ISSN: 2754-6705

Journal of Mathematical & Computer Applications

SCIENTIFIC Research and Community

Review Article

Open Access

Hybrid Cloud Solutions for Balancing On-Premise and Cloud Infrastructure

Rajesh Kotha

Software Development Engineering Advisor at Fiserv, USA

ABSTRACT

This paper aims to analyze hybrid cloud, as this is a Cloud and on-premise arrangement. The paper also examines the advantages and disadvantages of this approach, considering the different issues that organizations face when managing I.T. assets. This paper offers a brief about hybrid cloud solutions, how they have influenced and been used and utilized in the current business environment, and most importantly, how they can benefit companies by expanding and protecting their information. The study establishes that hybrid cloud models are a perfect middle ground of the modern I.T. environment because they let organizations benefit from cloud computing while retaining the security and data control of the on-premise facilities.

***Corresponding author**

Rajesh Kotha, Software Development Engineering Advisor at Fiserv, USA.

Received: December 03, 2022; **Accepted:** December 10, 2022, **Published:** December 17, 2022

Keywords: Hybrid Cloud, On-Premise Infrastructure, Cloud Computing, Scalability

Introduction

In the ever-competitive environment, organizations are pressured to efficiently manage their I.T. resources regardless of their importance in the market. Depending on an organization's internal information technology infrastructure does not work effectively in the modern world because it is rigid. However, organizations may not fully adopt cloud solutions because the data is sensitive, there are regulatory restrictions, or they have invested heavily in premise systems. The solution is the hybrid cloud, a middle ground between the on-premise infrastructure and cloud services. This approach will allow an organization to keep its essential systems and data centralized. At the same time, cloud computing has advantages such as flexibility, cost, and efficiency. Hybrid cloud has recently become one of the most discussed topics as many organizations understand it can address most of their I.T. department needs. Applying both types of resources allows organizations to maximize the usage of I.T. assets and improve the adaptability of their operations to market conditions. However, the hybrid cloud model is not free from certain hurdles. Therefore, the decision to adopt this model should be made to maximize the benefits. Therefore, this paper aims to explain to the reader the concept of hybrid cloud computing, its advantages and disadvantages, and the applicability of the idea in the contemporary business world. In the following article, we will review the critical components of the hybrid cloud model, explore how to address the overlap between on-premise and cloud environments and explore use cases across verticals. In the same regard, discussing the future of hybrid cloud technology and how it will define I.T. infrastructure management's future will be pertinent.

Literature Review

The literature on hybrid cloud computing emphasizes how important it is in today's IT environments, where businesses try to strike a balance between the security and control of on-premise infrastructure and the benefits of cloud computing. According to Agbaje et al., hybrid cloud architectures provide a great deal of scalability and flexibility, allowing businesses to dynamically modify their resource allocation in response to demand [1]. This flexibility maximizes resource use and cost effectiveness, which is especially advantageous for sectors with fluctuating workloads. Furthermore, hybrid cloud solutions provide security and regulatory compliance by enabling businesses to use the cloud for less important operations and retain sensitive data on-site [2]. In industries where data protection and compliance are critical, like healthcare and finance, this combination of on-premise and cloud solutions is extremely important.

The body of literature about managing and integrating hybrid cloud environments is extensive. In their discussion of the difficulties in synchronizing on-premise systems with cloud services, Lin et al., highlight the technological challenges that enterprises must overcome in order to accomplish seamless integration [3]. The necessity for efficient identification and access management in both contexts, as mentioned by Deochake and Channapattan, made these difficulties much more severe [4]. Organizations must invest in both on-premise infrastructure and cloud services while addressing the security implications of integration, raising worries about potential increases in costs and security threats [5]. Notwithstanding these difficulties, research indicates that when hybrid cloud computing is done right, the advantages—such as enhanced business continuity and catastrophe recovery—often exceed the disadvantages.

Furthermore, research indicates that hybrid cloud solutions are becoming more and more important for promoting creativity and adaptability in a variety of industries. According to Shahidinejad et al., hybrid cloud architectures facilitate the quick rollout of new services and apps, enabling businesses to react quickly to shifts in the market and demands from their clients [6]. Organizations

may take advantage of current IT investments and embrace cutting-edge technologies like AI and ML by integrating old systems with contemporary cloud services. This adaptability is essential in sectors like manufacturing and retail, where hybrid cloud solutions are used to control high traffic times and enhance production processes [7]. In summary, the literature analysis underscores the growing significance of hybrid cloud computing as a tactical method for overseeing IT assets in a swiftly changing technological environment.

Problem Statement

When organizations seek to modernize their I.T. environment, they are confronted with issues that cannot be solved by continuing on-premise or adopting cloud computing. These challenges include

- **Scalability and Flexibility:** There are always situations in many organizations where the demand for computing resources varies, leading to an inept computing environment. On the same note, the scaling problem of the on-premise solutions is that one cannot scale up the solution quickly, which implies that the solution is either over-provisioned, expensive, or under-provisioned and limits the business.
- **Cost Management:** This implies that when some physical infrastructure remains on-premise, the costs incurred in maintaining and updating them can be quite a lot. Companies are in a position where they need to find how they can cut their expenses and, at the same time, improve the quality and security of their products.
- **Data Security and Compliance:** Due to these improvements in data privacy and high levels of regulation, such information must not be accessed by the wrong people. This entails the need to store some data and applications on internal servers while enjoying other features of cloud computing.
- **Legacy System Integration:** Some organizations have large I.T. systems established for many years and have invested a lot in their infrastructures that cannot quickly move to the cloud. As we have seen, there is a need for solutions that can interconnect this system with today's cloud services.
- **Performance and Latency:** Considering that some applications need to read data with low latency, it can be challenging to achieve it solely with the help of cloud storage. Here, it is the cloud solution against the performance demands of the strategic applications in the organization.
- **Vendor Lock-in:** Limited vendor choices: Selecting a single cloud service provider offers vendor lock-ins in which switching or migrating data and applications from one cloud provider to another is costly or complex.
- **Skill Gap:** Implementing new technologies might call for skills that may not be available within the company's human resources. This may compromise the skills to implement and manage new complex I.T. systems effectively.
- **Disaster Recovery and Business Continuity:** It is still crucial for organizations to be prepared for disasters and have proper disaster management and recovery strategies. The issue with on-premise solutions is that they are not as robust or location-diverse as disaster recovery plans need

.**Solution**

Hybrid Cloud

The study shows that the hybrid cloud solution is a strategic and efficient approach to solving some of the challenges that organizations face in managing their I.T. systems. Hybrid Cloud is more elastic and versatile, which allows organizations to design the infrastructure using on-premise and cloud resources. Here is the breakdown of this solution and how it can effectively balance the internal I.T. environment within an organization.

On-Premise Infrastructure

- **Physical Servers:** These are the initial servers hosted locally within the organization's internal server facility. They provide direct hardware control and are suitable for hosting critical applications or data.
- **Storage Systems:** Storage Area Networks (SANs) and Network Attached Storage (NAS) are also direct storage access systems for data that are on-premise and required for applications with low access latency.
- **Networking Equipment:** Routers, switches, and firewalls are considered the basic parts of the on-premise network because they secure connections between the various components of the I.T. infrastructures.
- **Virtualization Layer:** Many organizations implement virtualization solutions to improve resource utilization and flexibility in their physical computing facilities.

The on-premise infrastructure provides several advantages, including:

- Direct control over the hardware and the software is retained.
- Easy and inexpensive communication with the data and the applications
- The level up to which such an individual can be able to attain certain set regulatory compliance requirements
- Preventative measures of data leakage to avoid leakage of sensitive information beyond the company premises

Cloud Infrastructure

Infrastructure as a Service (IaaS) hosts and rents all computing facilities through the Internet; organizations can use this to increase their computing capacity. Platform as a Service (PaaS) avails a platform on which developers can host and run applications, thus freeing them from the task of managing physical resources [1]. Software as a Service (SaaS) delivers software applications over the web, so users do not have to employ their computers and other equipment.

The cloud infrastructure offers several benefits

- The flexibility to accommodate growth and incorporation of new specifications.
- Flexibility of the pay-as-you-go pricing models, which makes it affordable.
- Purchasing of new and advanced technologies and services
- Reduced overheads for maintenance of the I.T. departments

Balancing the Two

The concept of a hybrid cloud balances the usage of on-premise and cloud technologies

- **Cloud Management Platform:** A central appliance that would provide visibility and control of the on-premise and cloud environment to provide a single view of the whole environment.
- **Data Integration and Synchronization:** Products that enable local and cloud applications to be synchronized to keep exchanging information and ensure that applications can seamlessly integrate [2].
- **Network Connectivity:** Fast and highly available connections between the on-premise and cloud can be private or leased via a VPN.
- **Identity and Access Management:** Identity and access management solutions allow identity and access management to be implemented across on-premise and cloud applications [3].

- **Orchestration and Automation:** These applications can be utilized to automate services configure, and manage applications and resources in the hybrid environment.

The balanced approach allows for

- The amount of resources allocated to each section should be based on the workload of that section.
- Cloud environments can provide improved cost control
- Improved security and compliance are possible because local and confidential data can be stored on-premise while using the cloud for other purposes.
- Better flexibility and creativity in development and testing that can be provided through cloud services.

The Benefits of Hybrid Cloud Solutions

- **Flexibility and Scalability:** Another benefit of the hybrid cloud is the provision of dynamic resources that enable the scaling of the resource. It allows some critical systems to be maintained internally while adopting the cloud for other operations or demands that are only occasionally required [4]. This flexibility also assists the business in managing market demands by not over-provisioning on-premise resources.
- **Cost Optimization:** A Hybrid Cloud is advantageous to organizations since it helps them spread the I.T. cost between CAPEX and OPEX. Some of the advantages of using cloud resources include the following: people cannot be made to invest heavily in hardware and other related items since they are not so vital or required for long-term use. The pay-as-you-go model of cloud services is also advantageous in controlling costs more effectively.
- **Enhanced Security and Compliance:** Hybrid cloud computing allows organizations to store their data and some of the most essential applications in their data centers, meaning they have complete control over the security processes. This approach is most suitable for industries that receive much attention from regulatory bodies. However, applications and data that are not sensitive can still be migrated to the cloud because the cloud providers have better security features.
- **Improved Disaster Recovery and Business Continuity:** Replicating the resources locally and on the cloud enhances an organization's disaster recovery readiness when hybrid cloud solutions are used. Cloud-based backup and recovery solutions can provide geographic redundancy, and applications are still available even in a local calamity.
- **Accelerated Innovation:** By adopting the hybrid cloud model, one can leverage the latest cloud services and technologies and, at the same time, make optimal use of prior investments in I.T. solutions. It also allows companies to move faster in adopting new technologies like artificial intelligence, machine learning, and IoT platforms that can drive innovation and unlock value.
- **Workload Optimization:** A hybrid cloud means an organization can place workloads in whichever location is optimal regarding performance, security, or costs. These optimizations can lead to improved global system performance and resource usage.
- **Support for Legacy Systems:** Every company has applications that are not cloud-capable or should not be run on the cloud because of their risk characteristics. This enables such ancient applications and systems to remain on-premise but integrate them with new-generation cloud apps and services, which can be done via a hybrid cloud model.
- **Enhanced Collaboration and Accessibility:** The cloud parts of a hybrid solution can improve communication since everyone has access to the resources and applications they require at any location with internet connectivity. This capability is precious in the current world, where remote and distributed work is the order of the day.

Limitations of Hybrid Cloud Solutions

- **Challenges in Management:** Some may see handling a hybrid cloud arrangement as more complex than handling an on-site setup or a pure cloud environment. This means that I.T. teams are faced with the reality of having to deal with two different environments and make them work together in ways that may be challenging and require acquiring new skills and tools [5].
- **Integration Challenges:** Integration of on-premise systems with cloud services can be challenging from a technical perspective since dealing with old programs is challenging. The connection between data and application between the two environments often presents some complexities, typically demanding deep endeavor and skill.
- **Potential for Increased Costs:** Although the hybrid cloud model is one of the models that has a high level of cost-saving potential, it has the potential to incur more costs than what is required. It also leads organizations to a situation where they might end up paying for on-premise infrastructure and cloud services while not having an efficient need for both.
- **Security Concerns:** Although the hybrid cloud enhances the security of the cloud in certain ways, it also introduces new security challenges [6]. It is always a challenge to secure any two environments, and mixing the on-premise networks with the cloud networks exposes several new risks if they are not addressed well.
- **Challenges in Data Governance and Compliance:** Among the challenges is creating policies and ensuring a good handle on data governance in the on-premise and cloud environments. This means that organizations must ensure that data protection will be complied with irrespective of the location, which is difficult under the hybrid system.
- **Performance Issues:** Hybrid cloud solutions can also have latency issues if not properly implemented, particularly where applications need data on one side of the on-premise/cloud divide. It can also impact the operating efficiency of high-demanding applications.
- **Skill Gap and Training Requirements:** A hybrid cloud solution includes aspects that are difficult to manage, and such a solution may require a diverse set of skills that may not be present in an organization. This can lead to high costs in training or retraining employees to the right skill level as required in that area.

Impact

- **Operational Efficiency:** Hybrid cloud placements organize workload where it can achieve a set of performance, cost, and security characteristics in conjunction with local resources in a traditional enterprise data center model. This leads to improvement in overall operation output and efficiency in the utilization of resources.
- **Cost Optimization:** According to the notion of the hybrid cloud infrastructure, it may be complicated to implement during the initial stages of usage. On the other hand, it can be cost-effective during the subsequent stages. This leads to the fact that it enables organizations to use effective on-premise solutions for stable workloads combined with the pay-as-you-go public cloud model for increasing workloads [7].
- **Agility and Innovation:** A hybrid cloud approach provides

flexibility for the series deployment of new services and applications to the cloud. The flexibility enhances organizations' probability of meeting the new market forces and the customers' demands, hence stimulating innovation and competitiveness.

- **Enhanced Security and Compliance:** Receiving an opportunity to use the best of both worlds – concentrated sensitive data and critical applications are on-premises, and only the most effective security elements are in the cloud – can make this company more secure. They also provide more opportunities for compliance-related aspects to remain fulfilled.
- **Improved Disaster Recovery:** Hybrid cloud solutions help an organization be more disaster-prepared than traditional solutions. They are primarily used as backup or failover environments that could help reduce RTO and RPO.
- **Scalability:** Hybrid solutions enable using variable amounts of resources within solutions to scale the solutions up if necessary. This means enterprises can switch to the public cloud instantaneously during a high-traffic period, which may not call for the over-provision of private infrastructure.
- **Skill Development:** Most data suggest that this shift is occurring regarding new competencies in I.T. departments using hybrid cloud solutions. This can increase job satisfaction and help organizations recruit and retain quality employees for staff functions [5].

Uses

- **Financial Services:** Hybrid Cloud is of great benefit, especially to banks and any other related institution, as the information belonging to the clients can be stored physically at the institutional premise while cloud computing power can analyze the data and allow the clients to access their accounts.
- **Healthcare:** In compliance requirements like HIPAA, patient files are contained on-site at medical centers and other healthcare industries for record-keeping, while the cloud is used for other usages and data analysis.
- **Retail:** Hybrid clouds support a situation where retail stores have higher traffic during a specific month of the year, as the cloud manages the website while POS systems are on site.
- **Manufacturing:** In manufacturing, data for manufacturing and analysis along with the Cloud structure for manufacturing and customer relationship management system is centralized while logistics is managed on-premise [8].
- **Media and Entertainment:** Production-line activities are carried out within the organized company setup and on-premise systems, while the delivery of content and streaming are services outside the company.
- **Research and Education:** Hybrid cloud solutions are adopted in universities and research institutes to store large datasets locally and utilize external clouds for computational purposes and collaboration.

Scope

- **Edge-to-Cloud Integration:** With the advancement in edge computing, the hybrid cloud is expanding to edge areas, creating a flow from edge to on-premise and cloud.
- **A.I. and Machine Learning:** To optimize their usage of hybrid-cloud platforms, users primarily train A.I. and ML models in the cloud while performing inference locally or at the edge.
- **5G and IoT:** The availability of 5G networks and the development of connected 'things' increase the coverage of hybrid cloud solutions useful for such smart city and industrial IoT applications.
- **Quantum Computing:** Quantum computing may also evolve to integrate with classical systems, including using quantum resources in the hybrid cloud.
- **Blockchain Integration:** Blockchain is slowly finding its way into hybrid clouds, especially regarding supply chain and financial services.
- **Sustainable Computing:** Its applicability is now from a technical aspect and an energy and environmental perspective, where the work can even be assigned according to the power consumption measurements of different centers.

Conclusion

Hybrid cloud solutions have evolved into a compelling strategy for managing the I.T. requirements of contemporary firms. Combining on-premise and cloud infrastructures, such solutions present efficient, modular, and secure approaches to managing I.T. assets. This paper describes a hybrid cloud as a practical solution because of the cost-saving potential, increased security, and flexibility in functionality for enterprises across industries. However, using a hybrid cloud has challenges, as explained below. The use of both client-server and distributed computing, problems of integration, and existing security problems make it necessary to plan and organize the deployment process. The implications also concern its influence on the organizations' I.T. departments and possible changes required in several skills and instruments. However, hybrid cloud solutions have had a positive effect on business operations. Delivering data center modernization, digital business acceleration, I.T. security, and globalization, the hybrid cloud emerges as an enabler for business change and growth. Regarding the future, the real question is more about the extent to which further advancements can occur in the hybrid cloud. When it comes to improved and innovative hybrid cloud solutions, one can expect the further integration of edge computing and quantum resources, advanced A.I. management, and enhanced sustainability features that reflect new technological demands and continuous changes in business needs.

References

1. Agbaje MO, Ohwo OB, Ayanwola TG, Olufunmilola O (2022) A Survey of Game-Theoretic Approach for Resource Management in Cloud Computing. Journal of Computer Networks and Communications 2022: e9323818.
2. Hosseini Shirvani M, Amin GR, Babaeikiadehi S (2022) A decision framework for cloud migration: A hybrid approach. IET Software 16: 603-629.
3. Lin Y, Qu T, Zhang K, Huang GQ (2020) Cloud-based production logistics synchronisation service infrastructure for customised production processes. IET Collaborative Intelligent Manufacturing 2: 115-122.
4. Deochake S, Channapattan V (2022) Identity and Access Management Framework for Multi-tenant Resources in Hybrid Cloud Computing. Proceedings of the 17th International Conference on Availability, Reliability and Security pp: 1-8.
5. Tabrizchi H, Rafsanjani MK (2020) A survey on security challenges in cloud computing: issues, threats, and solutions. The Journal of Supercomputing 76: 9493-9532.
6. Shahidinejad A, Ghobaei-Arani M, Masdari M (2020) Resource provisioning using workload clustering in cloud computing environment: a hybrid approach. Cluster Computing 24: 319-342.
7. Matenga AE, Mpofu K (2022) Blockchain-Based Cloud Manufacturing SCM System for Collaborative Enterprise Manufacturing: A Case Study of Transport Manufacturing.

Applied Sciences 12: 8664.

8. Abualigah L, Diabat A (2020) A novel hybrid antlion optimization algorithm for multi-objective task scheduling problems in cloud computing environments. Cluster Computing 24: 205-223.