Literature Review - Cloud Computing Service Providers

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1 Introduction

Cloud computing services are currently available to meet most of the information technology needs. It changes how businesses and public institutions use information technology mostly in the midst of this pandemic. Put bluntly, cloud computing is the delivery of computing services, including servers, storage, databases, networking, software, analytics, and cloud services, to provide faster innovation, versatile resources, where you usually only pay for cloud services, so the costs are reduced. There are a wide range of cloud computing services, all of which have certain basic features and benefits in common. It includes infrastructure as a service (IaaS), platform as a service (PaaS), serverless, and software as a service (SaaS). In this report, we are going to discuss the comparative evaluation on the most prominent cloud computing service providers Google Cloud Platform and Microsoft Azure based on their service model, Virtual Machine (VM), storage, Operating System (OS) environments offered, security, performance and scalability, pricing model, auto-Scaling/elasticity, and monitoring tools/service provided and finally provide our viewpoints on the advantage and disadvantages of different types of cloud platforms.

2 Comparative Evaluation

2.1 Service model (IaaS, PaaS, SaaS)

Infrastructure as a Service (IaaS) is a model where the service provider provides and maintains core infrastructure for the customer. Customers pay for the software's on a subscription model. Platform as a Service (PaaS) however, provides environment for building, testing, and deploying software applications, service provider maintains and manages underlying infrastructure. Software as a Service (SaaS) provides a software where the service provider manages and maintains both hardware and software, with the appropriate service agreement, service providers also ensure the availability and the security of the app and your data as well.

Service model	IaaS	PaaS	SaaS
Microsoft Azure	Eliminates capital expense and reduces ongoing cost. So many enterprises implement Windows therefore compatibility is a plus • Virtual Machines	Significantly reduce the time it takes their applications time to get on the market. • App Services	Software is accessible from anywhere, on any device, and data is always backed up. • Office 365
Google Cloud Platform	Offers most of features Microsoft Azure and offers complete control of the systems and unlimited flexibility • Compute Engine	Ability to Connect with Google Cloud storage products and enhanced security • App Engine	Software is accessible from anywhere, on any device, and data is always backed up. • Google Drive

Table 1: Service model (IaaS, PaaS, SaaS)

2.2 Virtual Machine (VM) Instance Types Offered

Performance and scalability are the responsiveness of the system to run any action in a time interval with the ability to handle massive load without sustaining impact on performance.

Azure Autoscale from Microsoft is a service that can scale automatically to match demand to accommodate workload. Azure Autoscale will scale out to ensure capacity during workload peaks and scaling will return to normal automatically when the peak drops. Microsoft also offers payment plan options to manage scalability, you need to predict the current average and peak times for your workload.

Google Cloud however provides Database products like BigQuery, Cloud Spanner, and Cloud Bigtable can deliver consistent performance across massive data sizes. Cloud Monitoring provides metrics across your apps and infrastructure, helping you make data-driven scaling decisions.

	General Purpose	Compute Optimized	Memory Optimized	Storage Optimized	Gpu	High Performance Compute
Type	Av2, B, Dcsv2, Dv2, Dsv2, Dv3, Dsv3, Dav4, Dasv4, Ddv4, Ddsv4, Dv4, Dsv4	Fsv2	M, Mv2, Dv2, Dsv2, Ev3, Esv3, Eav4, Easv4, Ev4, Esv4, Edv4, Edsv4	Lsv2	NC, NCv2, NCv3, ND,NDv2, NV, NVv3, NVv4	H, HBv2, HC, HB
Description	Balanced CPU and Memory	High ratio of compute to memory	High ratio of memory to compute	High disk throughput and IO	Specialized with single or multiple NVIDIA GPUs	High memory, fastest compute power, and most powerful
Uses	Testing and development, small-medium databases, low-medium traffic web servers	Medium traffic web servers, network appliances, batch processing, application servers	Relational database services, analytics, larger caches	Big Data, SQL, noSQL databases	Compute intensive, graphics-intensive, visualization workloads	Batch processing, analytics, molecular modelling, fluid dynamics, low latency RDMA networking

Table 2: Microsoft Azure

	Predefined					Custom	Accelerated Computing
Type	n1-standard	n1-highmem	n1-highcpu	f1-micro	n1-ultramem n1-megamem	Create your own	GPUs
Description	Standard Balanced, good for consistent workload	High ratio of memory to computer	High ratio of compute to memory	Shared Core Burstable, good for changing workloads	Good for in-memory databases	User defines compute and memory, good for custom needs	Good for graphics processing and other GPU uses

Table 3: Google Cloud Platform

2.3 Storage

Microsoft Azure	Google Cloud Platform
1. Disk (standard SSD/HDD, premium SSD, ultra-disks)  • Microsoft Azure has disk storage for azure virtual machines. • It can be access by application and other services as needed. • Disk Storage allows data to be persistently stored and accessed from an attached virtual hard disk. 2. 3 types of Disk • Standard SSD/HDD for less critical workload • Premium SSD is for mission-critical production application • Ultra-disks for data-intensive workload such as SAP HANA, top tier databases and transaction-heavy workload.	1. Block storage (persistent disk, local SSD) **PERSISTENT DISK** • Reliable, high-performance for virtual machine instances Benefits 1. Industry-leading price and performance 2. Offers low-cost storage when bulk throughput is of primary importance. 3. Consistent high performance for both random-access workload and bulk throughput. 4. Share data easily 5. Multi-reader mounting, so many virtual machines can read data from a single Persistent Disk. 6. Attaching a disk to more virtual machine does not affect performance or cost 7. Scale without interruption 8. Unlimited flexibility by allowing to resize storage 9. No downtime even it is used on or more virtual machine at the same time Key Features 1. Seamless backup and restore 2. Automatic encryption 3. Independent volumes **LOCAL SSD** • Temporary storage uses cases such as caches or scratch processing space. Benefits 1. High-performance, ephemeral storage 2. Attached to the server that hosts your VM instance, which offers superior performance 3. Very high input/output operations per second (IOPS), 4. Very low latency compared to other block storage options

Table 4: Storage Comparison

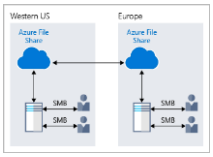
1. Files • Offers fully managed files shares in the cloud are accessible through industry standard Server Massage Block and Network File System (preview protocols) • Can be mounted a file storage share to access file data by using applications running in Azure virtual machines or cloud services. But, only as a desktop application would mount a typical SMB share. • Unlimited number of Azure virtual machines or roles can mount and access the file storage share simultaneously There are 2 typical usage to share files 1. Diagnostic data 2. Application data sharing Why use azure files? 1. Make it easier to migrate application since many on-premises applications use file shares 2. Store configuration files on a file share, can be access from multiple VMs. To ensure everybody find the tool and utilities which used by multiple developers that stored on a file share 3. Write data on a file share and process or analys e the data later, for examples are diagnostic logs, metrics and crash dumps  This diagram shows that, azure files can be used in different two location • Files shared is encrypted through SMB protocol • Files can be access from any location in the world by only using URL.	1. File stores PREDICTABLE PERFORMANCE • Can speed up to 480k IOPS and 16GB/s • Can handle your highest performance workloads ELASTICITY TO MEET BIG COMPUTE NEEDS • High scale, meets the need of high-performance business, • Easily grow or shrink your instances if any requirement changes, via Google Cloud Console GUI, gcloud command line, or via API- based controls Simple to provision, easy to mount • Fully managed, NoOps service • Easy mount files share on Compute Engine VMs • Tightly integrated with Google Kubernetes Engine

Table 4: Storage Comparison

Container object (blob)	Data transfer
 -not limited to common file formats -contain gigabytes -messages are encrypted for other application -for business benefit, blob is stored in containers, which this can help to organize blobs depending in business needs ADVANTAGES -does not require developers to think about or manage disks - uploaded data are called blobs Blob is ideal for: • serving images or documents directly to a browser • storing giles for distributed access • Streaming video and audio. • Storing data for backup and restore, disaster recovery, and archiving. • Storing data for analysis by an on-premises or Azure-hosted service. • Storing up to 8 TB of data for virtual machines.	DATA TRANSFER SERVICES • move or backup data to a Cloud Storage bucket either from ither cloud storage providers or from on-premises storage • Move data from one Cloud Storage bucket to another, so that it is available to different groups of users or applications. • Periodically move data as part of a data processing pipeline or analytical workflow. • data transfer and synchronization easier. TRANSFER APPLIANCE • Hardware appliance can be used to securely migrate large volume of data (from hundreds of terabytes up to 1 petabyte) to Google Cloud Platform without disrupting business operations.

Table 4: Storage Comparison

Table STORE PETABYTES OF STRUCTURED DATA • Let you scale up without having to manually shard your dataset • Use geo- redundant storage which means data is stored will replicated here times within a region SUPPORTS FLEXIBLE DATA SCHEMA • For web app user data, address books, device information, and other metadata • Without locking down data model into particular format, this because some different rows might have different particular of rows MADE FOR ENTERPRISE • It will update data stores simultaneously, especially in data stores who used by multiple of users in simultaneously. DESIGNED FOR DEVELOPERS • Has multiple building apps such as .NET, Java, Android, C++, Node.js, PHP, Ruby and phyton • Offers advanced offer especially in table storage especially OData • Accessible via REST API which can be called by any language that make HTTP/HTTPS requests.	Mobile app services CLOUD STORAGE FOR FIREBASE • Help user to store photo and videos quickly and easily • Build at Google scale. google will build the prototype to production using the same technology that powers apps like Spotify and google photos. ROBUST UPLOADS AND DOWNLOADS • It will automatically pause and resume the transferred as the app loses and regains connectivity, which save time and bandwidth. STRONG USER-BASED SECURITY • It integrates with Firebase Authentication to provide simple and intuitive access control • Allow access based on user identity or properties of a file and other me data by using declarative security model.
	Collaboration, communication, and file storage -GOOGLE WORKSPACE - MODERN COLLABORATION TOOLS TO SUPERCHARGE TEAMWORK • Includes Docs, Sheets and slides. This is for teams, it can be do it at the same time simultaneously SECURE, ENTERPRISE-GRADE VIDEO CONFERENCING • Google meet can be used. it is easier to use, • Can have up to 150 participant per call • Record of video meeting will be saved to google drive who did not attend the meeting

Table 4: Storage Comparison

2.4 OS environments offered

OS environmental is environmental in which users run application software. Azure is cloud computing for building, deploying and managing applications and services through a network center

MICROSOFT AZURE	Google Cloud Platform
MICROSOFT AZURE PRODUCTION NETWORK (AZURE NETWORK) MICROSOFT CORPORATE NETWORK (CORPNET) **<u>Guest operating system</u>** Azure running on guest operating system and VMs have no opportunity to run Remote Desktop Protocol. Any changes to baseline configuration settings must go through the change and release management process Azure datacentre • Microsoft cloud infrastructure and operations(MCIO), manage physical infrastructure and datacenter facilities for all microsoft online services. • MCIO primarily responsible for managing the physical and environmental controls within the data centers, as well as managing and supporting outer perimeter network devices. Service management and service teams • Each service team is responsible for an area to support Azure	Chrome OS -Gentoo Linux which designed by google. -proprietary software - operating system in which both applications and user data reside in the clouds - primarily runs web applications -written in c, c++, JavaScript, HTML5, Phyton, Rust. -CHROME ENTERPRISE • Launch in 2017 • Capabilities intended for business use GUEST ENVIRONMENT - Each supported operating system that is available on Compute Engine requires sprecified environment packages - LINUX guest environment - The Window guest environment

Table 5: Operating System Environments Comparison

2.5 Security

Microsoft Azure	Google Cloud Platform
Azure security centre -strengthen cloud security posture -secure your cloud resources, SQL, networks, application and workload running in azure Azure Defender -protect hybrid cloud workloads including servers, data, storage, containers and IoT. Microsoft defender for Endpoint (servers) - Protect Linux servers. - Assess application vulnerabilities in virtual machine - - protect data that is hosted in Azure Virtual Machine on premises or other clouds - Detects unusual attempts to access Azure Storage Azure Arc - Extend security coverage to workloads outside Azure STREAMLINE SECURITY MANAGEMENT - Use AI and automation quickly identify threats, - Streamline threat investigation - Help automate remediation Why Azure for security? - Microsoft invest more than USD 1 billion annually on cybersecurity research and development - Employ more than 3500 security experts who are dedicated to data security and privacy - Has more certifications than any other cloud provider such as FIPS 140-2 for US government.	- Help create stronger passwords - Protect your devices - Avoid phishing attempts - Browse internet securely SECURITY CHECK-UP - It built step by step tool to give personalized and actionable security Recommendations to help you strengthen the security of you google account 1. Create Strong Passwords 2. Keep Track of Multiple Passwords - Helps protect and keep track of the passwords you use on sites and apps. 3. Defend Against Hackers With 2-Step Verification - helps keep out anyone who should not have access to account by require to use a secondary factor on top of username and password to log in account 4. Keep Software Up to Date - Protect yourself from security vulnerabilities 5. Keep Potentially Harmful APPS OFF YOUR PHONE - Google play protect runs a safety check on apps from google play store. 6. Use A Screen Lock - lock your screen to keep others from getting into your device. 7. Lock Down Your Phone If You Lose It - can visit google account and select 'find your phone' to protect data in a few quick steps.

Table 6: Security Comparison

2.6 Performance and Scalability

Performance and scalability are the responsiveness of the system to run any action in a time interval with the ability to handle massive load without sustaining impact on performance.

Azure Autoscale from Microsoft is a service that can scale automatically to match demand to accommodate workload. Azure Autoscale will scale out to ensure capacity during workload peaks and scaling will return to normal automatically when the peak drops. Microsoft also offers payment plan options to manage scalability, you need to predict the current average and peak times for your workload.

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2.7 Pricing Model

Pricing Model	
Azure	Google
Microsoft Azure provides a comprehensive cost estimation for the infrastructure configuration by using a pricing calculator. This tool helps to save more cost and provides a report comparing the Azure product cost and other cloud services. Azure is cost saving as it combines all the offers and discounts together to fit unique development needs and significantly reduce the cost. A substantial discount is given for 1 to 3 years for reserved VM instances. A discount up to 40 percent for Azure Hybrid Benefits will be granted if running Microsoft Application on-premises. It will also provide extra discount on cloud infrastructure software provided having a Microsoft Enterprise Agreement (EA). One of the most exclusive offers is Azure provides a free tier of basic equipment, 12 months famous free service and $200 credit for all paying services.	Google cloud pricing model is different from Microsoft Azure. A continuous usage discount up to 30 percent if using the same instance for most of a given month. Besides, Preemptible VM Instance provides an 80 percent discount for jobs that can be restarted later. We are also eligible for up to 57 percent discount when making a long-term pledge to use a VM. Lastly, GCP provides a free selection of various essential utilities and $300 credit for trying other services.

Table 7: Pricing Model For Both Cloud Services

2.8 Auto-Scaling/Elasticity

Auto-scaling	
Azure Auto-scale scale apps to meet changing demand and it consists of three main advantages. The first one is it allows autoscale using a wide variety of metrics. It is a built-in feature in cloud service that aids in the performance of applications according to their requirement. Secondly, it is budget friendly as it only uses your money for only what you need. Free from paying machines that are not using. Scale down any virtual machine during midnight when nobody is using it as it is very flexible and can be cost-effective as well. Lastly, Azure can determine any mistake and response quickly. It helps to monitor performance metrics and remind us of any changes in the system.	Google Autoscaling is under the feature managed instance groups and it is formed from a collection of VM. Google also provides built-in load balance and auto-healing which is one of their services. An autoscape instance adds or deletes a managed instance community instance. Although both regulated and unmanaged instance groups occur in Compute Engine, autoscaler can only serve the managed instance groups.

Table 8: Auto-Scalling/Elasticity for both cloud services

2.9 Monitoring Tools/Service Provided

Monitoring tools/service provided	
Microsoft Azure provides full management of the systems, software and network. It maintains and evaluates all operational telemetry in a consolidated, fully operated, scalable data store which is efficient and cost-effective. Besides, it also checks your conclusions and discovers hidden designs with advanced research engines and dynamic query language. Lastly, they incorporate common DevOps, problem management, IT system and security and activity management software.	Google cloud collects in real time measurements from hybrid and multi cloud infrastructure. One of the key features are SLO monitoring which automatically infer or configure the service-level objective (SLOs) for application. Next feature is managing your framework by cloud monitoring to track applications and market metrics. Lastly, users can experience and control all Google Cloud tools and facilities built into the Google Cloud console without external instrumentation.

Table 9: Monitoring Tools/Service Provided For Both Cloud Services

3 Opinions

3.1 Microsoft Azure and Google Cloud Platform

The question nowadays is generally not whether or not to choose a cloud platform, but rather which service will be the best. Before making the final decision, let's examine what aspects should be taken into account.

Firstly, regarding the pricing, GSC only provides one type of pricing plan in which we pay monthly according to our use. Committed Usage Discounts are one enticing

pricing feature that Google provides. "Under this scheme, if you commit for either 1 or 3 years, you can buy "a particular number of vCPUs and memory for up to a 57 percent discount off regular rates. An additional bonus is the inclusion of all virtual machines in operation. Google has also pledged to its customers that because of an increase in technology, it will pass on any price reductions that the business will achieve. On the other hand, using Microsoft Azure, to have the same permanent network-attached storage, we have to connect premium SSD storage. But again, if we equate the two, it's around 1/3 of the expense of using the Google Cloud Platform again. Azure charges $1,602.68/month as opposed to $532.82/month for Google Cloud.

Secondly, in terms of speed, Google revealed last year that it is investing in the Faster Cable infrastructure by which it will be able to speed up to 10 Tbsps. for its Google Cloud and Google App users (Terabits per second). The speed considerably improves performance. Higher speeds also affect costs and allow more data processing in less time. Google is also known for providing connectivity for low-latency networks.

Thirdly, considering live migration, Google provides live virtual machine migration between host computers, enabling organizations to work 24/7 without any performance hindrance. Back in 2014, Google launched this programmed. Live maintenance enables the business, without rebooting the computers, to restore and upgrade applications, including security-related programmers. Companies will be no lock-ins to contend with. The business also immediately restarts the virtual machines in case of failure, so they are up within minutes. This feature is not offered by either AWS, Azure, or smaller providers like Digital Ocean. So, compared to other cloud providers, this is a very significant differentiator for Google Cloud.

Next, because of the data mining, Google stands out. We will get some amazing ideas from Google's groundbreaking cloud warehousing applications, such as Google BigQuery, and batch and real-time data analysis software, such as Google Cloud Dataflow and Google Cloud Dataproc. For starters, BigQuery is an entirely controlled data warehouse that enables us to process vast volumes of data at super-fast speeds. Any new machine learning and artificial intelligence technologies are also unveiled by Google at the meeting. For now, Google may be lagging behind Amazon, but at the pace at which its activities are ramping up, it won't be long before Google catches up.

Google Cloud has had a tremendous impact, particularly in the world of web and mobile app development, where Google technology can be accessed by small or large businesses. It has made things easy for app developers and made them more accessible. Hover, in the future, its reliance on connectivity with the internet may hinder its progress. Therefore, we choose Google Cloud Platform as the cloud service provider for our software development.

GOOGLE CLOUD PLATFORM (GSC)	
PROS	CONS
Performance - Whether in terms of latency, speed, processing power or redundancy in networks, is cloud hosting. By giving its clients access to their private distributed backbone, Google has gone the extra mile. Their vast network of optic fibre associate degreed servers gives them an incomparable advantage over the competition. This private network can be obtained at its premium level, while the traffic at the quality level is routed via the public Internet in general. Choosing the premium level will give you lower latency, greater reliability and higher speeds.	Support - The assistance from Google is not the best when it includes addressing customer problems. Any user of this platform receives free of charge support at the Bronze level. This includes paperwork for goods, group support and support for billing problems. A silver, gold or platinum kit may be ordered by clients. It could be a road to having a better level of help to select a better price. But, bear in mind that the payments for assistance are very costly.
Pricing - Google has a basic Google Compute Engine pricing model, and it's usually about 40-50 less expensive than AWS and Azure. They have a discount for Sustained Use that allows you to enable reserved instance pricing without paying upfront or expecting to predict and purchase instances.	Speed - The Google Cloud Platform is a strong, powerful, built-in infrastructure. Nevertheless, it does not innovate quickly enough to keep up with AWS and other rivals, who are well ahead. Although GCP frequently announces new features and modifications, the modifications take a frustrating while to return to work.
Live Migration - Google has another big business that is not offered by its key rivals. During maintenance activities, you will conduct live migrations of Virtual Machines, meaning you will migrate live loads and your services or websites will have practically no downtime.	

Table 10: Google Cloud Platform Pros and Cons

MICROSOFT AZURE	
PROS	CONS
High Availability - The Microsoft Azure cloud provides high availability and redundancy in data centres on a global scale, unlike other vendors. Because of this, Azure can deliver a 99.95 percent service level agreement, or SLA, (about 4.38 hours of downtime per year), something that can not be accomplished by other companies.	Requires Management - As with everything, Microsoft Azure has a few possible drawbacks. IaaS (Azure) transfers the computational resources of your business from your data centre or office to the cloud, unlike SaaS systems where the end-user consumes knowledge (for example, Office 365). Azure needs to be expertly handled and supported, which requires patching and server monitoring, as with most cloud service providers.
Data Security - Following the standard security model of Detect, Evaluate, Diagnose, Stabilize and Close, Microsoft Azure has a strong emphasis on security. This model, coupled with powerful cybersecurity controls, has helped Azure to achieve multiple compliance certifications, all of which identify Azure as an IaaS security leader. The platform is not only secure, but the end user is also covered by Azure. This multi-level defence is crucial as security threats continue to multiply globally on a daily basis, targeting end users and placing the data of your organisation at risk. For enhanced security, Azure offers easy, user-friendly services, such as multi-factor authentication and password specifications for applications.	Requires Platform Expertise - Azure needs experience, unlike local servers, to ensure that all moving parts operate efficiently together. Over-provisioning of cloud resources is a common mistake by business managers who are not completely interested with how well (or poorly) their cloud servers operate. Although a common error, the computational capacity of servers would not translate equivocally in the cloud on the assumption, potentially costing organisations thousands of dollars per year.

Table 11: Microsoft Azure Pros and Cons

3.2 Conclusion

To conclude, after narrowing down the varieties of cloud computing services out there to Microsoft Azure and Google Cloud Platform, both offers all basic features required and benefits. While researching and evaluating for the best cloud services comparing the service model (IaaS, PaaS, SaaS), Virtual Machine (VM) instance types offered, storage provided, OS environments offered, security, performance and scalability,

pricing model, Auto-Scaling/Elasticity, and monitoring tools/service provided. We picked Google Cloud Platform on the most prominent cloud computing service providers based on our viewpoints on the advantage and disadvantages of this platform.

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