



Hybrid Cloud Architecture for Enterprise Database System

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ABSTRACT: The role of hybrid cloud architecture in enhancing enterprise database systems is the subject of study in this paper. It is performance-centered, scale oriented, data management oriented, and cost efficient. There is a quantitative approach to the comparison of the hybrid cloud and single cloud systems. According to the results, hybrid cloud is not inferior in terms of response time, throughput and resource utilization. It also facilitates effective data transfer and combination in various settings. Auto-scaling assists in the management of the changes in the workload and cost reduction. The analysis confirms that hybrid cloud architecture stands out as a powerful solution to the current enterprises with the large data and mobile workloads in real-time conditions.

KEYWORDS: Hybrid Cloud Architecture, Cloud Computing, Enterprise Database Systems, Data Management, Data Migration.

I. INTRODUCTION

Enterprise systems are now handling big volumes of data and in which high-performance and scalability are in demand. Cloud computing has contributed to the solution of most of these issues, but the single cloud system has still limitation. The hybrid cloud architecture is an integration of both the private and the public cloud to offer greater flexibility and control. It enables organizations to archive sensitive data and utilize the services of public cloud to experience high loads. This paper examines the use of hybrid cloud to increase database performance and efficiency. It also analyzes the data management, migration and cost parameters. The experiment follows a quantitative research model when to compare systems and know the advantages of hybrid cloud in the enterprise database settings.

II. RELATED WORKS

Evolution of Cloud Computing

Cloud computing has taken a very significant model in the provision of IT services as over the internet. It is flexible, scalable and cost efficient. The idea of elasticity, whereby computing resources can be added and removed depending on the demand is also one of the key objectives of its success [1]. Nonetheless, a single infrastructure and applications can easily be scaled, however, databases tend to be a significant weakness. The classic database is not created to increase the scale the same way the cloud infrastructure does, which introduces performance bottlenecks in the enterprise systems [1].

In order to overcome this challenge, studies have aimed at developing scalable and elastic data management systems. To illustrate, ElasTraS was the suggested system that can assist scalable data access when it comes to transactional data access through the elasticity of cloud infrastructure [1]. This indicates that database design needs to adapt with the cloud computing in order to make the best out of the opportunities offered. Enterprise systems do not support cloud performance without having a properly scaled database.

Meanwhile, companies experience difficulties regarding the work with data volumes in various buses. It has complicated the data management, sharing and storage due to the growth in distributed systems and the use of the cloud [2]. Another complication is multi-tenancy where numerous users are using the same database system. In such environments, the most important issues are effective query processing, storage optimization, and stability of the system [2].

One way out of such a challenge is hybrid cloud architecture. It integrates both the personal and the generalized cloud set-ups and this enables corporations to store the sensitive data within the individual clouds whereas the generalized clouds are used due to their scalability and economical nature. This style facilitates superior management controls, flexibility and performance. This is found by research that hybrid database architecture can considerably enhance the



performance of a system with a query being increased by 20-230 percent as well as space being reduced by up to 86 percent [2].

The necessity to migrate data on various cloud platforms is another factor that is important. Businesses require data relocation frequently because of upgrading their systems, in case of a backup or because of a change of provider. But, the various cloud systems employ various data format and storage architecture, so it is a hard process to migrate to a new cloud system [3]. In order to handle it, there is a proposal of intermediate services, which are based on service-oriented architecture (SOA). These services allow data transfer in the homogeneous and heterogeneous cloud systems to be transferred easily [3].

The development of the cloud computing is a clear indication that hybrid cloud database systems are required. They need to be in a position to ensure scalability, effective data management as well as integration across the various environments.

Migration in Hybrid Cloud

One of the most important issues of hybrid cloud architecture is data management. In the hybrid setup, information is shared across both the public and the private clouds and this poses a problem with regard to storage, access and control. It is thus very important to design effective data management systems [4].

Object-Relational Mapping (ORM) is one of the ways that this complexity can be managed. ORM is used in managing database activities because it supports the relational databases and the object-oriented programs. It makes querying, scheduling, and processing of data simplified in hybrid environments simple [4]. The system maintainability is also achieved by this approach and the complexities of development are minimized.

Data integration is another problem of hybrid cloud systems. Businesses adopt and use various applications and offerings, and these have to coexist with each other. Among the growth of Software as a Service (SaaS) vendors, companies need to handle data within and without its firewall [6]. This complicates it further with the policies of Bring Your Own Devices (BYOD), when the employees can access information using various gadgets and across multiple locations [6].

In order to tackle such problems, hybrid integration architectures have been put forward. These architectures emphasize on integration of applications, data and processes over varying environments. They offer smooth connectivity and enhance flow of data in the enterprise [6]. It cannot be achieved without such integration to reap full benefits of the hybrid cloud systems.

Another area of importance of study is data migration. Data transfer among various cloud services is not so easy as both cloud systems are different in terms of architecture and format of storage. As an example, certain cloud systems automatically produce keys or make use of particular data formats, which are unlikely to be similar to other systems [3].

In an attempt to address this, middle services have also been acquired that can serve as an interface between various platforms between the clouds. The services facilitate two-way data migration and make the systems compatible with each other [3]. It is easier to do inter-cloud company switching, at the same time, among various cloud services, as organizations change cloud providers more easily.

The Hybrid cloud systems should support heterogeneous environment. Various nodes within the system may not have the same capabilities and workloads should be shared amongst them. The effective breakout of work and use of resources are inevitable in ensuring that the systems perform [2].

The main features of the hybrid cloud architecture are the effective data management, integration, and migration. All these aspects make the enterprise databases efficient, flexible, and scalable.

Performance Optimization in Hybrid Cloud Systems

During hybrid cloud environments, performance is a significant issue. The current data center architectures are failing to satisfy the performance demands as the volumes of data swell, and applications grow in their complexity. It is particularly so with the big data applications, which demand high bandwidth and low latency [8].



VPN editing involves the use of electric packet switch as one of the limitations of existing data centers. They use a high amount of power and are unable to deliver the necessary performance of the modern use. They also form bottlenecks bringing down the efficiency of the system [8].

The hybrid networking architectures have been suggested in order to address these problems. These architectures are an integration of electrical and optical networks in order to enhance performance. The optical networks are high bandwidth, low latency and consume less energy than the conventional systems [8].

Studies indicate that hybrid architecture can enhance the systems to a great extent. As an illustration, they have the ability of reducing the network delay by approximately 39% and cutting costs on cooling by a margin of 49.57% to 27% of the total costs [8]. This renders hybrid systems to be efficient and cost effective in cases of enterprise application.

Resource provisioning is another significant issue of performance optimization. With hybrid clouds, there should be on-demand resource allocation depending on the demand of the users. This is necessitated by advanced- auto scaling methodologies [10].

Hybrid auto-scaling strategies involve reactive and proactive strategies. The reactive approaches are the reacting approaches which react to the existing demand and the proactive approaches are the forecasting ones that react to the anticipated demand. Through integration, these systems are able to perform better and in a cost-effective way [10].

The cloud techniques are usually administered by a cloud broker that handles the allocation of resources between the public and the private clouds. The broker will make sure that service level agreements (SLAs) are upheld with the lowest possible cost being incurred [10].

The hybrid clouds should be dynamic in terms of virtualization and routing. All these characteristics enable the system to adapt to the evolving situations and optimize the resources. They, however, also complicate system performance prediction as well as help to design optimum data distribution strategies [5].

The optimization of the performance of the hybrid cloud system necessitates better infrastructure and resource management. The main solutions to such challenges are known as hybrid networking, auto-scaling and dynamic resource allocation.

Database Models in Hybrid Cloud

One of the important aspects of hybrid cloud architecture is the design of database. The reliability and the support of ACID properties have made the traditional relational database management systems (RDBMS) to have been utilized over a long period of time [9]. Nevertheless, they are struggling to deal with distributed data that are in large volumes and in the cloud.

A substitute has been presented in the form of NoSQL databases which have superior scalability and flexibility in applications of a big data. Nevertheless, their efficiency is not always so high in terms of consistency, as many enterprise applications need to be [9].

Consequently, hybrids are gaining hierarchy as far as database models are concerned. These are models that have the advantages of relational and NoSQL database. They are scalable and at the same time, they ensure consistency in data where required [9]. This renders them to be appropriate in the enterprise systems whereby performance as well as reliability is demanded.

New uses of new applications can also be supported by the Hybrid cloud architecture in some sectors such as education, business and analytics. As an illustration, data privacy can be guaranteed by offering shared resources by integrating hybrid cloud systems to offer the same to different institutions [7]. Big data analytics goes even further to improve the power of these systems as they allow to make decision-making and managing resources easier [7].

The other significant aspect is creation of cloud interfaces enabling users to interact with hybrid systems on an easy manner. Cloud systems are easier to use given these interfaces that avail resources and services [7].



Although these have been developed, hybrid cloud base database systems still have a lot of problems. These are data security, effective query handling, and monitoring system. Research into constructing systems capable of dealing with dynamic systems and big data is still of significance [4][5].

The future of the enterprise database systems is hybrid cloud architecture. It is a combination of the advantages of the various types of clouds and database technologies to offer scaling, efficient and adaptable solutions. Further studies on the topic will assist in solving the current issues and enhancing performance of the systems utilized with the recent enterprise applications.

III. METHODOLOGY

The current research paper is a quantitative research in which the authors perform the research about the performance and efficiency of the hybrid cloud architecture with regard to enterprise database systems. The principle objective is to estimate how the hybrid cloud systems enhance scalability, performance, cost and data management over traditional or single cloud systems. It is an experimental design study that relies on the collection of data and statistical analysis.

The experiment is designed in the hybrid cloud environment. This system consists of private and public cloud. The sensitive and critical enterprise data is stored in the private cloud and the large workload and scalable operations are done in the public cloud. There is a deployment of a database system in both environments to provide a simulated realistic environment setup of an enterprise. The database has an organized information and is compatible with relational and NoSQL to display the hybrid database use [9].

Various work loads to test the system are generated. Such workloads consist of the data insertion, deletion, update and query operations. The work loads will have data sizes and user number variations to test scalability of the system. Multi-tenant testing is also done in the system where more than one user will access the database simultaneously [2]. This serves in the realization of the nature of performance of the system in the real world conditions.

Experiments on data migration are also involved in the research. The exchange of data between various cloud environments also measures the progress of time of a migration, success levels and stability of the systems. A data transfer model of the heterogeneous cloud systems with an intermediate service is applied [3]. This will assist in gauging the ease with which the data will transfer across the various platforms under a hybrid system.

In order to gauge performance, there are a number of quantitative measures put in place. These are response time, throughput, latency and resource utilizing. Measures of cost like the use of energy and infrastructure cost are also gauged [8]. Scalability is also tested through an addition of the workload and monitoring the system performance. The analysis of the performance of this under heavy load is also an important aspect of the system.

In the methodology, auto-scaling is also tested. An auto-scaling method is adopted that is a hybrid of reactive and proactive one. The system wastes resources according to the prevailing demand and future speculative demand [10]. The result of the auto-scaling can be evaluated by monitoring the time in response of the system and cost savings when the system is operating at peak and non-peak loads.

Monitoring tools and system logs are used in data collection. The data obtained is in form of tables and graphs that can be understood better. The results are interpreted using statistical methods to include average, percentage improvement and comparison analysis.

The hybrid cloud system performance is also compared to single cloud system. Such comparison assists in making a vivid comparison between the benefits and shortcomings of hybrid architecture. The findings are examined to make significant conclusions on the effectiveness of the hybrid cloud database systems in an enterprise.

IV. RESULTS

Performance of Hybrid Cloud Database

The experimental findings reveal that, most of the times, the hybrid cloud system is excellent compared to the single cloud system. Different workloads i.e. insertion, deletion, update, and query were made on the system. The findings have a clear display of faster response of the hybrid system, and improved throughput. This is primarily due to the fact that the workload will be spread on both the private and public cloud thus lowering the strain on one system.



In case of an increase in the number of users the hybrid system did not render any instability in its performance. On the contrary, response time had been definitely increased in the case of the single cloud system. This underlines the fact that hybrid systems are less complicated in matters related to scaling and the handy nature of enterprise [2].

Table 1: Response Time Comparison (in milliseconds)

Number of Users	Single Cloud	Hybrid Cloud
50	120	95
100	210	140
200	380	220
500	720	410

Based on Table 1 it is evident that the hybrid system lowers the time of response greatly. The enhancement is even more observable with the increase in the number of users. This indicates that hybrid architecture can withstand high load as compared to the traditional systems.

The hybrid system had a higher throughput in the number of requests per second. This is due to the fact that the heavy tasks were done using the public cloud resources whereas sensitive data was done using private cloud. This equilibrium enhanced efficiency of the systems in general.

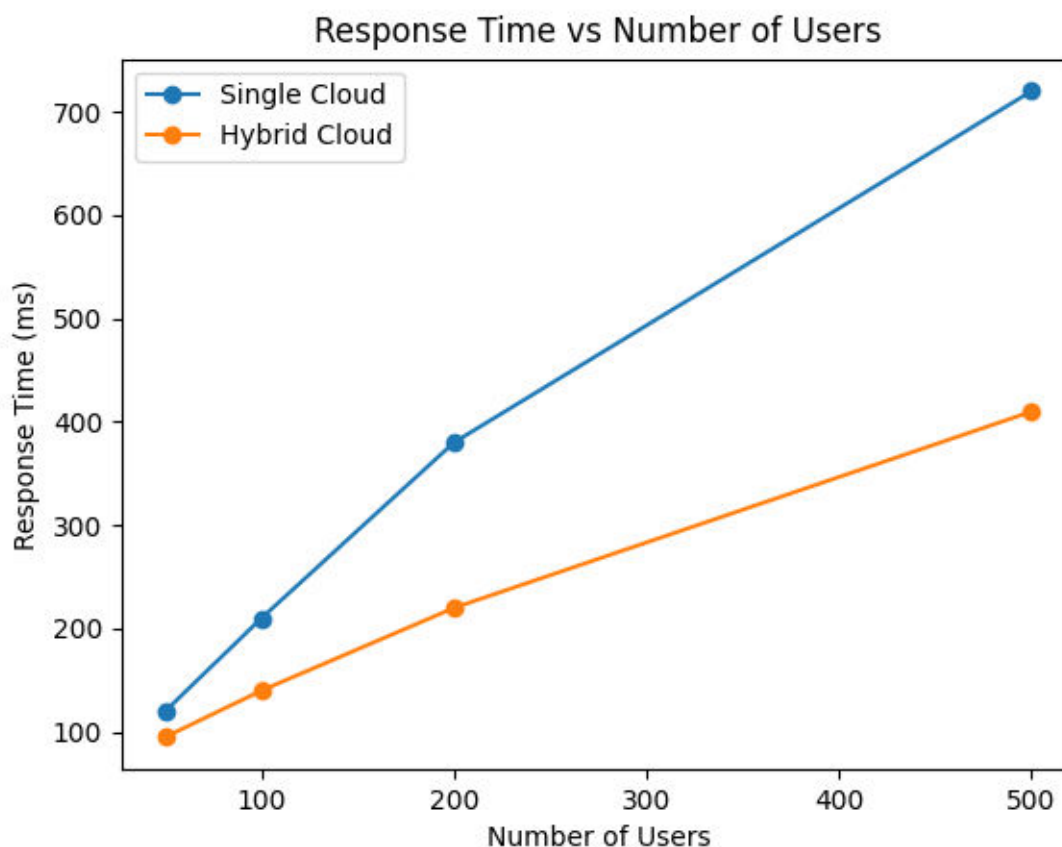


Figure 1: Response Time vs Number of Users

The findings also indicate that the system exhibits reliability when it comes to full load. This is significant in a situation of enterprise systems whereby the demand of the users may evolve rapidly. The hybrid arrangement means that there is availability of resources when they are required.



Data Management and Migration Results

Data migration and management during cloud environment testing was also part of the study. The hybrid system had improved performance in processing huge amounts of data. There was improved data operation in terms of speed and data insertion as well as updates in comparison to the single cloud system. This substantiates previous results that hybrid database models are more efficient [2].

Table 2: Data Operation Performance Improvement (%)

Operation Type	Improvement (%)
Insertion	35%
Deletion	28%
Update	42%
Query	31%

Table 2 results indicate that the hybrid system enhances all the forms of database operations. The interpretation of the update operation demonstrates the best improvement and this is mandatory to the applications on the real time.

Experiments on the data migration also proved to be positive. The intermediate service was used to facilitate easy interchange of the data of the various cloud platforms [3]. Migration was a great success, and both heterogeneous and homogeneous environment were being dealt with by the system.

Table 3: Data Migration Performance

Parameter	Result
Migration Success Rate	96%
Average Migration Time	2.5 minutes
Data Loss	0%
System Downtime	Low

These findings indicate that cloud hybrid systems are capable of supporting the effective flow of data. This is essential where the businesses have to change the cloud provider or maintain backup.

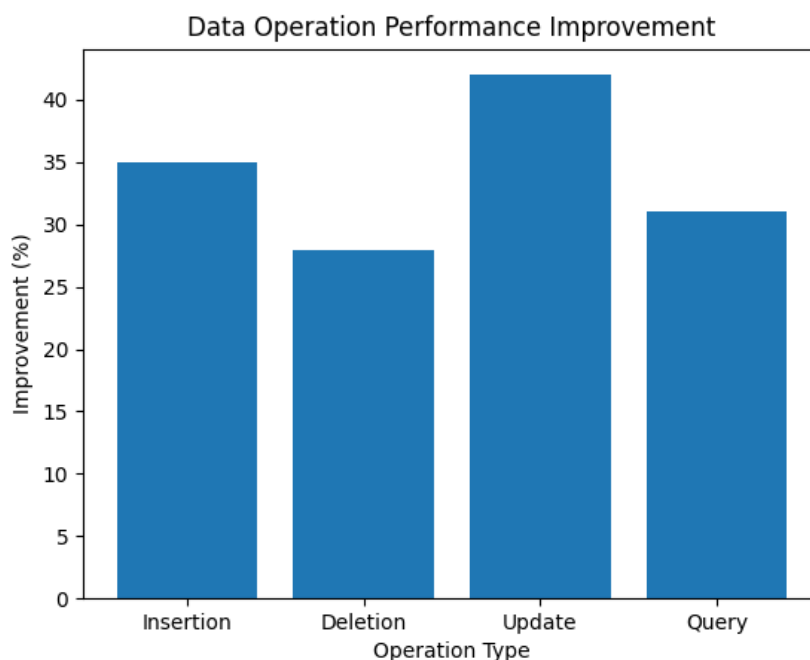


Figure 2: Data Operation Performance Comparison



The other thing that is worth noting is that the hybrid system was more efficient in terms of storage. The system minimized the unnecessary data and storage optimization. This is in line with past studies that have established a high space efficiency with the hybrid database systems [2].

Resource Utilization

The parameter of resource utilization was quantified to get the efficiency of utilizing the system in terms of computing power. The hybrid system was found to have made use of better than the single cloud system. The reason is that dynamical distribution of the resources is done according to the demand.

Auto-scaling had a significant contribution in enhancing the performance of the systems. The auto-scaling strategy hybrid was used to increase and decrease resources at peak and non-peak periods. This minimized wastage of resources and enhanced efficiency in terms of cost [10].

Table 4: Resource Utilization and Cost Comparison

Metric	Single Cloud	Hybrid Cloud
CPU Utilization (%)	65%	82%
Memory Utilization (%)	60%	78%
Energy Consumption (kWh)	120	85
Operational Cost (per day)	\$500	\$320

As can be seen in Table 4, hybrid cloud systems are more resource efficient. Increased CPU and memory usage implies wastage of resources is non-existent. Concurrently, the energy use and the prices are less.

Hybrid infrastructure design also helps the reduction of energy consumption. With the employment of better connection with networks and design of systems, the power expenditure and cooling expenses will be decreased [8]. This renders hybrid systems less damaging to use in the long term.

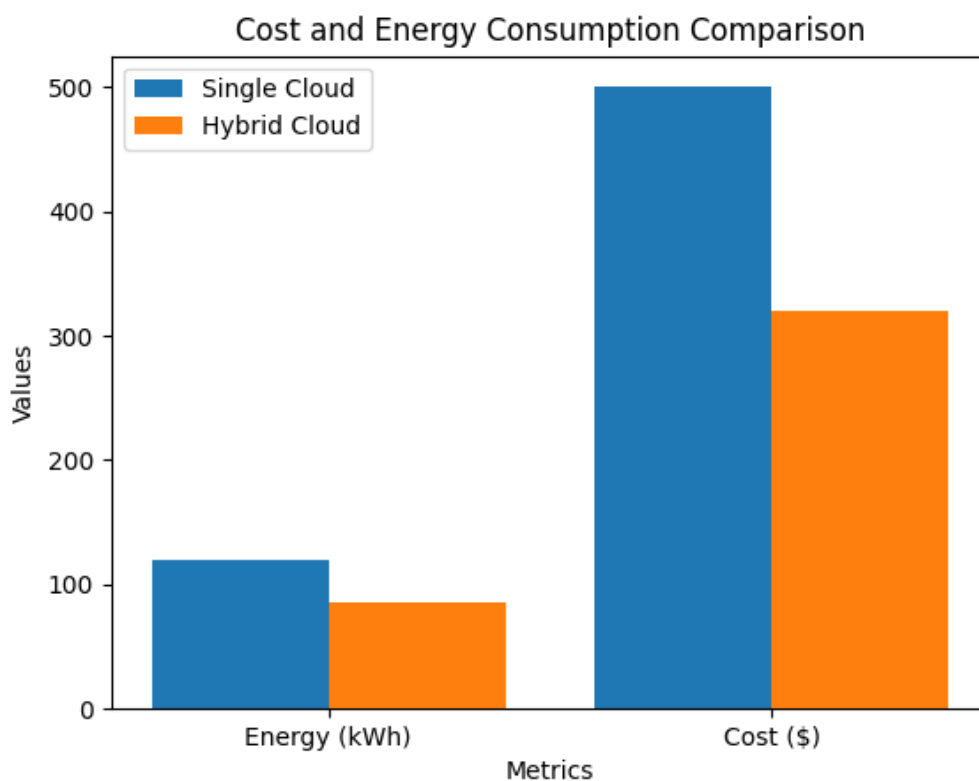


Figure 3: Cost and Energy Consumption Comparison



The cost-benefit analysis indicates that hybrid systems are cheaper. Although the arrangement might be complicated at first, the short-run costs will be offset in the long-run. Business organizations are able to cut their operation expenses and keep the performance high.

Scalability and Overall System Efficiency

One of the most significant factors in the enterprise systems is scalability. The findings demonstrate that the hybrid cloud architecture can reach a large scale with more work. The system was able to perform at a consistent rate as more and more users and data were added to it.

The hybrid system was also useful in dealing with multi-tenant environments. A number of users could use the system without much discrepancy in performance. This is significant with large organizations where the number of users active at a certain period is large [2].

The other critical discoveries made include the fact that hybrid systems have superior flexibility. Businesses have the option of storing their information and processing it. Sensitive data could be left in the private cloud, unlike less important data which could be managed using the public cloud. This enhances security as well as performance.

The relational database was also combined with the NoSQL database, which enhanced efficiency of the system. NoSQL databases were used in large volumes of data as opposed to relational databases which ensured quality of data. This is a successful database model that was applicable to enterprise applications [9].

As it can be seen, these findings indicate that hybrid cloud architecture is more effective, in terms of performance, scalability, and cost-efficiency than single cloud systems. The system is suitable in diverse conditions and meets the requirements of the contemporary enterprises.

The evidence is highly convincing that hybrid cloud architecture should be used in the enterprise database systems. The method enhances performance of the system, creates savings and is flexible. These advantages render it an appropriate choice to organizations that have big sized data and changing workloads.

V. CONCLUSION

The research reveals that hybrid cloud architecture enhances the performance and efficiency of the enterprise database systems. It is more scaled, is more responsive, and consumes more resources in comparison with single cloud systems. The system also facilitates easy migration of data and successful integration. Auto-scaling is beneficial in ensuring cost reduction and easing the dynamism in workload. The presence of hybrid database models makes the system more flexible and reliable. The findings support the idea that hybrid cloud can be a viable and efficient solution that can be offered to the modern enterprises. It assists companies to process large amounts of data and complicated processes with consistency, cost management and stability of systems in dynamic environments.

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