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Research paper

Critical Analysis of Cloud Platform Tools: AWS, Azure, GCP

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Abstract

The adoption of Cloud computing is a hot topic in the IT industry as it gained massive interest in the last few years by deploying multiple applications from on premise data centres to cloud in a bid to reduce cost, latency and boost agility. There are different Cloud Service Platforms based on different criteria such as models, budget and so on. The majors in technology are Google Cloud Platform (GCP), Mi-crosoft Azure, Amazon Web services (AWS), and various cloud platforms for deployment of applications. To help enterprise organizations select the right platform, we represent here three different cloud platforms with detailed pros and cons and comparisons of the top 3 cloud service providers, AWS, Azure, GCP. In this research, not only, a critical analysis of cloud service provider has been applied to underpin the research, but also a web-based application will be deployed on each platform to do the performance analysis of the cloud platforms. This paper aims to do the analysis of well-known CSP's by highlighting a) compute services, b) networking services, c) storage services, also in the deployment models a) price per hour b) latency per hour. The enterprise can find the conclusion which has been made based upon the criteria, to identify the cloud platform offering optimal performance for enterprise clients.

Keywords: *AWS; Azure; Cost; Cloud Computing; Cost; Latency; VM.*

1. Introduction

Due to advancements in technology, most enterprises are moving towards the cloud that leads to accelerating business transformations [1]. There are numerous cloud service providers companies showing rapid growth in the market that has created tough competition for choosing the right service provider. This research paper focuses on the top three major market cloud platforms such as Microsoft Azure, AWS, GCP that can be used to effectively manage the needs of the organization [2]. Furthermore, the comparison of these providers helps users to choose the right platform based upon certain criteria. This paper also critically analyses application deployment comparisons based on the different aspects such as latency, cost, response time.

In the past decade, the growth of infrastructure in the IT industry has increased tremendously. This requires the management of infrastructure in an efficient, scalable, and reusable way. Historically, it was a manual process of managing infrastructure by physically placing and configuring servers by people in their own data centers. Say it on VMware using hypervisor or by any other means [3]. This process results in several problems as it involves huge costs, time, and complexity of purchasing and managing own data centers. Also, as the life of the servers generally is around 5 years, it requires complex migrations which sometimes last months to a year.

The first problem is cost as one must have professionals to execute necessary steps starting from installation to maintenance. This leads to an increase in management overhead and complexity. The second big problem is speed and agility. Since the manual process is slow, it increases the struggle of administrators to set up infrastructure for managing loads of applications. The third major problem is maintenance and performance evaluation. After successfully installing infrastructure, one must look into the system to ensure optimal performance. The last problem is inconsistency. As professionals need to surf various screens it results in skipping steps and causing inconsistencies. It can also be caused as different engineers use it to set up development, testing, and production environments for similar applications.

The first trend towards cloud computing was collocation. It gave users the economic planning of renting physical space, instead of investing in own data center [5]. The second trend is Virtualized data centers that share similarities with the private data centers and colocation facilities in the past decade. The elements of virtualized data centers have the same components of physical data centers servers, processing power, disk storage, and load balancers but now they are virtual devices instead of physical devices. Virtualization does provide a few benefits: Utilizing capital expenses into operating expenses.

It came as a cure for all the problems stated for manual processing. It reduces the cost of installation and maintenance of data centers. Also, it allows us to set up infrastructure very quickly, thus solving severe problems such as scalability, reliability, and availability. Moreover, you will pay for what you use instead of having capital expenditure on physical infrastructure in data centers [6].

There are numerous cloud computing service providers available in the marketplace. Here is the list of the most common cloud service providers [7] [8]:

- Amazon Web Service: Virtual private cloud, dominant vendor
- Microsoft Azure: Private cloud with legacy expertise in enterprise data centers.
- Google Cloud: Provides public cloud solutions.
- Alibaba Cloud: Virtual Private Cloud Services.
- IBM Red Hat OpenShift: Hosted private cloud services with Paas offerings.
- Oracle: Leader in database and Enterprise storage
- NetApp: strong vendor in the storage market, cloud-like deployments for private cloud.
- HPE: Helion Managed Private, managed virtual private cloud services.
- Cisco: the leader in networking.
- VMWare: Arguably the top name in private cloud
- Dell EMC: Enterprise Private Cloud Solutions
- Connectria Managed Cloud: Private Cloud provider
- Rackspace Technology: managed private cloud services.

The difference between physical and cloud management is shown in fig. 1, which illustrates the difference in configuration and maintenance responsibilities between traditional on-premises physical or colocation infrastructure and cloud-based infrastructure. In traditional systems, the user handles both configuration and maintenance, while cloud platforms offload these responsibilities to the provider, enhancing scalability and reliability.

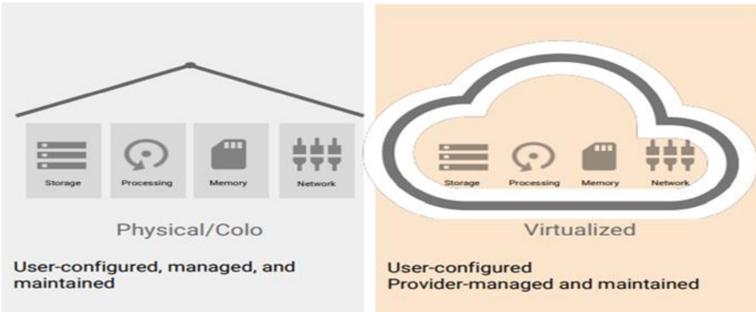

Fig. 1: Comparison Between Physical Infrastructure and Cloud Infrastructure Management.

1.1. Market share of various public cloud providers

A fierce 3-way contest for ascendants in the cloud market continues between the three technology giants, Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). These 'Big Three' cloud hyperscalers hold a significant part in the cloud computing market. The comparison of the world's biggest cloud players against one another in terms of market shares is shown in Fig 2 [9] [10]. Pie chart comparing market share percentages among leading CSPs. AWS holds the largest share (~32%), followed by Microsoft Azure (~19%) and Google Cloud Platform (~7%). Other providers such as Alibaba Cloud and IBM are categorized under "Others." Data represents global distribution trends as of 2024.

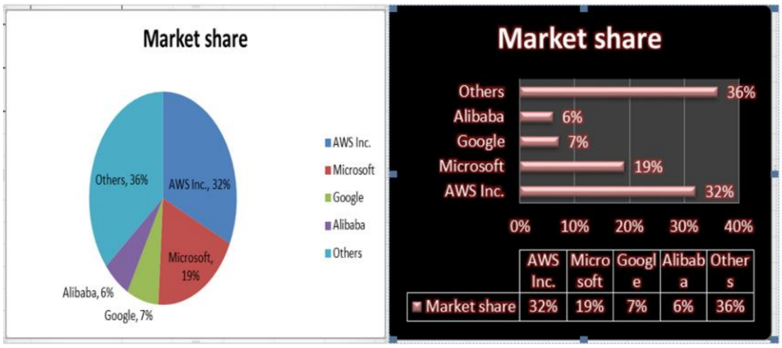

Fig. 2: Market Share Distribution of Public Cloud Service Providers (2024).

The most common three main platform providers are AWS, Azure, and Google Cloud Platform (GCP) [11]. Each platform has features that could be used to match the developer's requirements of an application. The question that arises among learners and business owners is the right choice of a service provider [12] [13]. In this paper, we will compare these three best providers based upon some criteria and by deploying an application on each platform.

Section II of the paper consists of related research done on this area. Section III consists of comparisons of three major cloud providers based upon some factors. Section IV consists of application deployment on these providers. Section V discusses the result analysis and section VI consists of the Conclusion.

2. Literature review

This section is related to the previous research facts of analysis of performance of various cloud platforms by many authors' works. The impacts of cloud computing on business flows, financial flows and supply chain information can be analysed [1]. Few of the work are discussed here as the author [2] has done comparison of various clouds based on storage, compute and management tools. Along with this, some research has also done using price plan of different service providers as mentioned in [3]. While deciding best suitable cloud, the load transfer can be one of the factors. The cloud with minimum migration time and error occurrence has been proposed by author [4]. The study [5] has done about the impacts of choosing cloud services by using computation, storage, and infrastructure. The comparison study of different platforms [6] using certain features has been done by the author. The optimization model has been used for evaluation of performance of public cloud in IaaS by the author [7]. The big data can be analysed using Microsoft, google platforms which has been discussed in [8]. The application of cloud platforms in IOT has been discussed and best outcome cloud platform will be used depending upon the user choice [9]. In this, the author [10] summarized and compared the features of AWS, Azure & GCP to provide help to organizations and users. The cloud can also be used to migrate the data in order to optimize the data. The problems and solutions to this area have been discussed by the author [11]. During migration of Data on cloud, the cost and time estimate can be done by using simulation models [12]. Since, the big data is stored on cloud, hence security is always the concerned of cloud. Such issues have been discussed in this research by the author [13]. The author [14] has proposed an algorithm that can provide effective trading strategies for the buyers and sellers of the computing resource. The quality of service provided by cloud can also be optimized based upon multi-objective optimization and it has been discussed by authors [16]. The basic idea in this study [17] is to distribute tasks (diverse and complex nature) among the cloud resources in such a way that the problem of imbalance is avoided by scheduling algorithms. The empirical studies that address the issues on cloud-based mobile application testing are done by systematic study [18]. The author [19] has proposed various approaches to inform the legacy application migration decision.

For instance, [20] proposed a scalable neurocomputing framework using cloud-edge collaboration to optimize Industrial IoT deployments. Their results showed significant reductions in latency and energy usage when edge nodes were used to offload computation dynamically. This highlights the growing need to evaluate cloud platforms not only in isolation but also in how they integrate with edge computing environments. Similarly, [21] conducted a performance and cost analysis of serverless computing architectures across AWS Lambda, Azure Functions, and Google Cloud Functions. Their results demonstrated that while serverless platforms reduce infrastructure overhead and improve scalability, there is variability in cold start times, which affects real-time applications. The authors suggest that performance evaluations of CSPs should include event-driven workloads, particularly for latency-sensitive applications. Lastly, [22] presented a decision-making framework for multi-cloud deployment, addressing vendor lock-in, compliance, and availability through a hybrid-cloud orchestration model. Their evaluation indicated that combining providers (e.g., AWS + GCP) can offer optimized cost-performance ratios under diverse workloads, but it also introduces new integration and security concerns.

3. Comparison of AWS, AZURE, GCP

The two leaders in cloud computing are Microsoft and Amazon followed by Google, Alibaba, and IBM. In this paper, we will compare the top leading providers based upon the following key factors in the cloud computing world [1].

- Compute Services
- Networking Services
- Storage Services
- Cloud Service Offerings

1) Compute Services: - These services are the IaaS (Infrastructure as a Service) provided by the various cloud providers. This service helps us to create virtual machines of varying types like Linux and Windows distributions. It is precisely flexible and offers many options that do not exist in physical hardware. The below table will provide a high-level overview of various features under computing service by a different hyper scalar. The comparison based on these features is shown in table 1.

Table 1: Comparison Based on Compute Service Features

Services	AWS	AZURE	GCP
Global Infrastructure	25 Regions (India: Mumbai & Hyderabad) 80 AZ 230 PoP	60 Regions (India: Pune, Chennai, Mumbai) 3 AZ per region 130 PoP	24 Regions (India: Mumbai & Delhi 73 AZ 144 PoP
Compute	Elastic Compute Cloud (EC2)	Virtual Machine	Compute Engine
Custom VM Size	Not Possible	Not Possible	Possible – Minimum 1 vCPU
Containers in VM	Manual Installation	Manual Installation	Automatic Deployment on creation time
Alias IP Range	Not Applicable	Not Applicable	Applicable allowing deployment of multiple services
Scalability	Auto Scaling	Virtual Machine Scale Set	Managed and Unmanaged Instance Groups
Availability	Multiple EC2 Instances Required	Availability Set using fault and update domains	Live Migrate Automatic Restart
Pricing	By the hour or the second depending on which instances you run.	Hourly rate	Per Second billing
Discounts	Spot Instances Spot Fleets Committed Use	Reserved Instances Spot Instances	Sustained usage Committed usage Pre-emptible instances
Image Types	C Series: - Compute Optimized D Series – Storage Optimized G Series – Accelerated Computing M Series – General Purpose R Series – Memory Optimized T Series – General Purpose	A Series: - Entry-level VMs for dev/test Bs Series: - Burstable VMs D Series: - General Purpose Compute F Series: - Compute optimized VM G Series: - Memory and storage optimized VM H Series: - High-Performance Computing VM	Standard: - 3.75 GB/vCPU High Memory: - 6.5 GB/vCPU High CPU: - 09.GB/vCPU Memory-Optimized: - 14GB/vCPU Compute Optimized: 3.8 GHz Shared Core: 0.5 GB/vCPU
Disk Type	General Purpose: - SSD Provisioned IOPS: - SSD Throughput Optimized: - HDD	Ultra Disk:- SSD Premium Disk:- SSD Standard Disk: - SSD, HDD	Local Disk: - SSD Persistent Disk: - HDD or SSD RAM Disk

	Cold: - HDD EBS Magnetic		
Backup	Snapshots	Azure backup service	Snapshots Machine Images
Resize VM	Stop and Resize Instance Type	Stop and Resize VM	Yes
Security	Placement Groups	Dedicated Host Proximity placement group	Sole Tenant Node Shielded VM
Encryption	AWS Key Management System	Azure Key Vault Platform Managed Keys Customer Managed Keys	Google Managed Keys (GMK) Customer Managed Keys (CMK) Customer Supplied Keys (CSK)

2) Networking Services: - This service helps us to create our Virtual Private Cloud (VPC) on various cloud platforms. We will dissect networking into its fundamental components, which are networks, sub networks, IP addresses, routes, and firewall rules, along with network pricing. The comparison based on these features is shown in table 2.

Table 2: Comparison Based on Networking Service Features

Networking	AWS	Azure	GCP
Isolated Private Cloud	Virtual Private Cloud	Virtual Private Cloud	Virtual Private Cloud
VPC Scope	Regional	Regional	Global – Across Region Communication
VPC Types	Custom IP Range	Custom IP Range	Default – One subnet every region Auto – One subnet every region Custom – Accumulation of all subnet ranges
DNS Names	Route 53	Google Cloud DNS	Traffic Manager
Cache Content	Cloud Front	Content Delivery Network	Point of Presence
Private Network Connectivity	Direct Connect	Express Route	Cloud Interconnect
Internal and External IP	Internal – Subnet Range Public – Resource Pool reserved by AWS	Internal – Subnet Range Public – Resource Pool reserved by Azure	Internal – Subnet Range or Alias IP Range Public – Resource Pool reserved by GCP
Firewall	Security Groups	Network Security Groups	Firewall Rules
Routes	Created within VPC in a region	Created within VPC in a region	Created by default to the internet and other machines on the same network
Load Balancing	Application Load Balancer Network Load Balancer Classic Load Balancer	Standard and Application	Global:- HTTPS, SSL, TCP Proxy Regional:- TCP/UDP Network Internal:- HTTP, Internal TCP/UDP
Cross Premise Connectivity	Direct Connect	VPN Site to Site Point to Site	VPN Peering – Partner & Dedicated
Shared VPC	No	No	Yes Across Projects
VPC Network Pairing	Yes	Yes	Yes

3) Storage Services: - Every application needs to store data of different kinds like business data, user data, transactional data, media to be streamed, or sensor data from IoT devices. From an application perspective, the computer stores and retrieves the data whether it's a relational, document or object storage. In this module, we will compare various storage services available on different cloud providers. The comparison based on these features is shown in table 3.

Table 3: Comparison Based on Storage Service Features

Hyper Scaler	Storage Services	Database Services	Backup Services
AWS	Simple Storage Service (S3) using Buckets Elastic Block Storage Elastic File System Transfer Appliance using Snowball	AWS Aurora AWS Relational Database System Dynamo DB RedShift ElasticCache	Glacier Storage Type using S3
Azure	Storage Accounts – Blob Storage Accounts – Queue Storage Accounts – File Storage Accounts – Table Disk Storage Data Lake Store	Azure SQL Database MySQL PostgreSQL Azure Data Lake Cosmos DB Data Factory	Archive Storage
GCP	Google Cloud Storage Persistent Disk Local Disk Transfer Appliance Storage Transfer Google FileStore	Cloud SQL, SQL Server, MySQL Cloud Spanner Cloud Firestore Cloud Datastore Cloud Bigtable Cloud BigQuery Cloud Memory Store Any other database from Marketplace – MongoDB	Google Cloud Storage

4) Other Services – The below table compares some other important services provided by cloud providers. The comparison based on these features is shown in table 4.

5)

Table 4: Comparison Based on Other Service Features

Other Services	AWS	Azure	GCP
Platform As a Service	Elastic Beanstalk	Cloud Service	App Engine Standard Flexible Environment
Hybrid	EKS	AKS	Google Kubernetes Engine (GKE)
Monitoring	Cloud Watch	Azure Monitor	Operation Suite

DevOps	AWS Code Build AWS Code Pipeline	Azure Build & Release Pipelines	Cloud Build Cloud Spanner
Authentication & Authorization	Identity and Access Management	Azure Active Directory	Cloud IAM
Event-Based	Lamda	Functions Event Grid	Cloud Functions PUB/SUB
Infrastructure as a Code	Cloud Formation	Azure Resource Template	Deployment Manager
Source Code Management	AWS Code Commit AWS Code Artifact	Azure Code Versioning Azure Artifactory	Cloud Repositories Cloud Artifactory
Secrets	AWS Secret Manager	Azure Key Vault	Secret Manager

4. Comparison of application deployment on different cloud providers

According to the author [2], the marketplace of AWS has risen by 31% which is then followed by Azure and google having a market share of 20%, 7%. For the comparison of these 3 clouds, we have deployed an application on all these cloud platforms to analyze the best cloud based upon the following criteria.

1) Latency
2) Cost

4.1. Azure application deployment

The application that is going to be deployed in Azure platform is based upon the web using HTML. To deploy, firstly VM (Virtual Machine) will be created. The cost of creating VM on Azure is 8.3573 INR/hr as shown in Fig. 3 shows Screenshot from Microsoft Azure Portal showing cost estimation (8.3573 INR/hour) for a Standard Dads v5 virtual machine with 2 vCPU and 8 GB RAM. Pricing is calculated for deployment in the India Central region with pay-as-you-go configuration.

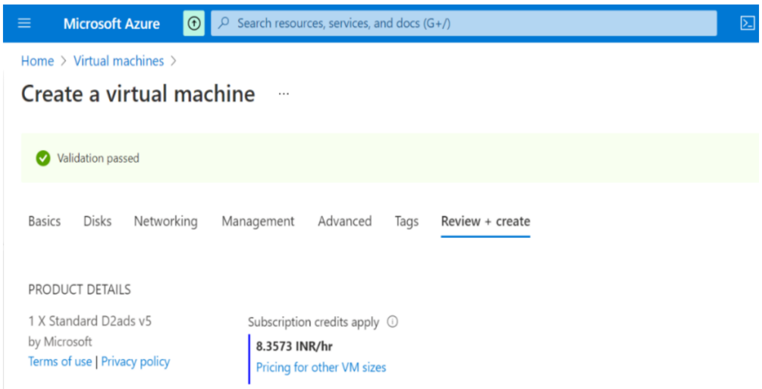

Fig. 3: Virtual Machine Pricing on Microsoft Azure (India Region).

After the creation of VM on Azure, the same web application will be deployed on the US CENTRAL and latency check is conducted from Mumbai (India), Dallas (New York), London (UK) respectively. The average time to reach the web application is 0.63s. The latency of each location is also visible in the following fig 4.

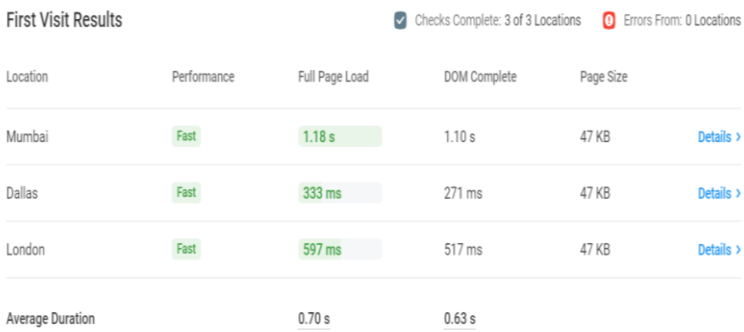

Fig. 4: Average Latency of Deployment on Azure Platform.

4.2. Google cloud platform deployment

The same web-based application will be deployed on Google platform. The cost of creation of an application on GCP is 5.54 INR/hr as shown in Fig. 5. Screenshot from GCP console showing pricing (5.54 INR/hour) for a virtual machine with 2 vCPU, 8 GB RAM, and 10 GB disk. The instance uses per-second billing, offering cost efficiency for transient workloads. Deployment was configured for the U.S. Central region.

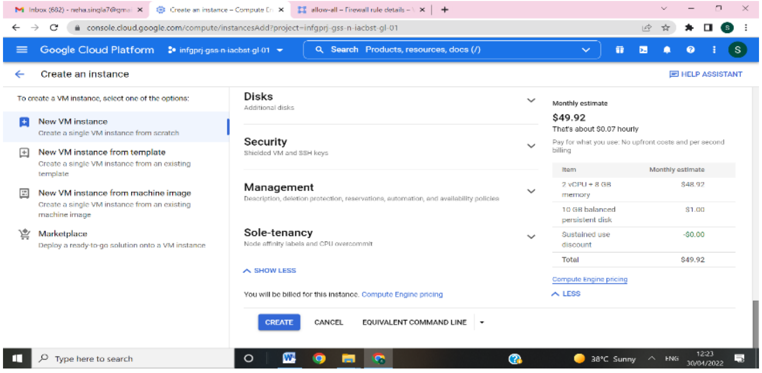

Fig. 5: Cost of Creating VM on Google Cloud Platform.

After the creation of VM on GCP, the same web application will be deployed on the US CENTRAL and latency check is conducted from Mumbai (India), Dallas (New York), London (UK) respectively. The average time to reach the web application is 0.25s. The latency of each location is also visible in the following fig 6. Measured latency of a deployed web application hosted on GCP (U.S. Central) tested from three locations: Mumbai (508 ms), Dallas (33 ms), and London (197 ms). The average latency is 0.25 seconds. The test was performed using synthetic monitoring tools.

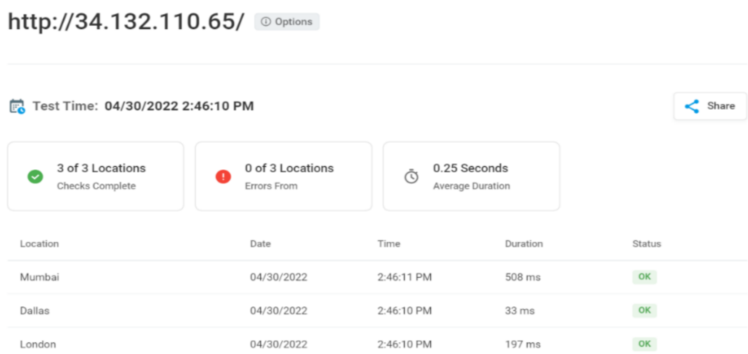

Fig. 6: Average Latency of Deployment on GCP.

4.3. Amazon web service deployment

The same web-based application will be deployed on AWS platform. The cost of creation of an application on AWS is 9.44 INR/hr for a t2.large instance (2 vCPU, 8 GB RAM) running Ubuntu 22.04. Pricing corresponds to the AWS U.S. East (Ohio) region using on-demand billing as shown in Fig. 7.

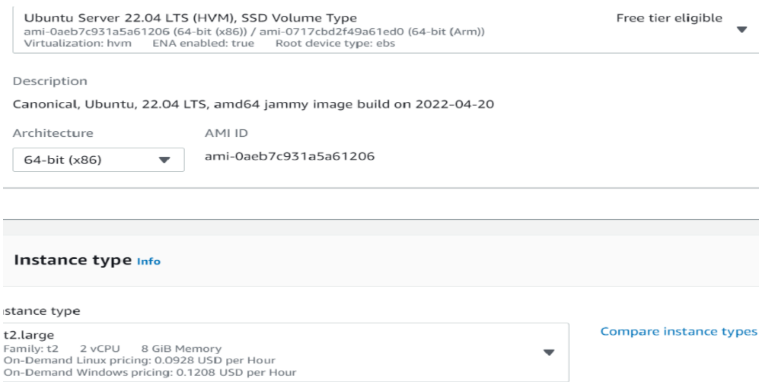

Fig. 7: Cost of Creating VM on Google Cloud Platform.

After the creation of VM on AWS, the same web application will be deployed on the US CENTRAL and latency check is conducted from Mumbai (India), Dallas (New York), London (UK) respectively. Measured latency from three geographic locations for a web application hosted on AWS (U.S. East). Results show: Mumbai (531 ms), Dallas (75 ms), and London (175 ms), with an average latency of 0.26 seconds. Shown in fig 8.

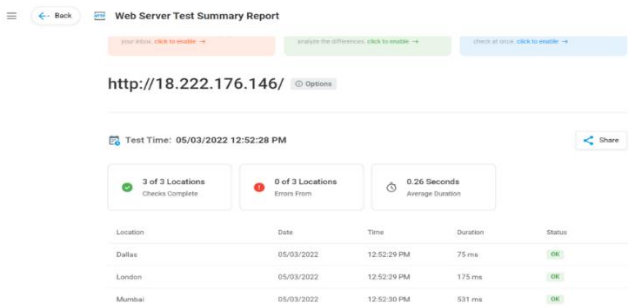

Fig. 8: Average Latency of Deployment on AWS.

5. Results and discussion

To analyse the results of various factors like cost (IaaS), Backbone network using latency to reach application, provisioning time the same application has been deployed on three different public cloud providers (GCP, Azure and AWS) with same locations (Region/Zone). In each public cloud, the networking performance of each cloud can be compared using latency to access the application from various parts of the world. The cost comparison is made to deploy the same infrastructure consisting of vCPU, RAM and Storage. The results analysis of latency and cost can be seen in the following table 5.

Table 5: Comparisons of Azure, AWS and GCP Platforms

S. No.	Criteria	Microsoft Azure	Google Cloud Platform (GCP)	Amazon Web Services (AWS)
1	Cost (INR/hr)	8.3573 ± 0.11 (n=5)	5.54 ± 0.05 (n=5)	9.44 ± 0.13 (n=5)
2	Latency (seconds)	0.63 ± 0.175 (n=10)	0.25 ± 0.089 (n=10)	0.26 ± 0.094 (n=10)

5.1. Cost analysis

We have deployed a virtual machine having 2vCPU, 8GB RAM and 10GB of persistent disk in different public cloud providers. Special consideration has been made for keeping the geographic location; sustained usage; workload type and storage type same so that it does not interference in cost analysis.

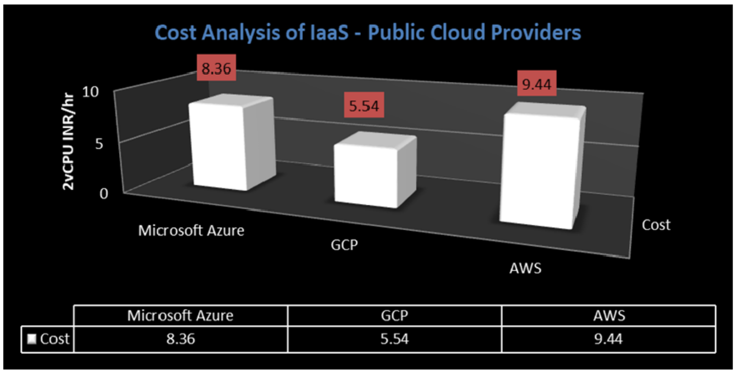

Fig. 9: Cost Comparison of VM Deployment Across Azure, AWS, and GCP.

As it has been clearly articulated in fig. 9 the cost for deploying the same infrastructure on Google cloud provider is cheapest, followed by Azure and then AWS. The major factor of cost optimization in GCP is Pricing for Compute Engine is based on per-second usage of the machine types, persistent disks, and other resources that users select for their virtual machines. We need to pay for a minimum of 1 minute followed by the number of seconds we consume whereas other cloud providers pay the specified per hourly rates depending upon instance type we use.

5.2. Latency analysis

Deployed a web application on Infrastructure as a Service in different public cloud providers in the same region. Special consideration has been made for keeping the geographic location infrastructure same so that it does not interference in the latency analysis.

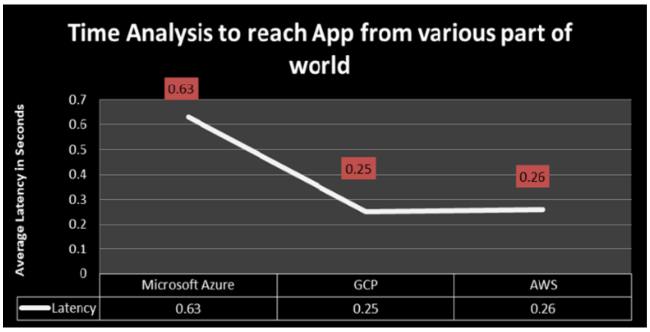

Fig. 10: Average Latency Comparison Across Azure, AWS, and GCP.

To derive the latency, we have accessed applications from different parts of world APAC, US and Europe and derived an average latency to reach application. As per analysis, the time taken to reach the application deployed in GCP was least followed by AWS and Azure as shown in Fig. 10. There are various factors that could derive the analysis of the network bandwidth, point of presence or edge locations of different cloud providers, location of their data centers and backbone network. As Google has the largest network, submarine cables and traffic is sent via the backbone network the latency is least in their environment.

5.3. Expanded performance metrics

While the current analysis focuses on two key factors—cost (INR/hr) and latency (in seconds)—these do not represent the full spectrum of performance considerations necessary for enterprise-grade cloud deployments. For a more comprehensive evaluation of cloud service providers (CSPs), additional metrics such as throughput, scalability, and reliability must also be considered. Throughput refers to the volume of requests or data processed per unit time, which becomes essential for applications with high transaction loads, such as financial systems or e-commerce platforms. Although not measured in this study, it is a critical performance indicator in cloud environments, especially under stress or concurrent user access. Scalability assesses a platform's ability to handle increasing workloads without degradation in performance. CSPs like AWS, Azure, and GCP offer autoscaling features, but real-world evaluation under load conditions (e.g., horizontal scaling of VMs or services) is needed to compare their practical effectiveness. This analysis was not conducted here due to the static nature of the test deployment, which involved a basic web application. Reliability, often expressed in terms of uptime (e.g., 99.99%), is vital for enterprise applications that demand high availability. While SLA guarantees from providers exist, empirical validation (e.g., measuring downtime or failover response) was beyond the scope of this study. Furthermore, regional outages, maintenance windows, and availability zone redundancy were not tested. The focus on cost and latency in this paper is intentional and justified by their direct impact on operational expense and user experience, especially for small to medium-sized enterprises and latency-sensitive applications like real-time dashboards or APIs.

5.4. Contextual factors and use-case implications

The results of this study are based on a simple web application, but real-world cloud performance can change depending on the type of work the application does. For example, compute-heavy tasks like AI training need strong CPUs or GPUs, while data-heavy tasks like big data analysis need fast storage and good data processing tools. Google Cloud is often better for data workloads, while AWS and Azure offer more high-performance options for compute tasks. For real-time applications like IoT or live systems, low latency is very important. GCP performed well in this area, so it may be suitable for such cases. As Rani et al. (2023) mentioned, cloud platforms behave differently in different industries. IoT, big data, and machine learning have special needs that must be matched with the right cloud features. So, while GCP showed the best cost and latency in our test, the choice of cloud should depend on what the application needs—speed, storage, cost, or reliability

6. Conclusion

The comparison of various public cloud providers has been made and as per result analysis it has been concluded that the GCP provides services with minimum cost and least latency. The analysis is based upon the current availability of infrastructure such as fiber network, data centers and edge locations in different regions worldwide. Since public cloud providers are ever evolving hence the scenario could be changed in future various demands of industry. The similar technique can be used to measure the infrastructure cost for consumer and latency of their application. Future work can include testing serverless and hybrid cloud setups, comparing security and multi-cloud performance. Optimization models may also be developed to help users choose the best cloud provider for their specific needs.

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