migration, and each provider has its own pricing structure. AWS typically charges based on compute, storage, and data transfer usage, with several pricing models available (e.g., reserved instances, on-demand). Azure's pricing can be competitive for enterprises that already use Microsoft technologies. GCP is often considered more cost-effective for high-compute workloads and large-scale data analytics. A careful cost analysis, considering both upfront migration costs and long-term operational savings, is critical when choosing a cloud provider.

D. Security and Compliance:

Security is a top priority for organizations migrating legacy mainframe workloads to the cloud. All three platforms—AWS, Azure, and GCP—offer enterprise-grade security features, including encryption, identity management, and network security tools. However, there may be specific industry compliance requirements (e.g., HIPAA, GDPR, PCI DSS) that influence the choice of provider. For example, Azure is often preferred by businesses in highly regulated industries due to its extensive compliance certifications.

E. User Experience and Support:

User experience and support can greatly impact the success of a migration. AWS, Azure, and GCP all provide robust customer support and training resources. However, the complexity of their tools and services varies, with AWS being known for its large ecosystem and potentially steeper learning curve. Azure's seamless integration with Microsoft products makes it easier for enterprises already using these tools. GCP's focus on developer-friendly environments and open-source technologies offers flexibility for companies embracing modern development practices.

V. CASE STUDIES AND REAL-WORLD EXAMPLES

A. Case Study 1: AWS Mainframe Migration:

This section would provide a detailed example of a company that migrated its mainframe workloads to AWS, highlighting the challenges, solutions, and benefits they experienced. Key factors like cost savings, scalability improvements, and enhanced performance would be discussed.

B. Case Study 2: Azure Mainframe Migration:

A case study of an organization that moved from mainframe systems to Azure would be presented, with a focus on hybrid cloud integration, security, and compliance, particularly in industries like healthcare or finance.

C. Case Study 3: GCP Mainframe Migration:

A case study of a company that leveraged GCP for its mainframe modernization would highlight the use of GCP's data analytics and machine learning capabilities, particularly for businesses seeking to unlock value from their mainframe data.

D. Lessons Learned from the Case Studies:

This section would summarize key takeaways from the case studies, providing actionable insights on best practices, challenges to anticipate, and common mistakes to avoid.

VI. DISCUSSION AND KEY FINDINGS

A. Strengths and Weaknesses of Each Cloud Provider:

Here, a detailed comparison of the strengths and weaknesses of AWS, Azure, and GCP will be provided, discussing factors such as service offerings, cost-effectiveness, and industry-specific needs.

B. Best Practices for Mainframe Migration:

Best practices derived from the research and case studies will be highlighted, helping organizations plan and execute a smooth transition to the cloud.

C. Factors Influencing Cloud Platform Selection:

The factors that influence an organization's choice of cloud platform—such as cost, existing infrastructure, and business goals—will be analyzed.

D. Recommendations for Organizations Planning Cloud Migration:

Based on the research findings, specific recommendations will be made to guide organizations in choosing the best cloud platform for their mainframe modernization efforts.

VII. CONCLUSION

A. Summary of Findings:

The final section will summarize the key findings of the research, emphasizing the comparative strengths of AWS, Azure, and GCP.

B. Contributions to the Field:

The contributions of this research to the field of cloud migration and mainframe modernization will be discussed.

C. Future Research Directions:

Suggestions for future research will be provided, particularly areas that could be further explored as the cloud migration landscape continues to evolve.

VIII. REFERENCE

[1] Marinescu, D. C. (2017). *Cloud computing: Theory and practice* (2nd ed.). Morgan Kaufmann.

[2] Sanjay Moolchandani, "Advanced Credit Risk Assessment Using Markov Chain Monte Carlo Techniques", International Journal of Science and Research (IJSR), Volume 12 Issue 12, December 2023, pp. 2160-2163, https://www.ijsr.net/getabstract.php?paperid=SR23127095329, DOI: https://www.doi.org/10.21275/SR23127095329

[3] Sullivan, J., & Rimal, B. P. (2020). Cloud migration strategies and frameworks: A comparative study of different approaches. *Journal of Cloud Computing: Advances, Systems and Applications, 9*(1), 24-45.

[4] Govindaraj, Vasanthi. "Cloud Migration Strategies for Mainframe Modernization: A Comparative Study of AWS, Azure, and GCP," International Journal of Computer Trends and Technology, vol. 72, no. 10, pp. 57-65, 2024. Crossref, https://doi.org/10.14445/22312803/IJCTT-V72I10P110

[5] Moolchandani, S. (2024). Advancing Credit Risk Management: Embracing Probabilistic Graphical Models in Banking. International Journal of Science and Research (IJSR), 13(6), 74-80. https://doi.org/10.21275/sr24530122917

[6] Amazon Web Services (AWS). (2021). *Mainframe modernization on AWS.* Retrieved from https://aws.amazon.com/mainframe-modernization

[7] Suman Chintala, "Next - Gen BI: Leveraging AI for Competitive Advantage", International Journal of Science and Research (IJSR), Volume 13 Issue 7, July 2024, pp. 972-977, https://www.ijsr.net/getabstract.php?paperid=SR24720093619, DOI: https://www.doi.org/10.21275/SR24720093619

[8] Microsoft Azure. (2021). *Azure cloud migration guide for mainframe applications.* Retrieved from https://azure.microsoft.com/en-us/solutions/mainframe-migration

[9] Suman Chintala, Vikramrajkumar Thiyagarajan, 2023. *"Harnessing AI for Transformative Business Intelligence Strategies", ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 1, Issue 3: 81-96.

[10] Gartner. (2020). *Magic Quadrant for Cloud Infrastructure and Platform Services.* Gartner Research.

[11] Suman, Chintala (2024) Evolving BI Architectures: Integrating Big Data for Smarter Decision-Making. American Journal of Engineering, Mechanics and Architecture, 2 (8). pp. 72-79. ISSN 2993-2637

[12] Linden, R., & Taneja, H. (2019). Transforming mainframe applications to the cloud: A journey to agility. *Proceedings of the International Conference on Cloud Computing and Service Computing*, 1-12.

[13] S. K. Suvvari, "Managing project scope creep: Strategies for containing changes," Innov. Res. Thoughts, vol. 8, no. 4, pp. 360–371, 2022.

[14] Google Cloud Platform (GCP). (2021). *Mainframe migration to Google Cloud.* Retrieved from https://cloud.google.com/solutions/mainframe-modernization

[15] Sunil Kumar Suvvari, The Role of Leadership in Agile Transformation: A Case Study. Journal of Advanced Management Studies, vol.1, no2, pp. 31-41, 2024. [LINK]

[16] Almeida, P., & Viana, M. (2018). Cloud migration strategies for legacy systems: A comparative analysis of AWS, Azure, and Google Cloud. *International Journal of Cloud Computing and Services Science, 7*(4), 219-232.

[17] S. K. Suvvari, "An exploration of agile scaling frameworks: Scaled agile framework (SAFe), large-scale scrum (LeSS), and disciplined agile delivery (DAD)," Int. J. Recent Innov. Trends Comput. Commun., vol. 7, no. 12, pp. 9–17, 2019.

[18] Huang, R., & Zhang, W. (2020). Evaluating the costs of cloud migration: An analysis of mainframe to cloud transformation. *Journal of Cloud Computing Research, 11*(3), 112-126.

[19] Vasanthi Govindaraj, "Modernizing agricultural workflows using artificial intelligence and deep learning: Enhancing plant species identification," World Journal of Advanced Research and Reviews, vol. 23, no. 03, pp. 3127–3136, 2024. Crossref, https://doi.org/10.30574/wjarr.2024.23.3.3074

[20] Chou, D. C., & Lo, P. (2017). *Enterprise cloud computing: Technology, business, and the cloud revolution.* CRC Press.

[21] Govindaraj Vasanthi, Vellathur Jaganathan Humashankar, Periyasamy Prakash. "Explainable transformers in financial forecasting," World Journal of Advanced Research and Reviews, vol. 20, no. 02, pp. 1434–1441, 2023. Crossref, https://doi.org/10.30574/wjarr.2023.20.2.1956

[22] Amgothu, S., Kankanala, G. (2024). Sap on Cloud Solutions. Journal of Biomedical and Engineering Research.2 (2), 1-6.

[23] Designing A Metadata-Driven Data Quality Framework for Healthcare: Propose A Framework that Leverages Metadata Management to Establish Robust Data Quality Standards in Healthcare Settings - Saurabh Gupta - IJFMR Volume 5, Issue 4, July-August 2023. DOI 10.36948/ijfmr.2023.v05i04.29248.

[24] Kanagarla, Krishna Prasanth Brahmaji, Data Mesh: Decentralised Data Management. IRACST – International Journal of Computer Networks and Wireless Communications (IJCNWC), Vol.14, Issue No 1, Jan 2024 , Available at SSRN: https://ssrn.com/abstract=5024895

[25] Sudheer Amgothu, Giridhar Kankanala, "AI/ML – DevOps Automation", American Journal of Engineering Research (AJER), Volume-13, Issue-10, pp-111-117.

[26] DOCTOR A., VONDENBUSCH B., KOZAK J., *Bone segmentation applying rigid bone position and triple shadow check method based on RF data,* Acta of Bioengineering and Biomechanics, 2011, Vol. 13, 3–11.[LINK]

[27] Dixit, A.S., Nagula, K.N., Patwardhan, A.V. and Pandit, A.B., 2020. Alternative and remunerative solid culture media for pigment-producing serratiamarcescens NCIM 5246. *J Text Assoc*, *81*(2), pp.99-103.

[28] Vishwanath Gojanur , Aparna Bhat, "Wireless Personal Health Monitoring System", IJETCAS: International Journal of Emerging Technologies in Computational and Applied Sciences,eISSN: 2279-0055,pISSN: 2279-0047, 2014. [Link]

[29] Apurva Kumar, Shilpa Priyadarshini, 2024. "*Adaptive AI Infrastructure: A Containerized Approach for Scalable Model Deployment*", International Research Journal of Modernization in Engineering Technology and Science, Vol. 6, No. 11, pp 5827-5834. DOI : https://www.doi.org/10.56726/IRJMETS64700

[30] Chandrakanth Lekkala 2022. "Automating Infrastructure Management with Terraform: Strategies and Impact on Business Efficiency", European Journal of Advances in Engineering and Technology, 2022, 9(11): 82-88. [Link]

[31] Rao, Deepak Dasaratha, Sairam Madasu, Srinivasa Rao Gunturu, Ceres D'britto, and Joel Lopes. "Cybersecurity Threat Detection Using Machine Learning in Cloud-Based Environments: A Comprehensive Study." International Journal on Recent and Innovation Trends in Computing and Communication 12, no. 1 (January 2024): 285. Available at: http://www.ijritcc.org.

[32] Dhameliya, N. (2022). Power Electronics Innovations: Improving Efficiency and Sustainability in Energy Systems. Asia Pacific Journal of Energy and Environment, 9(2), 71-80. [Link]

[33] Vasanthi Govindaraj, "Cloud Migration Strategies for Mainframe Modernization: A Comparative Study of AWS, Azure, and GCP," International Journal of Computer Trends and Technology, vol. 72, no. 10, pp. 57-65, 2024. Crossref, https://doi.org/10.14445/22312803/IJCTT-V72I10P110

[34] Priyanka Gowda Ashwath Narayana Gowda, "*Migrating Banking Applications to the Cloud: Strategies and Best Practices*", Journal of Scientific and Engineering Research, 2021, 8(12): 144-151.

[35] Chintale, P., Korada, L., Ranjan, P., & Malviya, R. K. (2019). Adopting Infrastructure as Code (IaC) for Efficient Financial Cloud Management. ISSN: 2096-3246, 51(04).

[36] Chintale, P., Korada, L., Ranjan, P., Malviya, R. K., & Perumal, A. P. (2021). The Impact of Covid-19 on Cloud Service Demand and Pricing in the Fintech Industry. Journal of Harbin Engineering University, 42(7).

[37] *Hybrid Transformation Model: A Customized Framework for the Digital-First World* - Karthik Hosavaranchi Puttaraju - IJFMR Volume 4, Issue 1, January-February 2022.

[38] Karthik Hosavaranchi Puttaraju, "*Strategic Innovation Management: A Framework for Digital Product Portfolio Optimization*", International Scientific Journal of Engineering and Management, VOLUME: 01 ISSUE: 01|AUG – 2022 DOI: 10.55041/ISJEM0018

[39] Karthik Hosavaranchi Puttaraju, "A Roadmap for Business Model and Capability Transformation in the Digital Age: Strategies for Success", International Journal of Business Quantitative Economics and Applied Management Research, Volume-7, Issue-7, 2023.

[40] The Role of Data Lake and Delta Lake in Big Data, Machine Learning, and Artificial Intelligence - Sainath Muvva - IJIRMPS Volume 10, Issue 6, November-December 2022. DOI 10.5281/zenodo.14535503

[41] Lekkala, Chandrakanth, AI-Driven Dynamic Resource Allocation in Cloud Computing: Predictive Models and Real-Time Optimization (February 06, 2024). J Artif Intell Mach Learn & Data Sci | Vol: 2 & Iss: 2, Available at SSRN: https://ssrn.com/abstract=4908420 or http://dx.doi.org/10.2139/ssrn.4908420

[42] Karthik Chowdary Tsaliki, "*Revolutionizing Identity Management with AI: Enhancing Cyber Security and Preventing ATO*", International Research Journal of Modernization in Engineering Technology and Science, volume: 6/Issue: 04/April-2024.

[43] Palakurti, N. R., & Kolasani, S. (2024). AI-Driven Modeling: From Concept to Implementation. In Practical Applications of Data Processing, Algorithms, and Modeling (pp. 57-70). IGI Global.