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Decoding the Cloud Giants: A Comparison of AWS, Azure and GCP

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Abstract: *The adoption of cloud services by companies and organizations is increasingly becoming essential for enhancing competitive performance in today's business environment. Cloud services represent a relatively new technological advancement. However, selecting the optimal cloud service to meet specific requirements remains one of the most significant challenges. Major commercial entities, including Amazon AWS, Microsoft Azure, and Google Cloud, provide a variety of cloud services through dedicated, reliable, and cost-effective web applications. These cloud services attract a diverse range of users and organizations across various sectors, such as healthcare, business, and education. This article aims to introduce cloud customers to the most prominent cloud services. Additionally, we explore the concept of cloud computing, defined as the delivery of computing resources over the Internet. Leading cloud service providers such as Microsoft Azure, Amazon Web Services (AWS), and Google Cloud Platform (GCP) offer on-demand cloud solutions, including processing power, memory, and databases, alleviating the need for users to invest in, operate, and maintain physical computers, hardware, and servers. This study compares the performance and services of three major cloud platforms—Google Cloud Platform, Amazon AWS, and Microsoft Azure—as well as their architectures and types of cloud services. Cloud technology allows resources to be dynamically scaled without the need for significant changes in infrastructure, additional staffing, or new software development.*

Keywords: Cloud Computing, Cloud Services, Cloud Providers, Cloud Infrastructure, Cloud Security, Cloud Scalability, Cloud Optimization, Amazon Web Service (AWS), Google Cloud Platform (GCP), Microsoft Azure

I. INTRODUCTION

The process of accessing resources, software and databases over the Internet and beyond the limitations of local hardware is called "cloud computing," or more specifically, "the cloud." This technology allows companies to flexibly scale their operations by delegating most or all of their infrastructure management to external hosting companies. The purpose of the practices and technical tools called cloud security is to fight internal and external risks to the security of companies. As organizations move forward with their digital transformation strategy and integrate cloud-based tools and services into their infrastructure, organizations need cloud security.

Amazon.com offers a comprehensive and popular cloud service platform called Amazon Web Services (AWS). Launched in 2006, AWS has since become a leader in the cloud computing industry, offering a wide range of cloud-based solutions and services to individuals, businesses and organizations of all sizes. AWS is designed to help users build and deploy applications, store and manage data, and scale their computing resources flexibly and cost-effectively.

Azure, also known as Microsoft Azure, is a reliable and widely used infrastructure and cloud services platform provided by Microsoft. Since its launch in 2010, Azure has evolved into a leading cloud provider, offering a wide range of cloud-based services and solutions to people, businesses and organizations around the world.

Google Cloud, also known as GCP (Google Cloud Platform), is Google's most popular cloud computing platform and provider. Since 2008, Google Cloud has rapidly grown in popularity and is now known for its cutting-edge technology, extensive global network, and a variety of cloud-based solutions that serve a variety of industries and use cases. Cloud computing is the ordering of IT resources over the Internet with distributed pricing, including servers, storage, databases, networks, software, analytics and intelligence. This method enables faster innovation, adaptive resources and

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economies of scale. Pay only for the cloud services you actually use, which lowers your computing costs, improves the performance and efficiency of your infrastructure, and allows you to scale with your business needs. The cloud is flexible, highly scalable, reliable, location independent and affordable because it operates in a distributed environment.

II. REVIEW OF LITERATURE

The rapid evolution of cloud computing has transformed IT, with Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP) as leading providers. AWS, holding a 34% market share, benefits from early market entry and extensive services. Azure, with 22%, leverages integration with Microsoft's enterprise products, excelling in hybrid environments, while GCP, at 10%, is noted for advanced analytics and machine learning capabilities. AWS offers over 200 services, ensuring high availability with a global data center network. Azure provides robust hybrid cloud solutions and integration with Microsoft products, while GCP excels in data analytics and machine learning. Pricing varies, with AWS offering detailed, though complex, pricing; Azure focusing on enterprise and hybrid solutions; and GCP providing cost-effective options for data processing. Security and compliance are strong across all three, with AWS known for identity management, Azure for enterprise security, and GCP for data privacy. User satisfaction is high for AWS due to extensive support and community resources, Azure for integration with Microsoft's ecosystem, and GCP for innovative developer solutions. Each platform's unique strengths cater to different business needs, existing technology investments, and strategic goals.

2.1 Problem Definition

As businesses increasingly transition to cloud computing to drive digital transformation, they face the challenge of selecting the most suitable cloud service provider from among the leading options: Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). Each platform offers a distinct set of services, pricing models, performance capabilities, and security measures, which can create significant decision-making complexities. The lack of a clear, comparative analysis that synthesizes these critical factors makes it difficult for enterprises to make informed choices that align with their specific operational needs, strategic goals, and budget constraints. This problem is exacerbated by the rapidly evolving nature of cloud technologies and the unique advantages and disadvantages inherent in each provider's offerings. Consequently, there is a pressing need for a comprehensive comparison of AWS, Azure, and GCP to provide businesses with the insights necessary to select the most appropriate cloud platform for their requirements.

2.2 Objective / Scope

Businesses transitioning to cloud computing struggle to choose the right provider (AWS, Azure, GCP) due to the vast array of services, pricing, and features each offer. This lack of a clear comparison framework hinders informed decision-making. This research aims to bridge this gap by providing a comprehensive comparison of these cloud giants to guide businesses towards the optimal platform.

III. TYPES OF CLOUD

Public Cloud

Public clouds are operated by external organizations that offer cloud services. On the Internet, these services are available as generic billing models. They offer solutions to minimize IT infrastructure costs and are a good choice for peak loads on local infrastructure. Public clouds are the best choice for small businesses that can start their business without large upfront investments and depend entirely on public infrastructure for their IT needs. The main feature of public clouds is the use of multi-tenant services. A public cloud is designed to serve multiple users, not a single customer. The user needs a virtual computing environment that is separated from other users and probably isolated.

Examples: Amazon EC2, IBM, Azure, GCP

Advantages of Public Cloud Following are the advantages of public cloud:

Public cloud can easily scale and reduce resources according to traffic and workload. This facilitates performance optimization and cost efficiency. It works in a distributed cloud model and helps to solve the investment needs of hardware and infrastructure, which reduces the overall cost.

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Disadvantages of using a public cloud Disadvantages of a public cloud include:
Relying on and storing data from third-party service providers can cause management and ownership issues the shared infrastructure of public clouds increases data risk. violations and unauthorized access. This creates security and privacy issues. The public cloud includes limited visibility into the underlying infrastructure, which can make effective performance monitoring and management difficult.

Private Cloud
Private clouds are conveyed frameworks that run on private foundation and offer clients energetic administration of computing assets. Instep of the sharing demonstrate of private clouds, there might be other frameworks that control the utilize of the cloud and the relative charging of distinctive offices or parts of the company. Private cloud benefit suppliers incorporate HP Information Centres, Ubuntu, Elastic-Private Cloud, Microsoft, etc.
Examples: VMware cloud Suite, OpenStack, Cisco Secure Cloud, Dell Cloud Arrangements, HP Hellion Eucalyptus

Advantages of a private cloud:
Customer information assurance: There are less security issues in a private cloud since the private foundation does not spill client information and other delicate information. Infrastructure to guarantee SLAs: private cloud gives certain capacities such as appropriate clustering, information replication, framework checking and upkeep, fiasco recuperation and other operational services. Compliance with Standard Strategies and Operations: Usage and utilize of applications must execute particular strategies concurring to third-party compliance guidelines. This is not conceivable with the open cloud.

Disadvantages of Private Cloud:
Limited Locale: Private Cloud is accessible in a particular locale. The get to is subsequently limited. Experience required: In a private cloud, security issues are less since client information and other delicate information are not spilled from the private foundation. Subsequently, gifted individuals are required to oversee and utilize cloud administrations.

Hybrid Cloud
A Hybrid Cloud is a heterogeneous conveyed framework shaped by combining offices of the open cloud and private cloud. For this reason, they are moreover called heterogeneous clouds. A major disadvantage of private organizations is the failure to scale on-demand and proficiently address top loads. Here open clouds are required. Consequently, a crossover cloud takes advantage of both open and private clouds.
Examples: AWS Stations, Purplish blue Stack, Google Anthos, IBM Cloud Lackey,

Advantages of Hybrid Cloud:
The taking after are the points of interest of utilizing Hybrid Cloud: Hybrid cloud is accessible at a cheap fetched than other clouds since it is shaped by a conveyed system. It works comes up with working quick with lower fetched and encourages in decreasing the idleness of the information exchange process. Most critical thing is security. A half breed cloud is completely secure and secure since it works on the disseminated framework network.

Disadvantages of Hybrid Cloud:
It's conceivable that businesses need the inside information fundamental to make such a half breed environment. Overseeing security may moreover be more challenging. Distinctive get to levels and security contemplations may apply in each environment. Managing a crossover cloud may be more troublesome. With all of the options and choices accessible nowadays, not to say the unused PaaS components and innovations that will be discharged each day going forward, open cloud and movement to open cloud are as of now complicated sufficient. It seems fair feel like a step as well distant to incorporate hybrid.

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Difference	Private	Public	Hybrid
Tenancy	Single tenancy: there's only the data of a single organization stored in the cloud.	Multi-tenancy: the data of multiple organizations in stored in a shared environment.	The data stored in the public cloud is usually multi-tenant, which means the data from multiple organizations is stored in a shared environment. The data stored in private cloud is kept private by the organization.
Exposed to the Public	No: only the organization itself can use the private cloud services.	Yes: anyone can use the public cloud services.	The services running on a private cloud can be accessed only the organization's users, while the services running on public cloud can be accessed by anyone.
Data Center Location	Inside the organization's network.	Anywhere on the Internet where the cloud service provider's services are located.	Inside the organization's network for private cloud services as well as anywhere on the Internet for public cloud services.
Cloud Service Management	The organization must have their own administrators managing their private cloud services.	The cloud service provider manages the services, where the organization merely uses them.	The organization itself must manage the private cloud, while the public cloud is managed by the CSP.
Hardware Components	Must be provided by the organization itself, which has to buy physical servers to build the private cloud on.	The CSP provides all the hardware and ensures it's working at all times.	The organization must provide hardware for the private cloud, while the hardware of CSP is used for public cloud services.
Expenses	Can be quite expensive, since the hardware, applications and network have to be provided and managed by the organization itself.	The CSP has to provide the hardware, set-up the application and provide the network accessibility according to the SLA.	The private cloud services must be provided by the organization, including the hardware, applications and network, while the CSP manages the public cloud services.

Fig. 1: Here is a basic comparison table for Public, Private and Hybrid Clouds (Image Source)

Community Cloud:

Community clouds are conveyed frameworks made by joining the administrations of distinctive clouds to address the particular needs of an industry, a community, or a trade division. But sharing duties among the organizations is difficult. In the community cloud, the framework is shared between organizations that have shared concerns or assignments. An organization or a third party may oversee the cloud.

Examples: CloudSigma, Nextcloud, Synology C2, OwnCloud, Stratoscale

Advantages of Utilizing Community Cloud:

The taking after are the preferences of utilizing Community Cloud: Because the whole cloud is shared by various ventures or a community, community clouds are cost-effective. Because it works with each client, the community cloud is versatile and adaptable. Clients can change the reports agreeing to their needs and requirements. Public clouds have certain vulnerabilities compared to community clouds, which are more secure than private clouds.. Thanks to community clouds, we may share cloud assets, framework, and other capabilities between diverse enterprises.

Disadvantages of utilizing Community Cloud:

The taking after are the drawbacks of utilizing Community Cloud: Not all businesses ought to select community cloud. Gradual selection of data It's challenging for enterprises to share duties.

Applications of Community Cloud:

The taking after are the applications of community clouds: Media industry: Media companies are looking for speedy, straightforward, low-cost ways for expanding the effectiveness of substance era. Most media preparations include an amplified biological system of accomplices. In specific, the creation of advanced substance is the result of a collaborative handle that incorporates the development of expansive information, gigantic compute-intensive rendering errands, and complex workflow executions. Healthcare industry: In the healthcare industry community clouds are utilized to share data and information on the worldwide level with touchy information in the private infrastructure

Multi Cloud

Multi-cloud is the utilize of numerous cloud computing administrations from distinctive suppliers, which permits organizations to utilize the best-suited administrations for their particular needs and dodge seller lock-in. This permits organizations to take advantage of the distinctive highlights and capabilities advertised by diverse cloud providers.

Examples: Cloud Foundry, Kubernetes, Apache Mesos, Ruddy Cap OpenShift, Docker Swarm

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Advantages of utilizing Multi-Cloud:

The taking after are the focal points of utilizing multi-cloud: Flexibility: Utilizing numerous cloud suppliers permits organizations to select the best-suited administrations for their particular needs, and maintain a strategic distance from seller lock-in. Cost-effectiveness: Organizations can take advantage of the taken a toll investment funds and estimating benefits advertised by distinctive cloud suppliers for diverse services. Improved execution: By disseminating workloads over different cloud suppliers, organizations can progress the execution and accessibility of their applications and services. Increased security: Organizations can increment the security of their information and applications by spreading them over different cloud suppliers and executing distinctive security techniques for each.

Disadvantages of utilizing Multi-Cloud:

The taking after are the impediments of utilizing Multi-Cloud: Complexity: Overseeing numerous cloud suppliers and administrations can be complex and require specialized information and expertise. Increased costs: The taken a toll of overseeing different cloud suppliers and administrations can be higher than utilizing a single provider. Compatibility issues: Diverse cloud suppliers may utilize distinctive innovations and benchmarks, which can cause compatibility issues and require extra assets to resolve. Limited interoperability: Diverse cloud suppliers may not be able to interoperate consistently, which can restrain the capacity to move information and applications between them

IV. CLOUD SERVICES

Cloud service models are the different ways that cloud computing services can be delivered to users. There are three main cloud service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

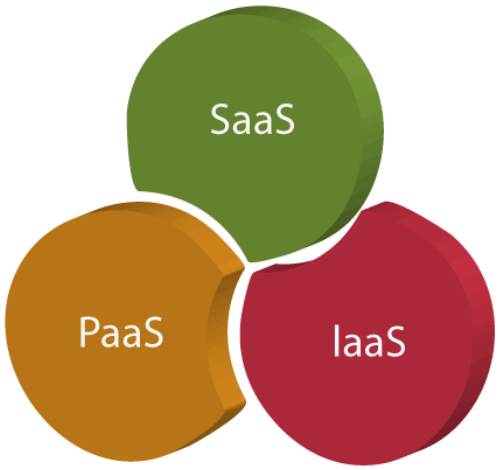

Fig 2. Cloud Service Models(Image Source)

Infrastructure as a Service:

In an IaaS worldview, a cloud benefit supplier has the server, capacity, organizing, and virtualization or hypervisor equipment that was already show in an on-premises information middle. Moreover, the IaaS supplier offers a run of administrations to transport those foundation parts. These incorporate capabilities for capacity versatility, such as reinforcement, replication, and recuperation, as well as comprehensive charging, checking, log get to, security, and load-balancing. Clients of IaaS have gotten to online instruments and administrations, and they can utilize the cloud provider's administrations to introduce the remaining parts of an application stack. IaaS (Infrastructure-as-a-Service): A crossover approach, in which businesses utilize cloud suppliers to handle their server, equipment, organizing, virtualization, and capacity needs whereas overseeing a parcel of their information and apps on premise.

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Fig 3. IaaS provider provides the following services (Image Source)

Software as a Service:

SaaS does absent with the necessity that businesses set up and run programs on their servers or in their information centers. This disposes of the fetched of acquiring, getting, and keeping up equipment as well as acquiring, introducing, and supporting computer program. Clients who utilize SaaS offerings subscribe to them or maybe than introducing the program or giving extra equipment bolster for it. They ordinarily pay for this benefit on a "pay-as-you-go" premise. By changing over costs to working costs, numerous expansive businesses can arrange their budgets more precisely and typically. SaaS clients can have stopped utilizing the administrations at any minute to halt paying for them. PaaS (Platform-as-a-Service): gives a custom application system that consequently oversees working frameworks, program upgrades, capacity, and supporting framework in the cloud, empowering organizations to streamline the advancement and conveyance of their applications

Fig 4. Software as a Service(Image Source)

Platform as a Service:

PaaS frequently does not take the put of a company's entirety framework. Instep, a company depends on PaaS providers for vital administrations like Java advancement and application facilitating. Clients can introduce computer program in

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a steady and viable environment given by a PaaS provider. Instep of building and keeping up the fundamental foundation and administrations, clients can centre on making and working applications. Computer program development-related PaaS items are predominant. These stages give capacity and computing framework as well as content altering, form control, compiling, and testing administrations to help computer program engineers in creating modern computer program more rapidly and viably. SaaS (Software-as-a-Service): computer program that is facilitated in the cloud and is as a rule available through a membership show. By overseeing servers, capacity, middleware, information, and other specialized issues, third-party suppliers diminish the taken a toll of IT assets and streamline back and support errands.

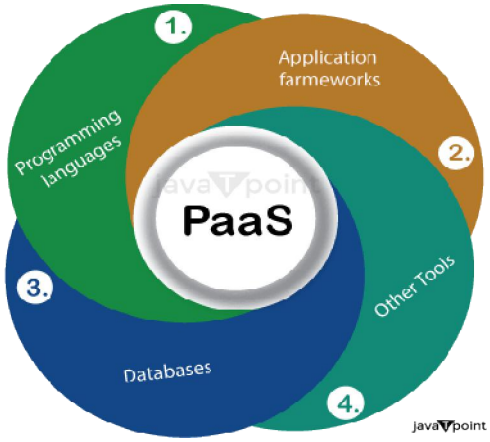

Fig 4. Platform as a Service (Image Source)

V. COMPARISON BETWEEN AWS, GCP & AZURE

Cloud computing has revolutionized the way businesses operate, offering scalable and flexible solutions for data storage, computing power, and application deployment. Among the leading cloud service providers, Amazon Web Services (AWS), Google Cloud Platform (GCP), and Microsoft Azure stand out for their comprehensive service offerings and global reach. This paper provides a detailed comparison of these three cloud giants, examining their histories, global presence, service types, development tools, virtualization technologies, pricing models, compute services, storage solutions, database services, networking services, pre-configured operating systems, and hybrid and multi-cloud capabilities.

5.1 Historical Background

AWS, launched in 2006, was the first major cloud service provider, setting the standard for subsequent entrants. Its early start has allowed AWS to develop a mature and comprehensive suite of services over time. GCP entered the market in 2011, leveraging Google's extensive infrastructure and expertise in search and data analytics. Microsoft Azure, introduced in 2010, quickly integrated with Microsoft's existing enterprise products, making it particularly appealing to businesses already using Microsoft technologies.

5.2 Global Presence

AWS operates in 33 regions worldwide, offering extensive coverage and enabling businesses to deploy resources close to their user base for lower latency and compliance with local data regulations. GCP operates in 40 regions, focusing on performance and network capabilities. Azure leads with 60 plus regions, providing the most extensive global footprint, ensuring high availability and redundancy crucial for global enterprises. Given below is a detailed information for each cloud provider.

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	Amazon Web Services	Google Cloud Platform	Microsoft Azure
Regions	33	40	60 +
Availability Zones	105	121	300 +
Edge Locations	13	187	190 +

Table 1: Global Presence Regions, Availability Zones, Edge Locations

(**Note:** This data was last updated on June 2024. Please check each provider's official global infrastructure page for the most accurate and up-to-date information.)

In cloud infrastructure, regions, Availability Zones, and Edge Locations play crucial roles in ensuring high availability, fault tolerance, and optimal content delivery.

5.2.1 Region:

A region is a geographical area that encompasses multiple data centers. Each region is isolated from the others to provide the highest possible fault tolerance and stability. Regions are the primary partitioning of cloud infrastructure, allowing for data residency and geographic compliance requirements.

5.2.2 Availability Zones:

Availability Zones (AZs) are distinct physical locations within a cloud provider's data center region. They are designed to be isolated from failures in other Availability Zones, providing redundancy and high availability for applications and data.

5.2.3 Edge Locations:

Edge locations are a key component of the content delivery network (CDN) infrastructure provided by major cloud providers. They are physical data centers or network nodes located at the "edge" of the network, closer to the end-users, with the goal of improving content delivery performance.

5.3 Service Types

AWS excels in Infrastructure-as-a-Service (IaaS) but also offers Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS), with its IaaS services being particularly well-developed for flexible and scalable infrastructure. GCP is strong in PaaS, emphasizing ease of use and integration with other Google services, while also offering IaaS and SaaS. Azure provides a balanced offering across IaaS, PaaS, and SaaS, with significant contributions in PaaS and deep integration with Microsoft software, making it a strong contender for enterprises.

Category	Amazon Web Services	Google Cloud Platform	Microsoft Azure
Compute	EC2, Lambda, ECS, EKS, Fargate, Batch, Elastic Beanstalk, Outposts	Compute Engine, Kubernetes Engine, App Engine, Cloud Functions, Cloud Run	Virtual Machines, App Services, Kubernetes Service, Functions, Batch, Container Instances, VM Scale Sets
Storage	S3, EBS, EFS, Glacier, Storage Gateway	Cloud Storage, Persistent Disk, Filestore, Storage for Firebase	Blob Storage, Files, Disk Storage, Data Lake Storage
Database	RDS, DynamoDB, Redshift, Aurora, DocumentDB, Neptune, ElastiCache, Keyspaces	Cloud SQL, Spanner, Bigtable, Firestore, Datastore, Memorystore	SQL Database, Cosmos DB, Database for MySQL, PostgreSQL, MariaDB, Synapse Analytics, Cache for Redis
Networking	VPC, CloudFront, Direct Connect, Transit Gateway, Route 53	Virtual Private Cloud, Load Balancing, Cloud Armor, Cloud CDN, Cloud Interconnect, Cloud DNS	Virtual Network, Load Balancer, Application Gateway, VPN Gateway, DNS, Traffic Manager, ExpressRoute

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Security	IAM, GuardDuty, Shield, WAF, KMS, CloudHSM, Secrets Manager	IAM, Security Command Center, KMS, Identity-Aware Proxy, Cloud Armor	Active Directory, Security Center, Key Vault, DDoS Protection, Information Protection
Analytics	Athena, EMR, Kinesis, Glue, Redshift, QuickSight	BigQuery, Dataflow, Dataproc, Pub/Sub, Data Fusion	HDInsight, Databricks, Data Factory, Stream Analytics, Synapse Analytics, Data Explorer
Machine Learning & AI	SageMaker, Deep Learning AMIs, Lex, Polly, Rekognition, Comprehend	AI Platform, TensorFlow on Cloud, AutoML, Natural Language, Vision, Speech-to-Text, Translation	Machine Learning, Cognitive Services, Bot Service, OpenAI Service
Developer Tools	CodeCommit, CodeBuild, CodeDeploy, CodePipeline, Cloud9	Source Repositories, Cloud Build, Cloud Code, Deployment Manager	DevOps, Pipelines, Repos, Test Plans, App Center
Management & Governance	CloudFormation, CloudTrail, CloudWatch, Config, Systems Manager	Console, Stackdriver, Cloud Monitoring, Cloud Logging, Trace, Debugger	Monitor, Log Analytics, Automation, Resource Manager, Policy
IoT	IoT Core, Greengrass, IoT Analytics, IoT Device Management	IoT Core	IoT Hub, IoT Central, Sphere, Digital Twins
Migration & Transfer	Migration Hub, Database Migration Service, Snowball, Snowmobile	Migrate for Compute Engine, Transfer Appliance, Data Transfer Service	Migrate, Site Recovery, Database Migration Service, Data Box
Application Integration	SQS, SNS, Step Functions, MQ	Pub/Sub, Cloud Functions, Endpoints	Logic Apps, Service Bus, API Management, Event Grid

Table 2. Services Offered by each Cloud Provider

5.4 Development Tools

AWS supports SDK for Eclipse, a popular integrated development environment (IDE). GCP offers direct support in Cloud9 IDE, a cloud-based development environment enabling coding from anywhere. Azure supports both Eclipse and Microsoft's Visual Studio, offering extensive development tools and a seamless experience for developers familiar with Microsoft technologies.

5.5 Virtualization Technologies

AWS uses XEN Virtualization Technology, known for high performance and robust security features. GCP employs KVM (Kernel-based Virtual Machine) Hypervisor Virtualization technology, which is open-source and highly efficient. Azure utilizes Hyper-V Hypervisor Virtualization technology, providing high scalability and integration with Windows operating systems.

A detailed illustration of the virtualization technology architecture is provided below.

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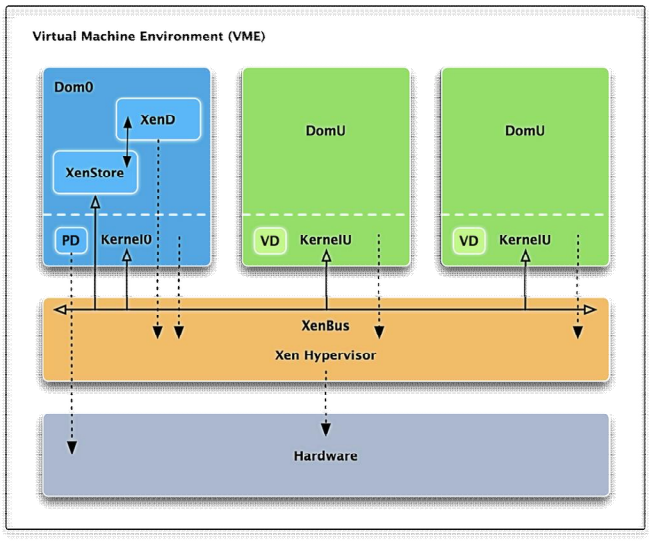

Fig 5. XEN Virtualization Technology (Image Source)

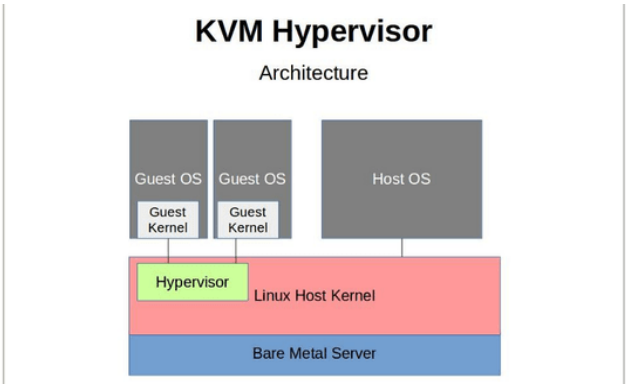

Fig 6.KVM (Kernel-based Virtual Machine) Hypervisor Virtualization technology (Image Source)

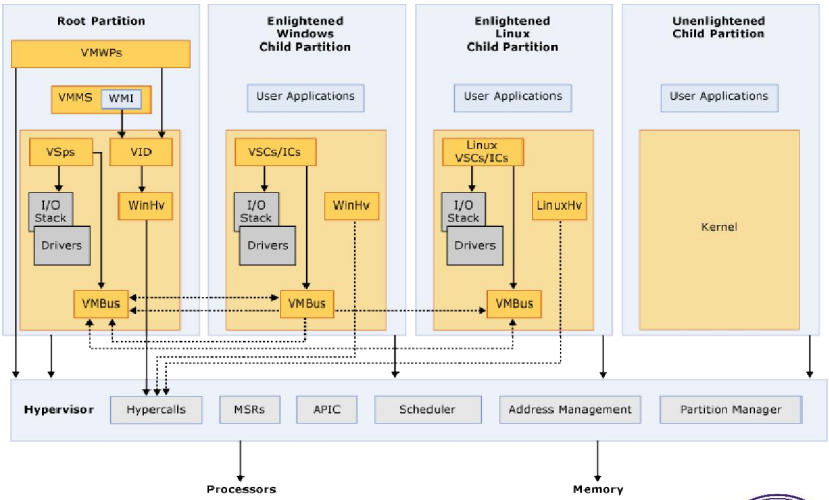

Fig 7. Hyper-V Hypervisor Virtualization technology (Image Source)

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5.6 Pricing Models

AWS features On-Demand and per-second billing, allowing users to pay only for what they use without long-term commitments. GCP offers "Pay as you go" and on-demand per-second billing, providing similar cost-efficiency and flexibility. Azure implements "Pay as you go" pricing, enabling businesses to manage costs effectively based on usage.

5.7 Compute Services

AWS's Elastic Compute Cloud (EC2) offers scalable computing capacity, allowing users to quickly scale up or down based on demand. GCP's Compute Engine provides highly customizable virtual machines tailored to specific workloads. Azure's Virtual Machine and Virtual Machine Scale Sets offer flexibility in deploying and managing large-scale applications, ensuring high availability.

5.8 Storage Solutions

AWS provides Amazon Simple Storage Service (S3) for object storage, Amazon Elastic Block Store (EBS) for virtual server disks, Amazon Glacier for cold storage, and Amazon Elastic File System for file storage. GCP offers Google Cloud Storage for object storage, Google Compute Engine Persistent Disks for virtual server disks, Google Cloud Storage Nearline for cold storage, and ZFS/Avere for file storage. Azure provides Blob Storage for object storage, Managed Disks for virtual server disks, Archive Blob Storage for cold storage, and Azure File Storage for file storage.

5.9 Database Services

AWS offers Amazon RDS for RDBMS and Amazon DynamoDB for NoSQL (Key-Value), as well as Amazon SimpleDB for NoSQL (Indexed). GCP provides Cloud SQL for RDBMS, Cloud DataStore and Cloud Bigtable for NoSQL (Key-Value), and Google Cloud Datastore for NoSQL (Indexed). Azure offers SQL Database for RDBMS, Cosmos DB for NoSQL (Indexed), and Table Storage for NoSQL (Key-Value).

5.10 Networking Services

AWS's networking services include Amazon Virtual Private Cloud (VPC), Elastic Load Balancer, Direct Connect, and Amazon Route 53. GCP offers Virtual Private Cloud, Google Cloud Load Balancing, Google Cloud Interconnect, and Google Cloud DNS. Azure provides Virtual Networks, Azure Load Balancers, ExpressRoute, and Azure DNS.

5.11 Pre-Configured Operating Systems

AWS, GCP, and Azure support various Linux distributions and Windows Server for virtual machines. AWS supports Amazon Linux, Cent OS, Debian, Oracle Linux, Red Hat Linux, Ubuntu, and Windows Server. GCP supports Cent OS, Debian, Ubuntu, Red Hat Linux, and Windows Server. Azure supports Cent OS, FreeBSD, OpenSUSE Linux, Oracle Linux, Ubuntu, and Windows Server.

5.12 Hybrid and Multi-Cloud Capabilities

AWS offers AWS Snowball, AWS Snowcone, AWS Outposts, AWS Local Zones, and VMware Cloud on AWS for hybrid and multi-cloud solutions. GCP provides Anthos, Traffic Director, Looker, and Cloud Build Operations. Azure offers Azure Arc, Azure Backup, Azure Active Directory, Azure Security Center, and Azure Blob Storage.

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VI. CLOUD SERVICES USED IN YEAR 2024

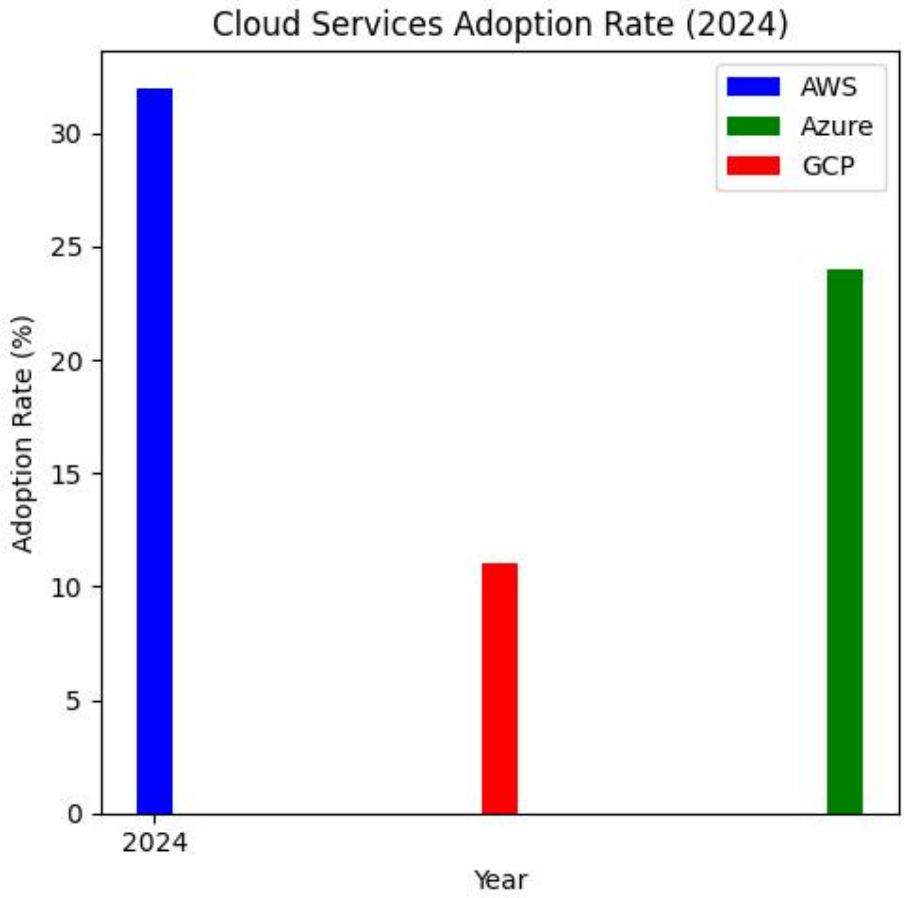

Fig 8. Usage of Cloud Services

AWS remains the dominant player in the cloud services market with the highest adoption rate **of 32%**.
Azure follows with a strong presence, holding a **24%** adoption rate, thanks to its integration with Microsoft tools.
GCP, while smaller in market share with an **11%** adoption rate, continues to grow, particularly in areas that benefit from its pricing structure and specialized services.

VII. ANALYSIS

AWS had a five-year head start in the cloud services market. It operates numerous regions and availability zones and holds about one-third of the market share. While AWS leads, Google Cloud Platform (GCP) is growing rapidly, with a development rate of nearly 100%. Many premium clients use all three major cloud platforms: AWS, Microsoft Azure, and GCP. AWS offers a wide range of services.

Azure is known for its integration capabilities with open-source and on-premises systems, particularly Microsoft tools widely used in businesses. GCP is noted for its more approachable pricing and discount schemes. In the ongoing competition among Microsoft Azure, AWS, and GCP, AWS is often seen as the leader. However, Azure and GCP are making significant strides, and it is challenging to predict how long AWS will maintain its dominance. Despite Azure and GCP's advantages, AWS has the unique benefit of being the first major cloud service provider.

Many businesses that use Microsoft tools find Azure appealing due to its seamless integration. GCP's attractive pricing structure, which includes services like YouTube and Google Search, is a significant draw for some users. Ultimately, choosing the best cloud service provider for specific needs is more crucial than selecting the leading provider overall.

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This discussion focuses on comparing the three primary cloud service platforms: Microsoft Azure, Google Cloud Platform, and Amazon EC2. Initially, the three key players are briefly introduced, followed by a comparison of their similarities and differences. The findings from this comparison are summarized below:

- **General Usage:** Microsoft Azure is the most widely used cloud platform. GCP offers Cloud9, a direct Integrated Development Environment (IDE) support. Amazon EC2, the oldest of the three, excels in the IaaS model.
- **Database & Virtualization:** GCP provides the most database options, while Azure offers the fewest. Amazon EC2 offers the broadest range of virtualization options.
- **Pricing:** All three platforms offer customized pricing plans based on customer usage.
- **Specifications:** Amazon EC2 has the most pre-configured operating systems, while Microsoft Azure offers the most support for machine learning systems. GCP provides the most runtime options.
- **Support:** All three platforms offer extensive support through forums and documentation.

VIII. CONCLUSION

This comprehensive comparison highlights the unique strengths and features of AWS, GCP, and Azure, each of which brings distinct advantages to the table. **AWS** is renowned for its mature and extensive Infrastructure-as-a-Service (IaaS) offerings, robust global presence, and a rich ecosystem of tools for development, analytics, and machine learning. Its flexible pricing models and comprehensive service range make it an excellent choice for businesses seeking scalable and reliable cloud infrastructure.

- **Google Cloud Platform (GCP)** excels in Platform-as-a-Service (PaaS), leveraging Google's powerful data analytics, artificial intelligence capabilities, and ease of use. GCP's focus on performance, innovative services like BigQuery and ML Engine, and strong network capabilities make it particularly appealing for businesses that prioritize data processing and advanced analytics.
- **Microsoft Azure** distinguishes itself with deep integration into Microsoft's extensive suite of enterprise products and services, offering a seamless experience for businesses already utilizing Microsoft technologies. Its comprehensive global footprint, balanced service offerings across IaaS, PaaS, and SaaS, and strong focus on hybrid cloud solutions make Azure an attractive option for enterprises looking for compatibility with existing Microsoft infrastructure.
- In summary, businesses should consider their specific needs and strategic goals when selecting a cloud service provider. **AWS** is ideal for those requiring a robust, mature IaaS platform with extensive global reach. **GCP** is suited for organizations that prioritize cutting-edge data analytics and AI capabilities. **Azure** is best for enterprises seeking deep integration with Microsoft products and an extensive global infrastructure. By understanding the unique offerings and strengths of each platform, businesses can make informed decisions to leverage the full potential of cloud computing

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