

# Cloud Computing Fundamentals: A Comparative Evaluation and Opinion on Cloud Computing Service Providers

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## 1 Introduction

The public cloud market is characterized by Amazon, Microsoft and Google, which offer the most stable, scalable and efficient cloud services. AWS, Azure and GCP, which are their corresponding cloud services, offer consumers a variety of storage, computing and networking options. Some of the common characteristics of the three systems include, but not limited to, instant provisioning, self-service, autoscaling, identity management, protection and compliance. Among these services, AWS is particularly more dominant. According to a 2020 Synergy Research Group survey, Amazon growth continued to closely mirror overall market growth so it maintained its 33 percent share of the worldwide cloud market. Second ranked Microsoft again grew faster than the market and its market share has increased by almost three percentage points in the last four quarters, reaching 18 percent. In this paper, comparisons between all the services will be done according to the considered aspects.

## 2 Service Model

In SaaS services, AWS provides the customer with a simple way to control their applications, such as user access and account creation. Azure enables users to connect and use cloud-based services on the internet. In order to allow the user to easily execute their product across a network, Google Cloud uses the Google Kubernetes engine. For PaaS services, every aspect of cloud uploading, including storage provisioning, load balancing, scaling, and application health monitoring, is handled automatically by AWS Elastic Beanstalk. The program runs the infrastructure and ensures that the software is successfully integrated with the new fixes and improvements made by developers and controls the application stack. Besides tasks such as email and management information, Google Cloud can enable application development and the use of created hosting resources and can be operated and managed for tracking, expansion and hosting.

## 3 Virtual Machine

Microsoft Azure, Amazon Web Services (AWS) EC2 and Google Cloud offer many kinds of Virtual Machines (VMs) based on types of memory, storage and computing such as general-purpose, computer-optimized, optimized storage, graphics processing unit (GPU) as well as high-performance computer. Azure provides B, Dsv3, Dv3 instance, AWS EC2 provides A1, M5, T3 instance for the general-purpose instance while Google Cloud provides E2, N2 to offer the client. In memory-optimized instance, Azure provides Esv3, Ev3, M instance, AWS EC2 provides X1, X1e, R5 instance while Google Cloud to send the customer M2, M1. AWS EC2 provides D2, H1, i3 instance for the optimized storage while Azure provides Ls instance to send the client.

## 4 Storage

With the support of cloud storage services, customers can get the capability to store, connect, manage and closely monitor their information. The main kind of storage available is block storage. Amazon's version of block storage is Elastic Block Store (EBS). For total and vital interpersonal tasks, EBS works in line with Amazon EC2. The block storage version of the Google Cloud Platform is Permanent Disks (PDs). In virtual machine disk, virtual machine backups and exchanging read-only information, PDs are preferable. The block storage for Microsoft Azure is Handled Disks. In a single-scale package, it can build up to 1000 VMs, point-in-time backups, SSD or HDD disks, and role-based access control for extra protection.

## 5 OS Environment Offered

AWS EC2 provides operating system which can run on Linux, macOS, Raspbian, and Windows Server etc. Microsoft Azure provides operating system which can run on Red Hat 7.3 or later, CentOS 7.3 or later, Windows, Linux etc. Google cloud can run on operating system which are CentOS, Debian, Fedora CoreOS, Red Hat Enterprise Linux (RHEL) and Container – Optimized OS(COS) etc.

## 6 Security

In terms of security, AWS is designed by using largest security partner and solution. The system is excellent for preventing threats, detecting suspicious activity, and responding rapidly and efficiently to any incidents. For Microsoft Azure, when setting up an account, users can opt for some security features. This action would improve consumer data security. Users can also encrypt all their data stored on the server side, which, if their profile is compromised, would prevent readable copies from being available. Finally, for Google Cloud, by giving users the option of letting Google Cloud handle their profile keys or letting the user manage their own. They come with an edge over their rivals. Users can easily rotate through keys, dispose of old keys, control key permissions, and audit key use by managing their own.

## 7 Pricing Model

Pricing is a less prominent component to vary these three companies, yet there are some similarities and differences among them indeed. They provide a free tier of limited service, and the charges of the service are regarding to the options of resources on-demand.

AWS Pricing	Azure Pricing	Google Pricing
<ul style="list-style-type: none"><li>- The platform comes with a cost calculator for its customer.</li><li>- Its pricing structure is complex</li><li>- The users are recommended using third-party management app for navigation</li><li>- Example of free tier: It does offer 750 hours of EC2 service on a monthly basis for up to 1 year</li></ul>	<ul style="list-style-type: none"><li>- The platform provides expert guidance to benefit the users</li><li>- Various pricing options provided with a view to attain customers' demands under different circumstances</li><li>- Free-trial service for business: It offers 750 hours of the Windows or Linus B1S addition of the primary compute platform per annum</li></ul>	<ul style="list-style-type: none"><li>- Google stands apart from the crowd in pricing through its customer-friendly and less transparent pricing structure</li><li>- Its price the service is steeply low than most cloud service providers and also offering some incentives and discounts for business utility</li><li>- Easier navigation and budget-friendly service</li><li>- Example of free tier: It offers F1-micro instance month-to-month for up to 12 months</li></ul>

## 8 Auto-Scaling / Elasticity

Amazon EC2 Auto-Scaling can be modified based on the condition the users define and it assists to maintain the application availability. For instance, it consists of the fleet management to regulate the health and functionality of the user's fleet. To add or remove EC2 instances, there are two features of EC2 Auto Scaling, namely dynamic and predictive scaling. The former will be responding to changing requirement whilst the latter will refer to the predicted demand and automatically schedule the right number of EC2 instances. However, both the dynamic and predicted scaling can be used at the same breath for faster scaling.

On the other hand, the increasing and decreasing of the virtual machine instances' number executing the application are automatic in Azure virtual machine scale set. Thus, the management overhead to monitor and optimize the application's performance due to its auto-scaling behavior and elasticity. When those defined verges are attained, the auto-scale rules will function to maintain the availability of the scale set. The users can also schedule events in order to automatically increase or decrease the scale set's capacity at fixed times.

Whilst for the autoscaling groups of instances in Google Cloud Computing, Managed Instance Group (MIG) offers the users capabilities to define the autoscaling rules. This feature assists the users to reduce costs when the demand is low, while helping the users' apps to engage the increases in traffic. For instance, the virtual machines are added when the load is increasing (scaling up), while they are deleted when the demand is decreasing (scaling down).

## 9 Monitoring Tools / Service Provided

AWS Key Tools	Azure Key Tools	Google Pricing
Artificial Intelligence		
<ul style="list-style-type: none"> <li>• SageMaker</li> <li>• Lex</li> <li>• Transcribe</li> </ul>	<ul style="list-style-type: none"> <li>• Machine Learning</li> <li>• Azure Bot Service</li> <li>• Cognitive Services</li> </ul>	<ul style="list-style-type: none"> <li>• Cloud Natural Language</li> <li>• Cloud Video Intelligence</li> <li>• Dialogflow Enterprise Edition</li> </ul>
Internet of Things (IoT)		
<ul style="list-style-type: none"> <li>• IoT Core</li> <li>• IoT Device Management</li> <li>• IoT Analytics</li> </ul>	<ul style="list-style-type: none"> <li>• IoT Hub</li> <li>• IoT Edge</li> <li>• Stream Analytics</li> </ul>	<ul style="list-style-type: none"> <li>• Cloud IoT Core (Beta)</li> </ul>
Serverless		
<ul style="list-style-type: none"> <li>• Lambda</li> <li>• Serverless Application Repository</li> </ul>	<ul style="list-style-type: none"> <li>• Functions</li> </ul>	<ul style="list-style-type: none"> <li>• Cloud Functions (Beta)</li> </ul>

## 10 Conclusion

From this report, the cloud computing services can be summarised with their most notable strengths. As for Amazon Web Services, the resources of Amazon are unmatched with a huge tool set that continues to expand exponentially. However, its cost structure can be frustrating, and its particular emphasis on the public cloud rather than hybrid cloud or private cloud means that it is not the top priority of AWS to communicate with the data center. Microsoft Azure, a near AWS rival with a cloud infrastructure that is exceptionally capable. If you're an enterprise user, Azure speaks your language, as Microsoft has the company history (and Windows support) for a few businesses. Azure understands you're already running a data center, and the Azure software works hard to communicate with data centers; a real strength is the hybrid cloud. Google Cloud joined the cloud market later, a well-funded competitor in the competition, and does not have the commercial emphasis that helps attract corporate customers. However, its technical experience is in-depth, and its industry-leading deep learning and artificial intelligence software, machine learning and data analytics are essential advantages.

## 11 Opinion

Lim Yeu Chen

As for my perspective, with a view to developing my software, I opt Google Cloud platform. Although it is still growing and the basic features are still in the beta phase, it can constantly help the user enhance their development. It is now in new creation of technology which is carbon neutral to support resource conservation. In terms of storage, Google is lacking of the storage solutions due to the absence of backup options, however, it offers both SQL and NoSQL support. In terms of pricing, Google stands out for making AI development easier to work advanced technology in ideal budget. The users can obtain some basic services with basic prices. In terms of tools, Google still has a long journey to catch up with AWS. The available tools and functions are a work in progress. Whilst in terms of compute, Google Compute is the highlight of their services. The users for both Windows and Linux can custom configure their platforms. The focus of GCP is on Kubernetes deployment – a scope of expertise for Google.

Afaf Binti Azman

From my point of view, I would choose Microsoft Azure as my service provider. For a developer, Microsoft Azure is ideal because connecting Visual Studio with Azure is very easy and straightforward. We can select either Windows or Linux to build a web app for the software. Azure has hybrid capabilities, making it distinctive. They allow easy mobility and a consistent, secure on-premise and public cloud platform. To boost accessibility and performance, Azure offers a wider range of hybrid connections, including virtual private networks (VPNs), caches, content delivery networks (CDNs), and ExpressRoute connections. The Security Development Lifecycle (SDL) is

an industry-leading safety process designed for Azure. It includes security at its root, and on Azure Cloud, private data & services stay secure and protected. The new regional standard for cloud privacy, ISO 27018, is the first to be implemented. For all operational activities and data on the Azure Cloud, Microsoft therefore guarantees the best in terms of safety.

#### Muhammad Afiq Aizzat

From my standpoint, the major weakness of Amazon relates to cost. Although AWS frequently reduces its rates, it is difficult for many companies to consider the cost structure of the organization and efficiently manage those costs when operating a high volume of workloads on the service. Undoubtedly, part of the reason for its success is the massive scale of its activities. As well as the most extensive network of worldwide data centers, AWS has a vast and growing variety of available services. Google is a distant third in market share on the downside, possibly because it does not have the conventional link with business customers. It is, however, increasingly expanding both its deals and its global datacenter presence. Based on my observation, I'd say that I'd choose Azure over any other cloud services because Microsoft Azure is decent in most aspects of comparisons. The platform is rightly built to develop, deploy and manage different services and applications across the vast Microsoft-managed datacenter network. The major reason for Azure's success: Windows and other Microsoft applications are implemented by so many businesses. Companies who use a lot of Microsoft apps also feel it also makes sense for them to use Azure since Azure is closely integrated with these other applications. This establishes allegiance to current Microsoft clients. If I were to choose one of these service for my software development, I'd definitely choose Azure.

#### Nor Fadli Ahmad

In my opinion, I would like to choose Microsoft Azure as my cloud service. It is because for start-ups and entrepreneurs, Azure's dedication to advancing the open-source culture and alignment with the tools and applications that many businesses are already using makes it perfect. That means it is easy to customize and integrate, and there are less compatibility issues. They have a vibrant culture, a reputable brand that is synonymous with corporate computing, and support. In term of compute, this is actually the only network to provide a hybrid cloud model for the big three. When it comes to scalability and security, that gives businesses the best of both worlds. They are best known for the service and AI optimization of Virtual Machines that is integrated into almost every feature and function. For pricing, it is flexible, reasonable and affordable for me. This platform is scalable and agile, according to the instruments that have been given. I can scale at will, up and down. And all my legacy data is always going to have a secure home. Lastly, it is the only platform out of three that provides more than one backup service and a website recovery feature in terms of storage. As a result, the requirements for backup redundancy as a cloud feature was significant.

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