# A Comparative Analysis of the Most Prominent Cloud Computing Service Providers

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## 1 Introduction

Cloud Computing refers to manipulating, configuring, and accessing the applications online. It offers  online data storage, infrastructure and application. Cloud Computing has numerous advantages. Some of the advantages are that people can access applications as utilities, over the Internet, manipulate and configure the application online at any time and so on. Although Cloud Computing is a great innovation in the world of computing, there also exist downsides of cloud computing. The example is in security and privacy. It is the biggest concern about cloud computing since data management and infrastructure management in cloud is provided by third-party, it is always a risk to hand over the sensitive information to such providers. Although the cloud computing vendors ensure more secure password protected accounts, any sign of security breach would result in loss of clients and businesses.  We need to do research on the most prominent Cloud Computing Service Providers; Amazon EC2, Google Cloud Platform, and Microsoft Azure. The detailed comparison and discussion of that three Cloud Computing Service Providers focused on the service model (IaaS, PaaS, SaaS), Virtual Machine (VM) instance types offered (such as micro, small, medium, large etc.), storage, OS environments offered, security, performance and scalability, pricing model, auto-scaling/elasticity and monitoring tools/service provided.

## 2  Comparative Evaluation

### 2.1 Service model (IaaS, PaaS, SaaS)

Both Amazon EC2, Google Cloud Platform and Microsoft Azure provide IaaS, PaaS as well as SaaS. For Amazon EC2, the difference between an IaaS and a PaaS is the type of service. In an IaaS, customers typically work with virtual machines that they configure themselves. In a PaaS, customers work with services created and maintained by the PaaS provider (Matt, 2018). Amazon also works as SaaS by providing easy-to-develop tools and applications to configure apps such as  Amazon CloudWatch, robust encryption to the data, and better authentication of user access through Identity and Access Management (IAM) and provide a strong set of APIs to easily integrate with all AWS services (Amazon's AWS as Software as a Service (SaaS), n.d).

For Google Cloud Platform, its offerings include IaaS, PaaS, and SaaS. Its IaaS products such as Google Compute Engine (GCE) allow enterprises to mix and match these services into combinations that provide the precise environment they need. Besides, GCP also offers PaaS such as App Engine handles most of the management of the resources for the users. While for the most familiar service model for most of us, which is SaaS, is also available in GCP. Examples of SaaS for GCP are DropBox and Google Drive which users can use for free (Google Cloud, n.d.).

Finally, Microsoft Azure also offers 3 of the service models. For IaaS, users can Build pay-as-you-go IT infrastructure by renting servers, virtual machines, storage, networks, and operating systems from a cloud provider. For PaaS, Microsoft Azure provides an environment for building, testing, and deploying software applications; without focusing on managing underlying infrastructure. For SaaS, users connect to and use cloud-based apps over the internet such as Microsoft Office 365, email, and calendars.

### 2.2 Virtual Machine (VM) instance types offered

In cloud computing, users can provision exactly the right type and size of computing resources as they need. This means the cloud computing is offered in several instances which can fit into every user's requirement. It is found that 3 of the cloud computing are providing tons and similar instances. In terms of  pricing, both offer similar prices for each particular instance, besides MC2 uses credit, while GCP and Microsoft Azure use USD dollars. For general

purpose machine (for application that needs a balance requirement), MC2 offered Mac, T4g, T3, T2, M5 and many more instances; GCP offered N1, N2, E2 and C2 instances; Microsoft Azure offers Bs-series, Av2 standard D2 and many more instances. Then for compute optimized machines (for applications that need good CPU), MC2 offered C6g, C5, C4 and many more instances; GCP offered C2, M1and C2 instances; Microsoft Azure offered F-series, Fs-series and Fsv2-series instances. Same goes to memory optimized machines,  accelerated computing machines and storage optimized machines (Maarek, 2020) (Google Cloud, n.d.) (Microsoft Azure, n.d.) (Amazon EC2, n.d.).

## 2.3 Storage

Cloud storage is a cloud computing model that stores data on the Internet through a cloud computing provider who manages and operates data storage as a service. It's delivered on demand with just-in-time capacity and costs, and eliminates buying and managing your own data storage infrastructure. This gives you agility, global scale and durability, with "anytime, anywhere" data access. Both cloud computing provide safe and pay-as-you-go storage which ease the users, and at the same time, provide tons of online storage products with different functionality.

Amazon EC2 and GCP is quite similar as they both have same types of online storage products such as object storage (Amazon simple storage service (s3) for EC2, cloud storage for GCP), file storage  (Amazon Elastic File System (EFS) for EC2, filestore for GCP) and block storage (Amazon Elastic Block Store (EBS) for EC2, Persistent disk for GCP). While for Microsoft Azure, the classification of storage service is different for example azure blobs, azure files and azure tables, but it's function is still similar as the other two. (Amazon EC2, n.d.) (Google Cloud, n.d), (Microsoft Azure, n.d.)

## 2.4 OS environments offered

The virtual machines you create in Amazon EC2 can use one of many OS types, from Linux, to Windows, and even VMware. Pretty much any OS you like can be run in an Amazon EC2 VM. In fact, Amazon EC2 is also the only cloud provider that supports macOS. However, for the most part Linux is the standard OS used for AWS infrastructure.

CentOS, Container-Optimized OS (COS), Debian, Fedora CoreOS, Red Hat Enterprise Linux (RHEL), SQL Server, SUSE Linux Enterprise Server (SLES), Ubuntu LTS, Windows client and Windows server are the parts of OS environment offered by Google Cloud Platform. CentOS is a free operating system platform that is derived from the sources of Red Hat Enterprise Linux (RHEL). Meanwhile, Debian and Ubuntu LTS also free operating systems offered by the Debian community and Canonical respectively.

The last one is Microsoft Azure offers services that leverage proprietary Microsoft technologies. In addition, to traditional cloud offerings such as virtual machines, object storage, and content delivery networks (CDNs). Microsoft Azure also offers cloud-hosted versions of common enterprise Microsoft solutions, such as Active Directory and SQL Server.

## 2.5 Security

Amazon Elastic Compute Cloud, also known as the Amazon EC2 is an element of Amazon Web Services (AWS). Amazon Web Services (AWS) offered the highest priority of cloud security. As an AWS customer, you benefit from a data center and network architecture that are built to meet the requirements of the most security-sensitive organizations. The AWS security services offer users the opportunity to secure their data, inspect security activities, and receive responses. These solutions give cloud users the confidence to trade in the cloud and benefit to pay less for the services. Among the well-known AWS security applications, EC2 is on the list which is known for its provision of secure, flexible computer capacity. With EC2, users can create and deploy the applications on their computer systems with minimal or no hardware constraints.

Google Cloud Platform infrastructure doesn't rely on any single technology to make it secure. Their stack builds security through progressive layers that deliver true defense in depth. This platform uses multi-layer of security in their cloud to protect operational & device security, internet communication, identity, storage services, service deployment and hardware infrastructure. Same goes to Microsoft Azure that using a concept of Defense in Depth, you add layers of security onto your systems make it more difficult for attackers to get access to your data. A

layered approach to securing computer systems. Thus, provides multiple levels of protection. Attacks against one layer are isolated from subsequent layers

**2.6 Performance and scalability**
Amazon E2C integrates with most Amazon Web Services, promoting compatibility and a high degree of flexibility, that allow database administrators to optimize for cost. And the scalable cloud platform allows you to scale up or down in minutes, and it has the ability to deploy thousands of server instances at lightning speed.

And Azure compute features rely on a network of virtual machines to enable a range of computing solutions that include development, testing, datacenter extensions, and app deployment. It's based on an open source platform that's compatible with Linux, Windows servers, SQL Server, Oracle, and SAP. Azure also offers a hybrid model that combines on-premises and public clouds, and it can be integrated into global load balancing.

While Google Cloud Functions is still in the beta phase, it shows a lot of promise with various features. The services can manage resources and deploy apps for you, automatically scale according to traffic or use in real-time, and deploy code from Google Cloud, Firebase, or Assistant. And you can also call functions up using HTML from any network or device.

**2.7 Pricing and model**
Amazon EC2, although the platform does provide its customers with a cost calculator. But the pricing structure is so complex. They do offer 750 hours of EC2 service per month for up to 12 months as a part of their free tier.

For Microsoft Azure The pricing options are mainly situational in an effort to cater to the unique needs of each customer. Like Amazon EC2, Azure offers 750 hours of the Windows or Linux B1S addition of their primary computer platform, Virtual Machines.

And for GCP they make their pricing structure more customer-friendly. And the list prices are lower than those offered by most cloud service providers and give steep discounts and other incentives to win business. Google's free tier incentive includes one F1-micro instance per month for up to one year, it is easy to navigate, and a budget-friendly service.

**2.8 Auto-Scaling/Elasticity**
Auto-scaling is a cloud computing feature that enables organizations to scale cloud services such as server capacities or virtual machines up or down automatically. It reduces the need for an operator to continually monitor the performance of a system and make decisions about adding or removing resources by taking advantage of the elasticity of cloud-hosted environments while easing management overhead. For Amazon EC2 autoscaling, it helps us to ensure that we have the correct number of Amazon EC2 instances available to handle the load for our application by allowing us to automatically add or remove EC2 instances according to conditions that we define.

Meanwhile, Google Cloud Platform auto-scaling  is a bit different, as it lets your apps gracefully handle increases in traffic, and it reduces cost when the need for resources is lower. After you define the autoscaling policy, the autoscaler performs automatic scaling based on the measured load.

Microsoft Azure auto-scaling provides built-in mechanisms that address common scenarios. If a particular service or technology does not have built-in auto-scaling functionality, or if we have specific auto-scaling requirements beyond its capabilities, you might consider a custom implementation. A custom implementation would collect operational and system metrics, analyze the metrics, and then scale resources accordingly.

**2.9 Monitoring tools/service provided**
Monitoring tools or monitoring services are used to continuously keep track of the status of the system in use, in order to have the earliest warning of failures, defects or problems and to improve them. Every cloud computing service has monitoring tools responsible for servers, networks, databases, security, performance, website and internet usage, applications and many more (TRY QA, n.d.). For AWS, there are monitoring tools called SolarWinds® Server & Application Monitor (SAM) which are able to optimize performance with high-visibility and proactive AWS monitoring (solarwinds, n.d.). For GCP, there is a monitoring tool called Manage Engine which are

able to monitor CPU and memory details, keep tabs on disk utilization, achieve maximum network efficiency, effectively track firewall metrics and track quota metrics with ease (ManageEngine Applications Manager, n.d.). While for Azure, Azure have first-party azure monitoring tools such as microsoft azure monitor and azure advisor, as well as third-party azure monitoring tools such as AppDynamics and Datadog (Rouse, 2020).

## 3 Opinion

Amazon EC2, Google Cloud Platform and Microsoft Azure both have their own unique features and target group, which lead to several advantages and disadvantages. For AWS, the advantages are they offer a complete toolset with a wide breadth of functions available for users and have been perfecting cloud computing services since 2006. Besides, they also have more compute capacity than most of its competitors by 5x which means it benefits more for big businesses and companies who are doing big projects. However, the disadvantages are that the wide catalog of offerings can be overwhelming and difficult to navigate for some users, resulting in the users forces to purchase an enterprise level support. Besides, AWS does not have a strong hybrid cloud strategy for those businesses that want to keep sensitive data in a private cloud.

Next, which is GCP, the advantages are that they have received a great reputation in the open-source community. They also have a flexible pricing model which users can pay as much as they work. The modern innovation of GCP is also one of the advantages that surpass other competitors. However, the disadvantages are GCP not focusing on supporting large, enterprise projects which causes big businesses not considering choosing GCP.

Lastly, which is Microsoft Azure, their advantages are that they also have a flexible billing. Besides, they are high reliability, high availability and easy to integrate for firms already running a lot of Microsoft software. Most importantly, their PaaS is becoming a strong suit for Microsoft. However, they also have some disadvantages. Their functions seem to be limited when compared against AWS, which means users with big projects will instead choose AWS over Azure. Besides, Azure only set up for Windows, which limited other users which did not use Windows. Azure also requires enterprise management from customers (AWS vs Azure vs GCP, n.d.).

From the explanation of advantages and disadvantages of each cloud computing, if I were to choose one of the cloud computing services, I will take some aspects into consideration. My current needs are doing university projects and storing private files. As Amazon EC2 is more suitable for those with big projects, AWS will not be in consideration. Compared to Azure and GCP, Azure is providing Microsoft Office 365 that will help me in doing university projects, while GCP has Google Drive that can store my files, as well as Gmail, where I can receive important messages from lecturer and official site. GCP seems to have more benefits for my needs compared to Azure. Therefore, I will be choosing Google Cloud Platform over the other 2 as GCP fits me the most compared to the others.

## 4 Conclusion

In conclusion, cloud computing has recently been the development of new technologies that have the potential to have a huge impact on the world. It has many benefits given to consumers and businesses. For example, some of the benefits it provides to businesses, are reducing operating costs by spending less on software maintenance and upgrades and focusing more on the business itself. But there are other challenges that must be overcome with cloud computing. People are very skeptical about whether their data is safe and personal. There are no standards or regulations around the world that provide data through cloud computing. Users are also concerned about who can disclose their data and own their own property. But once, there are standards and rules around the world, cloud computing will revolutionize the future.

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