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A cost-benefit analysis of AWS and Alibaba services for cloud migration

MSc Research Project
Cloud Computing

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A cost-benefit analysis of AWS and Alibaba services for cloud migration

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Abstract

Cloud migration is the process of transitioning applications, data, and overall IT infrastructure to a cloud platform. Although most newly developed applications are cloud-native ones, a number of on-prem applications could also be moved to the cloud if a good migration strategy is devised. This data-driven research delve into the cost-benefits of AWS and Alibaba services for two cloud migration strategies: rehosting (lift-and-shift) and replatforming (lift-tinker-and-shift). Key performance indicators such as scalability, response time, cost, bandwidth and throughput were gathered. Rehosting resulted in speedy deployment with better throughput and bandwidth, as in AWS, where response times were hugely reduced to only 120 ms in comparison to 194 ms of a local, on-prem application which served as baseline. This approach provided the best cost-benefit strategy, with monthly cost of $23.09 in AWS, balancing performance and cost. Although, it delivered better than local host, rehosting could not fully leverage cloud capabilities for scalability, especially on Alibaba where response time increased to 3272 ms with large error rates. In contrast, replatforming delivering a scalable and optimized approach, notably on AWS. Though response time surged to 239 ms, it still provided vital improvements in cost and scalability, with lower monthly cost of $12.30. Thus a few modifications to on-prem applications to use cloud resources is still worth exploring. Replatforming resulted in a response time of 84 ms with a price of $10.29 on Alibaba, offering a better balance on both cost and performance than rehosting. Although rehosting is preferable for faster deployments, replatforming provides significant long-term advantages in scalability, cost savings, cloud resource utilization, and performance. The study discovered that AWS shows **3.88x** better performance than AWS, while Alibaba is **28.89%** cheaper than AWS. The estimated cost and benefits are expected to assist organizations in making informed decisions concerning cloud migration.

1 Introduction

In today's continuously growing digital landscape, cloud computing has evolved as a platform of choice, altering the way organizations deploy, manage and scale their IT resources. The growth in demand for cloud services has brought several new challenges to the selection of cloud services (Thakur et al.; 2022). A formal methodology for the selection of cloud providers is highlighted as a critical challenge which needed further investigation.Cloud services allow businesses to manage computing resources on requisition, without investing huge large-scale capital in hardware or any related operational costs of maintaining physical data centers. The scalability, cost-efficiency and flexibility

have made cloud a key enabler of digital transition across enterprises from startups to large industries. Therefore, the migration of legacy applications and systems to cloud infrastructure is a critical task for industries to be competitive in this high-tech world.

1.1 Cloud migration

Cloud migration can be defined as the process of transitioning data, payloads and applications from physical environment to a cloud infrastructure[1]. It embodies a wide range of strategies, each one with its own number of challenges, benefits and trade-offs. Successful cloud migration could considerably improve an industry's performance by providing increased scalability, faster throughput, reduced load times and improved accessibility. Nevertheless, the migration procedure is complex as it requires accurate organizing, execution and a clear understanding of the cloud ecosystem[2].

Organizations adopting cloud computing has improvised way of building, deploying and maintaining their applications. Traditional on-premises frameworks are too expensive to maintain and are susceptible to inefficiencies. Due to the varying needs of computing resources, organizations with physical data centers must spend in excess capacity to handle large workloads during peak periods, even if those peaks do not occur frequently. This leads to heavy operational, with very limited ability to scale down in lower demand periods. On the other hand, cloud platforms would allow industries to scale their resources up or down dynamically as per their use and pay only for it, achieving higher efficiency and cost-effectiveness.

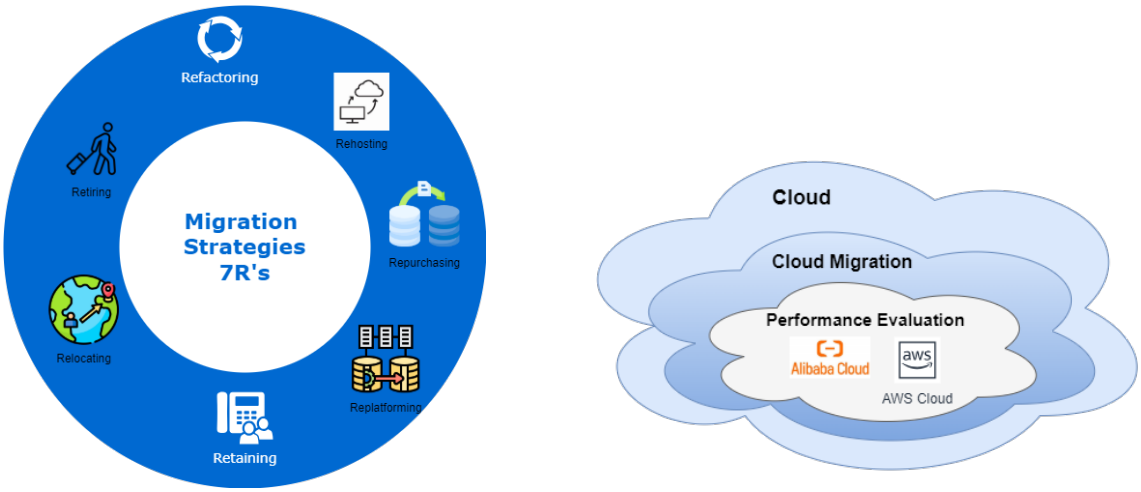


Figure 1: (a) 7 Rs of Migration and (b) Research Overview

Additionally, cloud platforms offer a huge variety of services improving the application functionality. The services include machine learning, artificial intelligence (AI), security tools and databases. To modernize the legacy applications, organizations opt cloud migration to take advantage of these services, thereby resulting in more secure and powerful applications. This makes cloud migration not just a cost saving measure rather a strategic move towards digital transition and innovation.

The process of migration for legacy applications can be complex especially for the ones that were not designed taking cloud frameworks in mind. Transitioning these ap-

[1] https://www.confiz.com/blog/choosing-between-rehosting-re-platforming-and-refactoring/
[2] https://www.oracle.com/cloud/cloud-migration/

plications need significant re-architecting to make sure that they can utilize the complete advantage of cloud-native services like load balancing, auto-scaling and server-less computing. Thus, organizations must wisely decide the correct approach to balance speed, cost and performance.

1.2 Migration strategies

Migration Strategies are the plans that assist organizations to move data, payloads and applications from on-premise enterprises to cloud platforms. Figure 1a shows the different migration strategies. There are 7 most commonly used strategies that can be implemented for application migration popularly known as the "7Rs" of cloud migration.[3].

1. **Rehosting ("Lift and Shift")**
    - The application is transitioned from on-premises to cloud just"as-is", without modifying the architecture.
2. **Replatforming ("Lift, Tinker and Shift")**
    - The application is transitioned to the cloud enabling few minor changes for taking advantages of cloud capabilities.
3. **Repurchasing ("Drop and Shop")**
    - The existing application is replaced with a new cloud-native application, i.e. moving a traditional application to a SAAS (Software-as-a-Service) model.
4. **Refactoring ("Re-architecting")**
    - The strategy is re-architecting or redeveloping application so that it can be fully optimized for cloud, applications are modified in such a way to utilize cloud-native features like containers, serverless computing and microservices[4].
5. **Retiring**
    - This strategy is identifying and eliminating applications or IT assets that are no longer needed to reduce investments and complexity.
6. **Retaining ("Revisit or Hybrid")**
    - Few applications are not suitable for migration due to security or technical constraints. This strategy involves using the legacy applications with an option to reconsider or revisit cloud migration in future.
7. **Relocating("Hypervisor-level lift and shift")**
    - Huge amount of servers or applications are transferred from physical servers to cloud at a given amount of time. It involves moving an existing virtual machine to the cloud.

[3] `https://docs.aws.amazon.com/prescriptive-guidance/latest/large-migration-guide/migration-strategies.html`

[4] `https://hevodata.com/learn/cloud-migration/`

A significant element in any cloud migration process is the selection of an appropriate migration approach. These approaches or strategies are vital because they command how migration takes place, the level of alteration that the existing applications will go through and how the migrated applications will operate in the cloud environment. The wrong selection of strategy can negatively impact an organization's performance leading to costs over expenditure, performance barriers or even service interruptions. Furthermore, the migration process can be further complicated by the selection of cloud platforms, with each cloud provider provides distinct features, support services and pricing models.

Cloud providers

Although AWS and Azure are the leading cloud infrastructure providers in recent years[5], Alibaba is catching up quickly, especially in Asia. AWS has long been a reference point in the cloud industry, providing a broad range of services and tools that assist cloud migration, along with comprehensive global infrastructure and an extensive ecosystem of third-party collaborations. However, Alibaba Cloud leads in Asia-Pacific region, offering competitive pricing and comprehensive services tailored to certain markets like China. While both the platforms offer similar core services, their differences with terms of pricing, architecture and regional benefits make it important for companies to consider which service provider is best for their exclusive needs.

Organizations opting for migration, finds it hard to choose a platform and strategy that best aligns to their goals, as the advantages and drawbacks of migration strategies on these two platforms have not been broadly studied. The main motive of the study is to evaluate how various cloud migration strategies affect key performance indicators when migrating legacy applications to AWS and Alibaba Cloud. The research focuses on comparative analysis between AWS and Alibaba Cloud as shown in Figure 1b, using various cloud services exploring complex approaches. By examining the differences between these service providers on performance and efficiency, the research provides significant insights on cloud infrastructure for the businesses to meet their financial benchmarks.

1.3 Research gap

It is no longer a question to move or not on-prem software to the cloud, but to decide on the *type of migration strategy and cloud vendor to use*. While Amazon Web Services (AWS) are well-known to cloud practitioners, very few people in Ireland are familiar with Alibaba Cloud. So, this research has brought a cost-benefit analysis of the reference cloud platform (AWS) and the less-famous Alibaba for two migration strategies. The research is intended to provide key quantitative insights on cost-benefits to consider for their next business transition.

The importance of this study lies in exploring how various migration approaches influence key indicators across the cloud platforms. Prior studies have majorly focused on individual strategy or specific metrics without a comprehensive process. Selecting the correct migration strategy is vital, particularly as operational benchmarks continue to rise. This research aims at addressing this pressing need, assisting companies make sound choices aligning performance objectives with financial limitations.

A recent survey shows a vital trend towards cloud migration as enterprises understood the need for improved solutions balancing performance and speed (Gholami et al.; 2016).

[5] https://www.statista.com/chart/18819/worldwide-market-share-of-leading-cloud-infrastructure-service-providers/

This research offers a practical guide for businesses navigating the migration complexities followed by evaluating the performance indicators on AWS and Alibaba Cloud, justifying the need for further research.

1.4 Research question

Cloud migration has emerged to be the crucial strategy for enterprises desiring for improved flexibility, better scalability and cost-efficiency. With fast acceptance of cloud computing, Organizations are rapidly moving their workloads to cloud frameworks. This transition, however, provides an intricate fields of migration strategies, each with its own pros and cons.

As organizations struggle with deciding the migration approach to adopt, knowing how these strategies contrast from each other becomes vital in navigating the trade-offs in cloud migration. *An impartial, quantitative evaluation of AWS and Alibaba services for cloud migration is missing.* The research question is:

- What is the cost-benefit of Alibaba and AWS cloud services for Lift-and-shift and Re-platforming migrations?

Costs are presented in US dollars (as of 6/12/2024) and benefits are provided in terms of key performance indicators, such as response time, error rate, throughput, bandwidth and cost. Other metrics could be considered, but the ones listed here are the more relevant ones driving decision-making for cloud migration.

1.5 Research objectives

To address the research question on the evaluation of performance indicators on Alibaba Cloud and AWS, various key steps will be performed:

1. Install the local dev environment and test application: An existing application will be deployed into these environments to ensure similarity, along with the integration of database and other back-end services by the implementation of these strategies.

2. Application deployment on Cloud : Cloud environments will be created on both platforms by configuring necessary tools and services like EC2 (AWS) and ECS (Alibaba) for lift-and-shift and AWS RDS (AWS) and Polar DB (Alibaba) for re-platforming.

3. Performance and Cost Assessment: Performance indicators such as response time and other metrics will be clearly defined and evaluated. Performance monitoring tools across the cloud providers like Apache Jmeter would be used to collect the metrics data under varying conditions and loads.

4. Comparison on Efficiency: It is followed by a thorough evaluation and comparison on the effectiveness of the strategies recognizing the benefits and trade-offs of each approach.

5. Recommendations for Organizations: Finally, the results will be consolidated into recommendations for industries, guiding them with guidelines for informed decisions based on financial results and cost considerations.

1.6 Outline

The structure of the report is organized as shown in Table 1.

Section	Key Points
2	Existing Works and Correlated Theories
3	Research Framework And Key Indicators Assessment
4	Research Design and Cloud Services
5	Execution of proposed approaches
6	Use Scenarios and Findings
7	Summary and Future directions

Table 1: Research Outline

Section 2 presented a brief account on existing works and relevant theories on migration approaches, as well as their key indicators. The suggested methodology for the evaluation of migration strategies along with the key metrics assessment is discussed in Section 3. The tools and cloud services used along process are discussed in Section 4. Section 5 describes the entire implementation of the research which is then followed by the interpretation of the outcomes of proposed use cases in Section 6. Finally, Section 7 presents conclusions and how this work can be extended in future.

2 Related Work

The rapid growth of cloud adoption has become essential to understand the performance key indicators of cloud migration strategies. The literature review intends to examine migration approaches and performance indicators between Amazon Web Services (AWS) and Alibaba Cloud focusing on the approaches and to highlight the gaps in existing studies.

2.1 Exploring Cloud Migration: Opportunities and Barriers

Cloud migration assists the organizations striving to promote scalability, flexibility and cost-efficiency by advanced cloud solutions. In their holistic analysis, the contributors combine few studies on cloud transition, between 2010 to 2013, identifying the necessity for an upgraded migration design, that is critical for progress in the cloud field. Figure 2 shows a basic illustration of Cloud migration. The researchers continued with a differentiation in Service-Oriented architecture (SOA) and Cloud Transition considering equipping and other challenges(Ahmad et al.; 2018). They further included their opinions pictorially by providing them as organized figures and tables talking about the aggregate outcome of the existing research offering comprehensive insights on the organizing, implementation, assessment and other prevailing challenges. Their research is vital for scholars and institutions implementing cloud migration.

By establishing a comprehensive understanding (Staevsky and Gaftandzhieva; 2023) outlines the primary assets and setbacks that companies face during cloud transition concerning the resources extended by leading cloud service providers and suggests strategies to assist in mitigating these challenges. Enterprises leveraged the advantages of multiple service architectures, like Platform as a Service (PaaS), Software as a Service (SaaS) and

Infrastructure as a Service (IAAS) to fully utilize the positives and benefits of each architecture. The authors also examined the leading cloud service providers, including AWS, Microsoft Azure, Google Cloud Platform , IBM, Alibaba and Oracle Cloud, focusing their cloud safety measures and assessing quality standards and security protocols designed to safeguard sensitive data. They also interpreted the available choices for scalability and uptime, discussed factors influencing scalability for altering workloads, integration considerations such as data transfer, application compatibility, performance optimization, latency, knowledge gaps, business continuity and cost management providing vital knowledge on cloud environment.

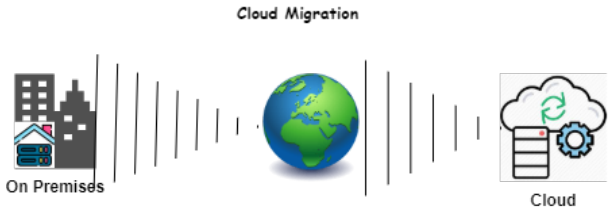


Figure 2: Cloud Migration

2.2 Execution of R-lane Migration Approaches

Performing cloud migration has been classified to 7 major ways, which is collectively called as R-lane strategies. Cloud migration can be done in 5 major steps, Various approaches and steps for migration are clearly defined along with the challenges faced during the migration (Jamshidi et al.; 2013). The authors considered the migration approaches as the Practical and Financial Assessments where the architecture is studied, they proposed the selection criteria for migration with proper planning and closely monitored the optimized migrated modules as per SLA and Financial requirements.

In accordance with the R strategies, a few case studies of Walmart migrations on cost, latency and migration approaches which had huge gains were studied (Varma and Se; 2022). While moving sensitive data to Google secure storage, using scala to transition Teradata to Google BigQuery, data management by Oozie flowcharts and how the data from AppNexus is pulled to Azure Cloud Secure was explained by the contributors and they concluded Rehosting to be a better option for migrations without workflows. They also briefed the influence of cost and productivity on the 6 Rs of migration approaches.

A well-planned approach can provide greater reliability and efficiency in terms of cost and operations. To sum up on this (Rama Parvathy; 2023), the author studied multiple migration strategies to understand what led to the efficiency deficit while database migration using several approaches like Big Bang, Rehosting, Replatforming, Trickle Migration and Refactoring. The writers detailed the pseudo code of each migration considering an IBM dataset. The outcome showed cost efficiency, reduced downtime and data loss proving that Trickle Migration overshadowed other migration approaches. It showed an improved performance of 5% than other migration strategies with 85.76%.

2.3 Cross-Domain Cloud Migration

SMEs often face difficulties in adopting cloud migration because of its increased complexities, security concerns and installation costs. To assist them, the authors delivered a model that optimizes cloud services (Balobaid and Debnath; 2020). They provided a

clear guideline with proper planning considering three stages of pre-migration, application migration and post migration to address their concerns inspiring them to embrace cloud migration and the need for future research.

Principal Component Analysis, an automated transition approach was proposed by the author for various cloud vendors (Narantuya et al.; 2017). This novel approach greatly reduced the latency between the virtual machines as demonstrated on Openstack platform. The framework was invented considering Dependencies detection for the services to be transitioned in correct sequence, Speedy transmission for improved performance and VM migration enabling for smooth migration across cloud environments. The PCA model tested during peak traffic outperformed existing migration strategies.

2.4 Performance Indicators Assessment

To figure out the influence of a migration strategy on system productivity, interpreting key indicators is significant. The author elaborated the challenges she faced while moving a monolithic web application to AWS cloud from a local server (Olariu; 2023). The cost metrics for the entire migration were clearly stated, providing a thorough analysis of migration expenses. This included the prices of reserved, pay as u go and serverless model against various AWS cloud services like CloudFront, Compute services of EC2, storage costs of S3, API gateways and Lambda functions. The execution procedure was not clearcut and lacked the interpretation of performance against cost challenging the entire work.

With a detailed flowchart, multiple key metrics were considered by the author during the migration of web apps, with tools and services offered by leading cloud vendors (Shastry et al.; 2022). It explained the pros and cons of the migration strategies on eminent cloud platforms like GCP, Azure and AWS guiding organizations to make wise decisions aligning to the financial benchmarks. The performance metrics evaluated were limited to scalability, accessibility, throughput and response time.

2.5 Maximizing cost efficiency and Productivity with AWS Services

Companies are moving towards cloud to minimize their total cost of ownership and maintenance costs. The author investigated the migrated pitfalls such as resource over usage and unfair cloud charges (Murugesan; 2024). He examined how the cloud migration cost could be optimized by considering several factors like semiconductor and energy costs considering organization's size and their cloud usage timings distinguishing AWS storage mechanisms. He utilized AWS spot instances that can make use of cloud's spare capacity at greatly reduced prices, he also opted for serverless computing to eradicate the server management costs with proper planning savings during data transfer and storage management, avoiding unwanted AWS charges.

Triggering Terraform migration scripts, the author used multiple AWS services like ECS, Fargate and Jenkins emphasizing the significance of testing and planning for effective migration (Pushpaleela et al.; 2022). A modernization strategy was considered with the stages like Analyzing existing architecture, Scheduling the migration approaches for data safety and Quality Assessment of migrated applications followed by the automated deployment of application insisting the importance of applying migration approaches for the application to operate effectively.

Paper	Description	Drawbacks
Ahmad et al., 2018	Briefs Cloud migration benefits, shortcomings, and SOA comparison.	Missing elaborated execution framework.
Staevsky & Gaftandzhieva, 2023	Explores cloud service models and their scalability features.	Limited focus on how challenges can be overcome.
Jamshidi et al., 2013	Details the 5Rs with structured frameworks.	No emphasis on real-time impacts.
Varma & Se, 2022	Proves Trickle Migration's efficiency with real-world examples.	Lacks wider insights on performance across diverse use cases.
Rama Parvathy, 2023	Examines Azure Migration, emphasizing Trickle Migration effectiveness.	Requires validation for larger datasets.
Balobaid & Debnath, 2020	Proposes a model addressing SME migration challenges.	Needs framework refinement for larger enterprises.
Narantuya et al., 2017	Introduces PCA automation for seamless Cloud VM migration.	Lacks integration and scalability for larger environments.
Olariu, 2023	Evaluates cost and performance on AWS.	No clarity on execution and covers limited performance indicators.
Shastry et al., 2022	Details a migration roadmap for various providers.	Performance indicators are limited.
Murugesan, 2024	Explores AWS cost-saving strategies.	Limited cloud comparisons.
Pushpaleela et al., 2022	Proposes automated AWS migration with Jenkins, Terraform, and Fargate.	Concentrates solely on AWS, limiting multi-cloud environments.

Figure 3: Literature Description and Drawbacks

The above research in Figure 3 focuses more on performance and Cost efficiency on popular cloud platforms, whereas this research

- will use an existing application with database;
- will focus on AWS and Alibaba Cloud.
- will perform migration using sequelize scripts ;
- will focus on multiple migration approaches rehosting and replatforming ; and
- will provide complete road-map on implementation;

The existing studies on cloud migration focused on the general comparison between the migration strategies while a few studies targeted the evaluation of performance indicators and cost in AWS platform. While the Migration strategies are clearly evaluated in various leading cloud providers, Alibaba Cloud seems to be underexplored. This illustrates the need for a comprehensive analysis on replatforming and rehosting approaches in AWS and Alibaba Cloud, guiding users navigating towards cloud adoption.

3 Methodology

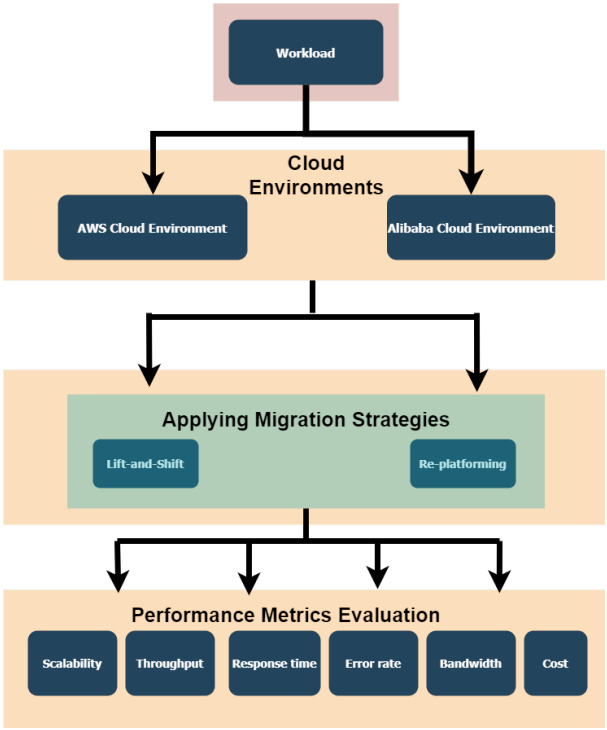


Figure 4: Research Workflow: Workload deployed to two cloud platforms, Two migration strategies Assessment and Evaluation of key performance indicators

The study investigates the influence of rehosting and replatforming migration approaches on cost efficiency and performance. The methodology employed in the research involves the key steps below for ensuring validity and reliability in results. The steps include Workload replication, Cloud Environments, Applying Migration Strategies and Performance indicators Evaluation as shown in Figure 4.

3.1 Reproducibility of results

A test application was employed in this migration study. The existing application is a Student Hub that is cloned from GitHub to a local setup (laptop) and run via Visual Studio Code. VS Code is integrated with GitHub for seamless version control of application. The replicated application serves as the testing benchmark, enabling comprehensive comparisons on Cloud Environments for different migration approaches. GitHub links:

- `https://github.com/azharakhter/student-portal-backend.git`
- `https://github.com/azharakhter/student-portal-frontend-react-js`

3.2 Cloud Environments

The workload is evaluated on two cloud environments, AWS and Alibaba. Performance and cost differences were evaluated, and are valid as of 5/12/2024[6]. As previously men-

[6]`https://www.alibabacloud.com/en/pricing?_p_lc=1&spm=a3c0i.29515631.6791778070.92.2e667ab3AA1IOL`

tioned, little is known about impartial, quantitative evaluation of AWS and Alibaba for cloud migration. AWS is a well-established leader in cloud computing, while Alibaba's presence is growing rapidly (especially in the Asia-Pacific region). However, for the cost-benefit analysis, a common geography was selected to make a fair comparison.

Feature	AWS	Alibaba Cloud
Global Reach	Global presence, strong in **North America** and **Europe**.	Strong in Asia, especially in **China**.
Regions	34	30
Availability Zones	108	89
Standard Compute Service	EC2 (Elastic Compute Cloud)	ECS (Elastic Compute Service)
Supported Operating Systems	Linux, Windows	Linux, Windows
Compute Pricing Models	On-demand, Reserved, Spot Instances	Monthly or Pay-as-you-go
Storage Services	Object, Block, Archive	Object, Block, Archive
Content Delivery Network (CDN)	Amazon CloudFront	Alibaba Cloud CDN
Database Services	RDS, Aurora, DynamoDB	Polar DB, ApsaraDB
AI and Machine Learning	SageMaker, Rekognition, Polly	PAI (Platform for AI)
Container Services	Amazon EKS, ECS	Container Service for Kubernetes (ACK)
Serverless Computing	AWS Lambda	Function Compute
IoT Platforms	AWS IoT Core	Alibaba IoT Platform
Monitoring and Management Tools	CloudWatch, Trusted Advisor	CloudMonitor, Cloud Quotas Management
Security and Compliance	Shield, WAF, IAM	Anti-DDoS, Cloud Firewall
DevOps Tools	AWS CodePipeline, Code Build	CloudShell, Cloud Toolkit

Figure 5: AWS vs Alibaba: a brief comparison and equivalent service names.

Global and regional presence

AWS has a widespread international presence, making it reliable for business in multiple geographic locations. Alibaba Cloud, with a strong presence in Asia-Pacific Region, especially in China offers competitive advantages for businesses to operate in this market[7].

Diverse Ecosystems

AWS offers broad services to a wide range of industries, offering several services and integrations, enabling flexible cloud solutions. On the other hand, Alibaba Cloud offers optimized services that meets the needs of industries in China, making Alibaba Cloud a cost-effective solution for companies targeting these markets, with services that meets local compliance and requirements. The differences between the cloud vendors are shown in Figure 5.

3.3 Migration Strategies

Two migration strategies are applied to the replicated application to study cloud's native features like compute, networking and storage which affect the performance of the application. The next step is followed by evaluating the key metrics on how these migration strategies influence performance and cost.

[7] `https://www.msp360.com/resources/blog/alibaba-cloud-vs-aws/`

3.3.1 Migration Strategies

- **Rehosting ("Lift and Shift"):** The workload is transitioned from on-premises to cloud just "as-is", without modifying the architecture[8].
- **Replatforming ("Lift, Tinker and Shift"):** The workload's database is replatformed to the Cloud, enabling few minor changes for taking advantages of cloud capabilities.

3.3.2 Defining Use Cases

- **Localhost:** It is the baseline setup, where the application runs on-premise.
- **AWS Rehosting:** The application is migrated to AWS without any major modifications.
- **AWS Replatforming:**The application's database is transitioned to AWS while the application still runs on-premise.
- **Alibaba Rehosting:** The application is transitioned to Alibaba without any major modifications.
- **Alibaba Replatforming:** The application's database is transitioned to Alibaba while the application still runs on-premise.

3.4 Performance Metrics Evaluation

Once the application is transitioned to cloud, key performance indicators (KPIs) are assessed to determine the success of each use case[9]. The key indicators are evaluated using Apache Jmeter[10]. Jmeter is a popular tool for calculating the performance of cloud applications under varying loads. A few of the performance indicators evaluated in the study is Scalability, Throughput, Bandwidth, Response time, Error rate and Cost.

- **Scalability:** It defines if the Deployment model supports Auto-scaling during excessive traffic.
- **Throughput:** It the measure of no of requests/hits that is processed per unit of time(second).
- **Response Time:** It keeps track of the time taken for the server to respond to the request.
- **Error rate:** It accesses the percentage of requests that resulted in error response from API(GET API), compared to total requests. The error response occurs when API responds with status codes like 404, 502 etc.
- **Bandwidth:** It is the measure of the data transfer rate, accessing the efficiency of the application.
- **Cost:** The total cost for considering cloud compute, storage and database services is analyzed for cost efficiency.

[8] `https://bluexp.netapp.com/blog/cvo-blg-cloud-migration-approach-rehost-refactor-or-replatform`
[9] `https://smartparse.io/posts/measuring-data-migration-success/`
[10] `https://jmeter.apache.org/index.html`

4 Design Specification

A cost-benefit analysis of AWS and Alibaba services is presented. The conceptual framework for such a comparison is shown in Figure 6. By evaluating costs and multiple performance metrics, the research will shed light on the main trade-offs organizations have to go through in the selection of an appropriate cloud vendor.

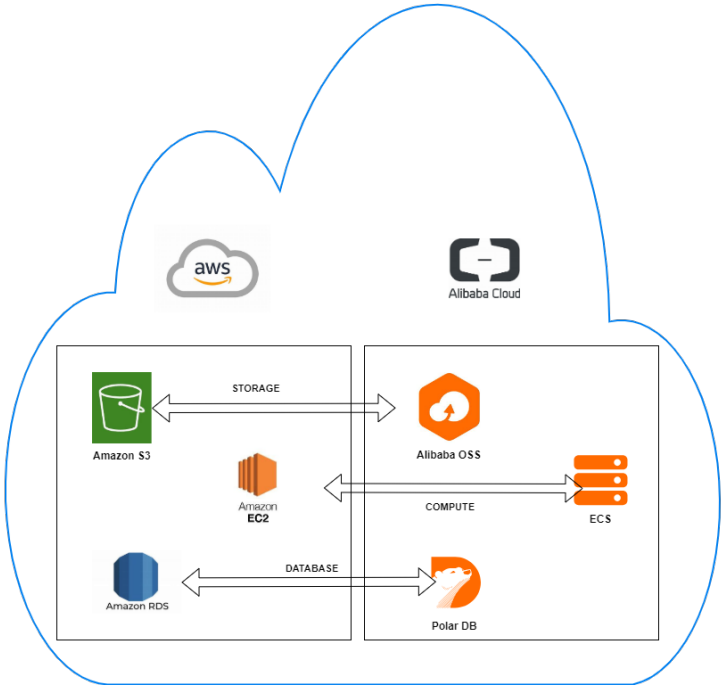


Figure 6: AWS vs Alibaba Services

As described earlier, the evaluation will focus on rehosting and replatforming migration strategies. From Figure 6, it is seen the mapping between well-known AWS services and their counterpart in Alibaba:

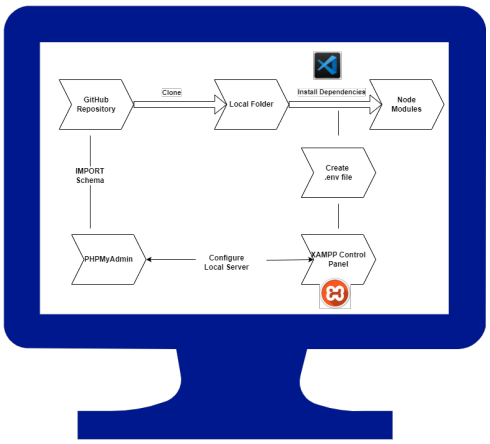
- Compute - AWS Elastic Compute Cloud (EC2) assists with scalable compute cloud capacity, in addition to it Alibaba ECS (Elastic Compute Service), a similar service from Alibaba is chosen for a novel approach.
- Storage- Amazon's Simple Storage Service(S3) is a popular tool for object storage enabling static file hosting. In comparison, Alibaba's Object Oriented Service is optimized for its flexibility and scalability.
- Database- AWS RDS, a widely known relational database is distinguished with an advanced relational database from Alibaba Cloud called Polar DB which outperforms relational databases in peak workloads.

In terms of performance, AWS overshadows Alibaba Cloud with significantly lower response times, better throughput and scalability. Particularly with tools like EC2 and RDS, AWS provides robust infrastructure for performance driven applications. On the other hand, Alibaba excels in cost efficiency, with lower prices for compute, storage and database services making it an affordable option.

5 Implementation

5.1 Local Environment Setup

- The first step is replicating the existing application. VS code is the IDE chosen for the application development; the application sourced from GitHub is cloned using git clone command from the links described in Section 3.1.
- After cloning the repositories, the needful dependencies are installed using the Node Package Manager, which installs the necessary packages listed in package.json file for the application to run correctly.
- To replicate the production-like environment for local deployment, XAMPP (a solution including necessary tools) is setup for a local server including Apache (the web server) and MySQL (for database)[11].
- MySQL, within XAMPP was enabled as the database back-end operating locally. The PHPMyAdmin tool interacts with the MYSQL database within XAMPP for database management, acting as a web interface for managing data.
- The database schema is imported to MYSQL using PHPMyAdmin, mirroring the production setup.
- The front end and back-end application repositories are configured along with the MYSQL database for proper functioning of application.
- A .env file is created to store sensitive information like database credentials and other configurations to the local environment. The flowchart of local host setup is shown in Figure 7a.



Database Migration	(ms)
AWS	4190
Alibaba	4050

Figure 7: (a) Local Environment Setup and (b) Database Migration Timings

[11] `https://www.apachefriends.org/download.html`

5.2 Applying Cloud Migration Strategies

5.2.1 Rehosting

1. Alibaba Rehosting: To rehost an application to Alibaba Cloud, Create a VM (ECS instance) in the cloud platform. Upload the backend of the application or clone the application from GitHub, install necessary software (NPM Packages) and create build files for the same using npm run build. Configure the security groups for the ECS instance, allowing inbound rules to access the application.

2. Go to OSS in Alibaba Console and create a new bucket, where all the static files (HTML and other files) are uploaded and set necessary permissions as public-read, making sure the files are accessible. Now, enable static website hosting option and configure bucket for the same.

3. Create a MYSQL database in Polar DB, configure the network and storage groups, allowing inbound connections from ECS instance in port 3306. Launch DBeaver and connect to the RDS endpoint. The time taken for the database to migrate from Local server to the Cloud-based database is shown in Figure 7b.

4. OSS frontend makes API calls to backend ECS, ensure the backend is configured with OSS url, ECS uses the Polar DB endpoint for making SQL queries. Restrict access to OSS, ECS and PolarDB using IAM roles. Figure 8a shows the steps involved in rehosting.

5. **AWS Rehosting-** The same procedure is followed for AWS rehosting, with alternate services for storage, database and compute functionalities. S3 frontend makes API calls to backend EC2, ensure the backend is configured with S3 URL, EC2 uses the AWS RDS endpoint for making SQL queries.

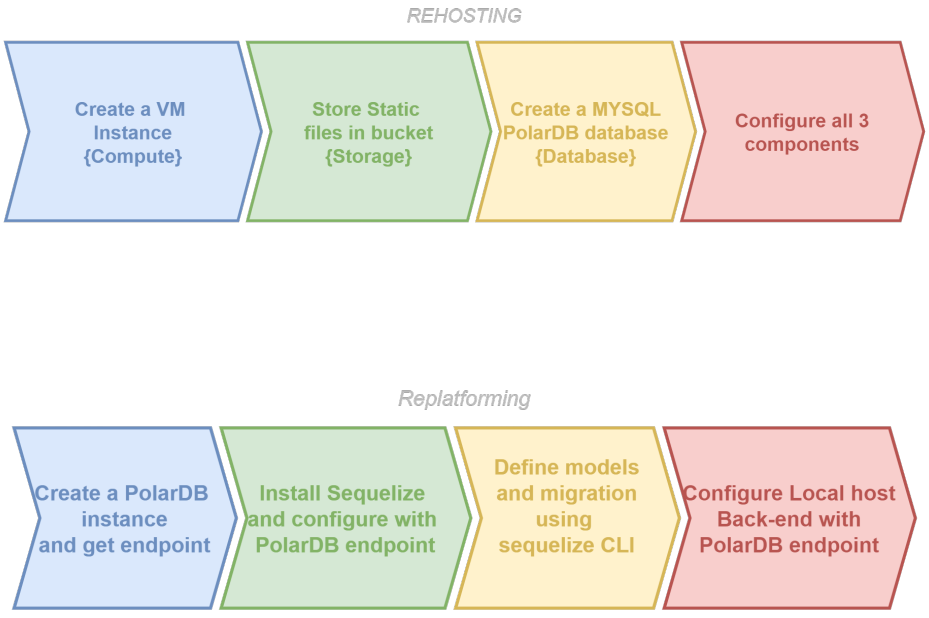


Figure 8: (a)Steps for Rehosting and (b)Steps for Replatforming

5.2.2 Replatforming

1. **Alibaba Replatforming-**Login to Alibaba Console and navigate to PolarDB, Select MSQL engine and other desired settings and note down the endpoint to connect with the application running locally. Figure 8b shows the steps involved in replatforming.

2. To move the database to PolarDB, the sequelize (Node.js ORM) is used to manage database migrations and connections. Install Sequelize and modify the config file to include the PolarDB endpoint.

3. Define the models and create migration using the sequelize CLI, finally run the command: *npx sequelize-cli db:migrate* to move the tables and schema to PolarDB database. Sequelize migration scripts were used for automating schema creation and reducing manual errors. Complex Databases consisting of user-defined functions and triggers require manual intervention and further testing.

4. Configure the Local host backend with PolarDB endpoint, for the application to fetch the details from PolarDB database. Thus, the database is alone replatformed to cloud platform in this approach.

5. **AWS Replatforming-** The same procedure is followed for AWS replatforming, with alternate services for database functionality. Locally running application uses the AWS RDS (Cloud Platform) endpoint for making SQL queries.

5.3 Performance and Cost Evaluation

1. Load Tests are carried out for the above 5 use cases by generating traffic to the application for measuring the key performance indicators in Apache Jmeter.

2. The latest version of jmeter is installed and run to start the GUI. A Test plan is created, defining the Thread Group with number of users, iterations and ramp-up time.

3. To simulate user requests to the application under test, the target URL, request type and payload are configured, followed by collecting and visualizing the performance metrics described in Section 3.

4. Listeners are added as per the metrics needed and the simulation is run. The results from Listeners are collected to compare the performance of migration strategies across the two cloud platforms. Figure 9 shows the steps involved in performance evaluation in Jmeter.

5. The cost analysis is calculated using the pricing calculators provided by individual cloud provider (AWS and Alibaba) considering Compute, storage and database costs and grouped as per resource utilization for each migration strategy on monthly and yearly basis.

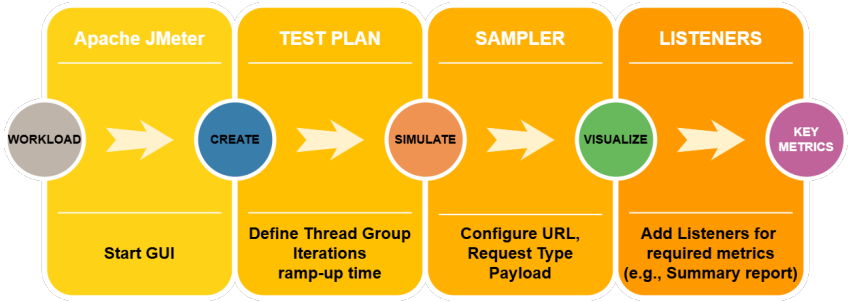


Figure 9: Steps - Performance Evaluation

6 Evaluation

In the following section, the use cases and evaluation of how different deployment strategies performed are discussed in detail.

6.1 Local Host Deployment (baseline deployment)

In order to make the cloud migration strategies more meaningful, here we include a baseline performance of a local server. In this approach, the application is deployed and run on a physical machine within a local environment (laptop). Involvement of cloud infrastructure is zero, meaning the application and its components along with the database are handled locally, thus explaining how the system performs in terms of speed and other factors. Figure 10a shows how the Local host KPI varied with AWS.

- **Average response time:** The response time of **194 ms** is decent for a local setup, but can be improved with cloud solutions.
- **Error rate:** The error rate of **0.21%** is low providing a more stable environment.
- **Throughput:** The throughput of **78.3 hits/sec** is reasonable for a setup with moderate workloads.
- **Average Bandwidth:** The bandwidth of **1533.02 kilobytes/sec** utilized by the system is relatively high for a local setup.
- **Cost Consideration:** The local host doesn't incur cloud costs, however the electricity bill, hardware and networking costs are huge for a laptop.

Metrics	Unit	Local Host	AWS Rehosting	AWS Replatforming
Samples		9395	15272	7684
Avg Response Time	milliseconds	194	120	239
Min Response Time	%	6	19	66
Max Response Time	%	5112	936	819
StDev		119.49	48.89	61.7
Error rate	%	0.21	0.13	0.26
Throughput	Hits/sec	78.3	127.7	63.8
Avg Bandwidth	Kilobytes/sec	1533.02	2410.97	1210.23

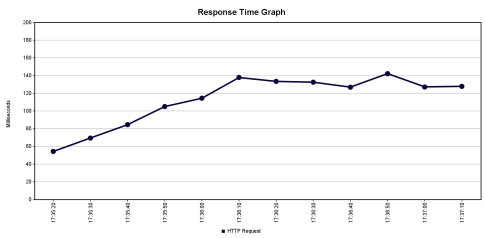


Figure 10: (a)AWS VS Local Host and (b) AWS Rehosting Response time Graph X axis: HTTP request Y axis: Time in milliseconds

6.2 AWS Rehosting

The existing application is transitioned to cloud with minimal changes in this approach. The entire application is lifted and shifted to AWS, the same code runs, but it uses cloud services for database, compute and storage. The back-end runs on EC2 instances, with static files stored in S3, the front-end is accessed via S3 and the database is hosted on AWS RDS. The entire setup mirrors the local host environment, but uses AWS services.

- **Average response time:** The response time of **120 ms** is better than a local setup due to infrastructure and optimization.The response time graph is shown in Figure 10b.

- **Error rate:** The error rate of **0.13%** is very low reflecting higher reliability of AWS.
- **Throughput:** The throughput of **127.7 hits/sec** is better than local host because of its scalability and network architecture.
- **Average Bandwidth:** The bandwidth of **2410.97 kilobytes/sec** is higher than local setup indicating AWS could handle huge workloads efficiently.
- **Cost Consideration:** Total monthly cost is around **$23.09** which includes the compute, database and storage expenses. The network infrastructure, reliability and scalability justifies the AWS service prices.

6.3 AWS Replatforming

The application remains on local servers while the database alone is moved to cloud services in this scenario. In this replatforming approach, only one component of the application is transitioned to cloud while the application continues to run on local host. The database migration was performed to AWS RDS while the remaining application components stayed local.

- **Average response time:** The response time of **239 ms** is slower than rehosting setup as expected due to application running locally and the only component hosted on AWS Cloud is database.
- **Error rate:** Moderately higher error rate of **0.26%** than rehosting, but still fairly low.
- **Throughput:** The throughput is reduced to **63.8 hits/sec** because of application being local and database being cloud-based introducing some overhead.
- **Average Bandwidth:** Lower bandwidth of **1210.23 kilobytes/sec** is consumed than in rehosting due to fewer interactions with AWS RDS Database rather than full deployment.
- **Cost Consideration:** Total monthly cost is around **$12.30** which includes the database expenses. The performance is lower as expected, because the only component hosted on AWS Cloud is database

Metrics	Unit	Local Host	Alibaba Rehosting	Alibaba Replatforming
Samples		9395	562	3610
Avg Response Time	milliseconds	194	3272	84
Min Response Time	%	6	0	1361
Max Response Time	%	5112	84462	745
StDev		119.49	8769.69	146.99
Error rate	%	0.21	11.21	0.55
Throughput	Hits/sec	78.3	4.7	29.9
Avg Bandwidth	Kilobytes/sec	1533.02	124.18	884.96

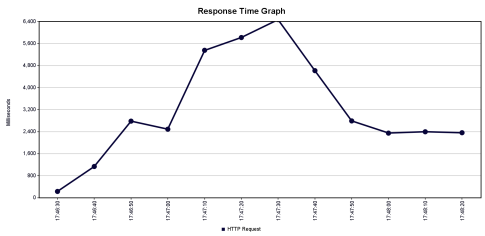


Figure 11: (a) Alibaba vs. Local Host, and (b) Alibaba Rehosting Response Time. Graph x-axis: Number of HTTP requests, and y-axis: Response time in milliseconds.

6.4 Alibaba Rehosting

Alibaba rehosting is exactly like AWS rehosting, where the entire application is transitioned to cloud environment with minimal changes. However, the services used are different. The application is rehosted in Alibaba Cloud's ECS for back-end while the OSS handles the front-end file storage and PolarDB as the cloud database. This setup mirrors the local setup but now uses Alibaba's cloud infrastructure. Figure 11a shows how the Local host KPI varied with Alibaba. The test scenarios were repeated multiple times at different times of the day, analyzing the standard deviation for stability.

- **Average response time:** The response time of **3272 ms** is significantly slower than AWS rehosting due to regional latency issues and misconfiguration.The response time graph is shown in Figure 11b.
- **Error rate:** Higher error rates of **11.21%** reflecting lower reliability.
- **Throughput:** The throughput of **4.7 hits/sec** indicates this approach struggles to work on concurrent requests.
- **Average Bandwidth:** Lower bandwidth of **124.18 kilobytes/sec** as compared to AWS reflecting limited scalability.
- **Cost Consideration:** Total monthly cost is around **$16.36** which includes the database, compute and storage expenses. The performance issues limit its suitability for real-time apps, while it is relatively cheaper than AWS rehosting.

6.5 Alibaba Replatforming

In this case, the database is moved to PolarDB, while the application continues running on local server. Like AWS replatforming, only the database is cloud-based.

- **Average response time:** The response time of **84 ms** is significantly improved over Alibaba rehosting due to only database being migrated to cloud.
- **Error rate:** The error rate of **0.55%** is acceptable reliability.
- **Throughput:** The throughput of **29.9 hits/sec** indicates this approach is better than Alibaba rehosting but lower than AWS.
- **Average Bandwidth :** Bandwidth of **884.96 kilobytes/sec** is apt for moderate workloads but still is lower than AWS.
- **Cost Consideration :** Total monthly cost is around **$10.29** which includes the database expenses, striking a balance between cost and performance but still couldn't match for bandwidth and throughput of AWS. Figure 12a shows the monthly and yearly cost of cloud services used in research as of December 2024.

6.6 Discussion

The results are interpreted below to find which migration approach performed better on different cloud service providers. Figure 12b shows the Summary of the results calculated during the research.

Cost Component	AWS	Alibaba
Storage	**S3**	**OSS**
First 50 GB (Monthly)**	$0.023 × 50 GB = $1.15	$0.02 × 50 GB = $1.00
First 50 GB (Yearly)**	$1.15 × 12 = $13.80	$1.00 × 12 = $12.00
Compute (1 CPU, 1 GiB)	**EC2**	**ECS**
Monthly	$9.64	$5.07
Yearly	$9.64 × 12 = $115.68	$5.07 × 12 = $60.84
Database (1 CPU, 1 GB RAM, 20 GB Storage)	**RDS**	**Polar DB**
Monthly	$12.30	$10.29
Yearly	$12.30 × 12 = $147.60	$10.29 × 12 = $123.4

Use Case	Avg Response Time (ms)	Error Rate (%)	Throughput (Hits/sec)	Avg Bandwidth (KB/sec)	Total Monthly Cost (USD)
Localhost	194	0.21	78.3	1533.02	N/A
AWS Rehosting	120	0.13	127.7	2410.97	23.09
AWS Replatforming	239	0.26	63.8	1210.23	12.3
Alibaba Rehosting	3272	11.21	4.7	124.18	16.36
Alibaba Replatforming	84	0.55	29.9	884.96	10.29

Figure 12: (a) Alibaba vs AWS Cost and (b) Outcome Summary

6.6.1 Key findings in terms of cost

- There is no cloud cost for local setup, but the operational expenses for hardware and maintenance is huge.
- AWS seems to be a costlier option than Alibaba with the total cost of around $23.09/month for the migration approaches.
- Alibaba is cost-effective with $16.36/month for the migration approaches offering better value for organizations aiming at budget friendly options.
- Costs were calculated on subscription on monthly basis for a specific amount of compute, storage, database services as required for the research during peak time intervals. For better interpretation of costs, the pay as u go pricing model is provided for varying scaling costs as shown in Figure 13.

Service	Pricing (Pay as u go)
Alibaba ECS (1 CPU, 1 GB Memory)	~$0.0188/hr
AWS EC2 (2 CPU, 0.5 GB Memory)	~$0.0052/hr
Polar DB	$0.11/hr
AWS RDS	$0.096/hr

Figure 13: Pay as u go Pricing

6.6.2 Key findings in terms of benefits (performance indicators)

- Local setup performed well while lagging in scalability & reliability at peak hours.
- AWS has shown good results across all metrics, particularly in rehosting, achieving speedy response times, higher throughput, optimized bandwidth utilization and lower error rates for better reliability. The database performance also seems to be enhanced while replatforming in AWS.
- Alibaba has been struggling in rehosting with poor response times and error rates due to configuration and cloud service limitations, while replatforming performed better while AWS still lagging, notably in throughput and bandwidth usage.
- Rehosting offered excellent scalability and performance in AWS. Replatforming is still effective when only the database is required to be migrated to cloud platform.
- For Alibaba, replatforming is a better option in comparison to rehosting but still falls short behind AWS cloud's performance.

6.6.3 Overall assessment

- AWS offers improved performance at 3.88x better in terms of overall performance but at higher costs, while Alibaba is 28.89% cheaper than AWS for yearly cost, but might be less suitable for certain workloads due to performance and error issues.
- AWS is the preferred option when the primary consideration is scalability, performance and throughput in higher demanding environments. If cost considerations are crucial and the system is not highly dependent on top performance, Alibaba is the most efficient option.

6.7 Limitations

The study has few limitations that has to be considered while interpreting the results. The research outcomes provide significant insights while the limitations below should be validated in future studies.

- The sample size of data gathered for the use cases are limited, larger data with longer durations could be more reliable and consistent.
- The study accessed very limited cloud service providers excluding other alternatives like Google and Microsoft Azure, influencing the generalizability of the outcomes.
- The Performance metrics were limited to response time, error rate, cost etc. While they are valuable, few extra factors like security and compliance could be considered.
- The performance outcomes were based on a single application, real world application could behave differently.

7 Conclusion and Future Work

The research aimed at evaluating cloud migration strategies by a comparative study in AWS cloud and Alibaba on performance and cost for multiple migration scenarios. The main motive was to determine which cloud service provider best supports migration, including few factors like response time, error rate, throughput, bandwidth and cost.

Final Outcomes showed that AWS outperformed **3.88x** the overall performance of Alibaba Cloud in migration scenarios while delivering faster response times and higher throughput. Besides, Alibaba Cloud is **28.89%** cost-effective than AWS in those migration scenarios. These outcomes highlight the trade-off between cost and performance in cloud service selection, emphasizing the need for tailoring choices as per requirements. This narrows the knowledge gap between well-known AWS and new competitor Alibaba in terms of cloud migration trade-offs. It is therefore expected that the analysis here presented assists companies to decide the best model to adopt.

The research focused on two types of cloud migration strategies. Other types could lead to different conclusions. Other aspects to study could be the software ecosystem and maturity of platform tools. Further research extensions could also involve a broader range of cloud providers, like Google Cloud, Heroku, and Microsoft Azure for a comprehensive analysis. Experimenting with real-time applications, considering additional services and exploring hybrid cloud infrastructures would offer deeper information into cloud migration choices. Finally, testing scalability and cost optimization strategies could also be seen as an interesting research direction.

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