

An Overview of Cloud Computing Service Providers: Amazon EC2, Google Cloud Platform and Microsoft Azure

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1. Introduction

Cloud computing, also referred to as the "cloud," is the use of multiple resources over the internet, such as software development platforms, computers, storage and software. Rather than storing files on a private hard disc or local storage unit, cloud-based storage makes it easier to save them to a remote archive. As long as an electronic computer has access to the internet, it has access to the data and the software programs to run the system. Cloud computing have been received well by the community especially for people making businesses as the concept of cloud computing such as cost-savings, increased productivity, faster and more efficient compared to other storage methods. Regardless, some would think cloud computing an overused buzzword that has been blown out of proportion at major tech companies by the marketing teams. A common reason to that includes that cloud computing will not work because it ensures that any organizations such as an email company that stores data in several places around the world must lose their ownership of their records. While this is not an insurmountable challenge, it shows the cloud storage problem similar to certain enterprises might have. We need to understand that the cloud computing is named as such because the information accessed is located remotely in the cloud or virtual space. Cloud storage providers allow users to store files and software on remote servers and then access all data over the Internet. This suggests that to obtain access to it, the user is not forced to be in a certain location, enabling the user to run system remotely.

The purpose of this paper is to establish the main fundamentals of Cloud Computing. Over the years, cloud computing in both media and among consumers have been receiving a great deal of attention yet not many people are not aware and not clearly defined about cloud computing. In order to provide quicker development, scalable infrastructure and economies, cloud computing is the implementation of computing services, including servers, storage, databases, networking, applications, analytics, and information over the internet.

This paper is organized into 6 sections. The first section outlines the background of Cloud Computing referring to several articles with some description. The second section describes about three types cloud models and some description of the cloud models. In the third section, types of cloud services are described along with some examples that have the respective cloud service. The forth section outlines about the top Cloud Computing Providers and comparison between three of the top Cloud Computing Provider which are Amazon EC2, Google Cloud Platform and Microsoft Azure. The fifth section is about the chosen Cloud Computing Providers for our software development and the reasons we chose our choice. The last section summarise the review on this Cloud Computing Providers.

2. Background of Cloud Computing

Cloud computing is about storing or accessing any programs, apps or data via the internet rather than directly on your hard drive [2]. Cloud computing is a service that focused on subscriptions where networked storage space and computational services can be accessed. In this era full of technologies, majority of people already experienced the use of cloud computing in their daily life. For a clear example the use of email such as Yahoo, Gmail and Hotmail which you can access through an internet connection and the contents of the email can only be access when you have internet connection. An email client system is very similar to how cloud computing works and that you can pick what information you have access to inside the cloud instead of accessing only your email [3]. Combined with improved IT versatility, the Cloud Computing platform provides the promise of significant cost savings. It is considered crucial that this technology be implemented by government and industry in response to differential economic constraints. Cloud computing infrastructure, however, contradicts many conventional datacentre and business device architecture and management techniques. Cloud storage is currently being used, but stability, interoperability, and portability are cited as significant hurdles to wider acceptance [4].

3. Cloud Models

Public – Public cloud refers to computing which IT is delivered via the Internet and shared across organizations. With high elasticity and scalability, there is wide range of functionality of the cloud from the common services like email, apps and storage to the enterprise-grade OS platform. It comes with low cost subscription and can even be free [2].

Private – Private cloud refers to cloud which is dedicated to a specific organization and only been used for that single organization only. The data center of this cloud may be located on premise or operated by third party. It is also customizable to meet the needs of organization as the needs may be vary from other organization [2].

Hybrid – Hybrid cloud is a combinational of cloud infrastructure between private cloud and public cloud where the apps and data workloads can share the resources based on policies aspects like security, performance, scalability, cost and efficiency [2].

4. Cloud Services

Infrastructure as a service (IaaS) – it is known as the most basic category of cloud computing where user can rent the infrastructure like servers and virtual machines (VMs), storage, network and operating system from the cloud provider on a pay-as-you-go basis [6]. Examples of IaaS are Amazon Web Services and Microsoft Azure [10].

Platform as a service (PaaS) – it is a cloud computing services that provide on demand environment for managing, evaluating or developing software applications. It is designed to provide an easy way for the developer to create web or mobile apps quickly without having to worry about the set up or underlying infrastructure[6]. Examples of PaaS are Google App Engine and Openshift [10].

Software as a service (SaaS) – it is a way of delivering software application over the internet. Usually it comes on a subscription basis where the cloud providers will host and manage the underlying infrastructure and take over the maintenance such as software upgrade and security patching [6]. Examples of SaaS are JIRA and Dropbox [10].

5. Top/Leading Cloud Computing Providers

These are some of top cloud computing providers in 2021: [5]

1. Amazon Web Services
2. Microsoft Azure
3. Google Cloud Platform
4. Alibaba Cloud
5. IBM

Amazon Elastic Compute Cloud (Amazon EC2) – A web service that provides compute capacity in the cloud that is secure and resizable. It provides an easier path for developers to create web-scale cloud computing. Amazon EC2 offers variety of compute platform with choice of processor, storage, networking, operating system and purchase model [11].

Google Cloud Platform – A suite of public cloud computing services offered by Google that offers various services for compute, storage, networking, big data, machine learning and the internet of things (IoT). The products in Google Cloud Platform include Google Compute Engines, Google App Engine, Google Cloud Storage and Google Container Engine [12].

Microsoft Azure – A cloud computing platform that allows the user to get access and manage cloud services and resources provided by Microsoft. These include storing the data and transform it into the requirement needed. The users need to have an active internet connection and the ability to get connected to Azure portal in order to get access to the resources [13].

There are several comparisons described between Amazon Elastic Compute Cloud (Amazon EC2), Google Cloud Platform and Microsoft Azure in several aspects such as Virtual Machine instance types offered, storage, OS environments offered, security, performance and scalability, pricing model, auto-scaling or elasticity and monitoring tools or service provided by respective cloud computing providers.

Aspects		Amazon Elastic Compute Cloud (Amazon EC2)	Google Cloud Platform	Microsoft Azure
Virtual Machine		Various types of Virtual Machine instance are provided based on the purposes they are designed to.		
		General Purposes: A1, T2, T3, T3a, T4g, M4, M5, M5a, M5n, M6g Compute Optimized: C4, C5, C5a, C5n, C6g Memory Optimized: R4, R5, R5a, R6g, X1, X1e, Z1d Storage Optimized: D2, H1, I3, I3en [26]	General Purposes: E2, N2, N2D, N1 Compute Optimized: C2 Memory Optimized: M2, M1 [28]	General Purposes: B, Dsv3, Dv3, Dasv3, Dav3, DSv2, Dv2, Av2, DC Compute Optimized: Fsv2 Memory Optimized: Esv3, Ev3, Easv3, Eav3, Mv2, M, DSv2, Dv2 Storage Optimized: Lsv2 [27]
Storage	Description [15]	Expansive storage capabilities is one of the greatest advantages of cloud computing. The followings are storage, database and backup features offered by respective Cloud Computing Providers.		
	Storage [15]	- Data Lake Storage - Simple Storage Service (S3) - Elastic Block Storage (EBS) - Elastic File System (EF5) - Storage Gateway - Snowball - Snowball Edge - Snowmobile	- Cloud Storage - Persistent Disk - Transfer Appliance - Transfer Service	- Blob Storage - Queue Storage - File Storage - Disk Storage - Data Lake Storage
	Database [15]	- Aurora - RDS - DynamoDB - ElastiCache - Redshift - Neptune - Database Migration Service	- Cloud SQL - Cloud Bigtable - Cloud Spanner - Cloud Datastore	- SQL Database - Database for MySQL - Database for PostgreSQL - Data Warehouse - ServerStretch Database - Cosmos DB - Table Storage - Redis Cache - Data Factory
	Backup Services [15]	- Glacier	- Nearline (frequently accessed data) - Coldline (infrequently accessed data)	- Archival Storage - Recovery Backups - Site Recovery

OS Environment Offered	It can run in OS like the following: [7] - Linux - MacOS - Raspbian - Windows Server	It can run in OS like the following: [9] - CentOS - SQL Server - Debian - SUSE Linux Enterprise Server (SLES) - Fedora CoreOS	It can run in OS like the following: [8] - Linux - Microsoft Windows
Security	In AWS, security is shared between the customer and AWS. The shared responsibility model describes this as security of the cloud and security in the cloud: [23] - Security of the cloud: The infrastructure that runs AWS services in the AWS Cloud is the responsibility of AWS itself. AWS provides the customer with services that can be used securely - Security in the cloud: It is the customer's responsibility to determine the service that they opt to use and they are also the one who will be responsible with the sensitivity of the data, the company's requirements and applicable laws and regulations.	There are 6 security layers in Google Infrastructure Security Layers: [24] - Operational Security: Responsible for Intrusion Detection, Reducing Insider Risk, Safe Employee Devices & Credentials, Safe Software Development - Internet Communication: Responsible for Google Front End, DoS Protection - Storage Services: Responsible for Encryption at rest, Deletion of Data - User Identity: Responsible for Authentication, Login Abuse Protection - Service Deployment: Responsible for Eccess Management of End User Data, Encryption of Inter-Service Communication, Inter-Service Access Management, Service Identify, Integrity, Isolation - Hardware Infrastructure: Responsible for Secure Boot Stack and Machine Identity, Hardware Design and Provenance, Security of Physical Premises	The security of Microsoft Azure is built on two pillars: [25] - Assume Breach: From the assumption that the system has already been breached, they focused on noticing and limit the impacts of breaching versus only trying to prevent the attacks. - Hardened by Default: As the infrastructure runs on well-defined hardware and software, they enables, configures and validates all the security features provided by default.

Performance and Scalability		Amazon EC2 uses advanced Ethernet networking technologies, optimised for size, security, fast availability, and low cost, like all things EC2. This network is remarkable and continues to prosper from the high rate of growth of Amazon. Amazon EC2 provides strong, solid scaling and incredibly poor scaling but most application could achieve an excellent performance while using Amazon EC2. Amazon EC2 offers almost infinite efficiency, security, cost savings, and high availability, making queues "a thing of the past." A long queue wait takes a long turn-around period for an event, regardless of the size and that is why Amazon's performance have a good rating in general [20].	Google Cloud Platform offered different tier of networks which makes them the first major public cloud to offer a tiered cloud network. The premium tier delivers traffic over the highly secure global network of Google's well-provisioned, low latency. Redundancy is important, and that is why there are at least three different routes (N+2 redundancy) to every two locations on the Google network, helping to ensure that even in the case of a disturbance, traffic continues to flow between the locations. This ensures the performance while using Google Cloud Platform lightning-fast load times by minimizing the traceroute hops and reducing the travelled distance by the data. Google Cloud Platform are able to manage 60k+ concurrent visitors without any troubles [22].	The ability to auto-scale according to the specifications of device use is one of the great features of the Azure service. In Azure, configuring scaling is better relative to conventional hosting. There is no reason to shut down the main server. It also removes the physical limitations of services being introduced. To meet workload, resources covered by Azure Autoscale will scale automatically to fit demand. Azure offers Azure Data Queues (Simple Queuing Service Based on Azure Storage) and Azure Service Bus with certain native first-party queueing services. This queue serves as a buffer between a job and a facility it invokes in order to smooth the occasional heavy loads and this help the Azure's performance greatly [21].
Pricing Model (based on Machine Learning)	General [14]	Recently started offering pay-per-minute billing.	Offers pay-per-second billing models which let users save way more. More discount also offered to the customers to help save up to 50% in some cases.	Already offers pay-per-minute billing.
	Smallest instance [14]	A very basic instance that includes 2 virtual CPUs and 8 GB of RAM will cost the user around US\$69 per month.	The most basic instance includes 2 virtual CPUs and 8 GB of RAM at a 25% cheaper rate so it will cost the user around US\$52 per month.	An instance with 2 virtual CPUs and 8 GB of RAM will cost the user around US\$70 per month.
	Largest instance [14]	The largest instance that includes 3.64 TB of RAM and 128 virtual CPUs will cost the user around US\$3.97 per hour.	The largest instance that includes 3.75 TB of RAM and 160 virtual CPUs will cost the user around US\$5.32 per hour.	The largest instance that includes 3.89 TB of RAM and 128 virtual CPUs will cost the user around US\$6.79 per hour.

Auto Scaling/Elasticity	The Amazon EC2 offer Auto Scaling features and services which was designed to enable user to launch or exit the system automatically to help ensure you have the right number of Amazon EC2 instances available to manage the load for your application. Amazon EC2 auto scaling features allows user to preserve the accessibility of apps by fleet management for EC2 instances, which identifies and removes any unsafe instances and through automatically scaling up or down the Amazon EC2 capability is according to requirements the user specify. To sustain efficiency and decrease power during slow periods to decrease prices, you can use Amazon EC2 Auto Scaling to automatically increase the number of Amazon EC2 cases during demand surges [17].	Auto scaling is a function of the managed community of instances on the Google Cloud platform. A set of homogeneous instances generated from a common example prototype is a controlled instance category. In order to spread incoming traffic through several virtual machine (VM) instances, Google Cloud supports server-side load balancing. Auto-scaling of the Google Cloud Platform dynamically integrates or excludes VM instances from a managed instance category depending on load increases or decreases. Auto scaling helps the applications to handle changes in traffic gracefully, and where the demand for energy is smaller, it lowers costs. The auto-scaling performs automatic scaling based on the calculated load after you specify the autoscaling policy [19].	Microsoft Azure provides auto-scaling feature for applications hosted on Azure. Auto-scaling Azure applications dynamically can be a great deal of benefit. Resources are automatically assigned to satisfy performance criteria in the auto-scaling process and often follow service-level agreements (SLAs). Without risking application efficiency, integrating auto-scaling functionality into your Azure applications will deliver minimal runtime costs. The auto-scaling function allows your application to automatically scale up or down according to your specified parameters. As demand rises, Azure's auto-scaling function scales out the cases impeccably. You can save money by flaking unnecessary instances automatically. Based on the scaling parameters, the Auto-scaling function Azure offered also helps to set alarms and updates [18].
Monitoring tools/Service Provided	The following are service tools provided: [15] - Developer, engagement and management tools - Machine learning and predictive analytics - Databases and storage solutions - Business productivity tools - App integration - Compute	The following are service tools provided: [15] - Data management and storage - App development - SMB business analytics and AI - Productivity and workload management tools	The following are service tools provided: [15] - Big data and predictive analytics - Game and app development - Scalable data warehousing - Blockchain technology DevOps - IoT integration

6. Chosen Cloud Service Provider

The Cloud Service Provider that will be chosen is Microsoft Azure. There are several reasons why we decided to choose Microsoft Azure among the three top cloud computing providers. In term of security they are offering, it is proven that Microsoft Azure serves the best compliance covering and it is the most trusted platform even by the U.S. government institutions. In addition, Microsoft Azure also became the first one to embrace the new international standard for Cloud privacy, ISO27018. This proves that Microsoft Azure provide the best safety of all operation and data on the Azure Cloud [16]. Secondly, Azure has the capability of hybrid type which makes it unique and it eases the mobility between the private and public Cloud. Azure provides wide range of hybrid connections including virtual private network (VPNs), caches and more to list [16]. Next, the use of Azure will eases the usage of other platform which is dependent on Microsoft tools like Office 365, Outlook and Sharepoint. In terms of pricing, Azure allows the user to pay for what they use to build or expand as it has the pay-as-you-go model pricing for the customers. This will somehow reduce the cost of IT administrator as the infrastructure is take care by the Microsoft on Azure. Microsoft Azure also offers Identity and Access Management (IAM) which enable the right users to get access to the right information which will somehow help to reduce the cost of identity management [16]. Lastly, Azure facilitates SQL and NoSQL data services which will help build in support for going deeper into the data and uncovering key insights to improve the business processes and decision making [16].

7. Conclusion

To summarize this research paper, cloud computing has opened multiple choices for both big and small company for a wider variety of uses in the field of computing and improves the ease of usage by offering connectivity to every internet connection. With this improved convenience, however, cloud computing still has some disadvantages at certain parts. You have little say over who gets access to the data and little to no comprehension about where it is stored. The security implications of getting data stored in the cloud must therefore be acknowledged to you to ensure the safety of your privacy. The cloud is a major target for bad people and can have pitfalls because it can be reached from an unsecured network and you must be aware if your data is being leaked. If you are thinking using the cloud services, always classify the details you are going to be putting out in the system and who will have access to the information in the cloud, and what you will do to guarantee that it is safe. In addition, appreciate your decisions in terms of what kind of cloud is better for your needs, what kind of provider is most helpful to you, and what the reputation and roles of the services you consider when you sign up the services.

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