A Comprehensive Analysis on Cloud Computing Service Providers

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1.0 Introduction

Nowadays, Cloud computing had become the main topic in the tongues of IT professionals because of its emerging importance in the industry. The basic idea of cloud computing is to provide computer services on-demand from applications to storage and processing power normally on internet and on pay as you go basis. To put it more simply, it is an application software infrastructure that saves data on remote serves which can accessed from the internet. Instead of having to set up a computing infrastructure or data center, you can rent an access to anything from your app to storage on cloud server which will save users from the set up and maintenance cost of computing infrastructures. Users can simply rent or pay for what you want to use on the time you use.

Cloud computing service providers are well aware of the importance of companies' data, and thus provides automated backup, and scalable, flexible plans. Cloud computing is not only limited to provide only computing infrastructures, as in SaaS (Software as a Service) that include consumer services like Gmail or smartphone photo back-up. Also, there are services which is useful for big companies to host all their data like Netflix or Amazon or Google and another companies.

In 2005, Amazon launched AWS (Amazon Web Service) with pre access for Small number of Customers. In 2010 Amazon launched simple Notification services which is a tool that allow developers to send messages from application to other system and people. Also, Amazon launched a tool which called AWS cloud formation that helps users to choose groups of materials of Aws to make the requested materials. In 2020 Amazon provide App flow which is a service to transfer data securely between third party SaaS and Aws services. Also, Amazon launch Honey code which is a platform without code to upgrade phone and web apps.

On the other hand, Microsoft launched Azure project in 2000 as an initiative called Red Dog. However, Amazon had already provided its cloud Computing services so Microsoft trying to catchup the news in 2008 in Microsoft developers conference. The chief of software section in Microsoft say that the company planned to launch its cloud computing service which called Azure which provide five categories of cloud services: Microsoft SQL Services for database, Windows Azure for Compute Microsoft, NET services for developers, live services for sharing files, and share point and Microsoft dynamics CRM. After that Microsoft start providing special versions of their Computing services. In 2014, Microsoft officially renamed Windows Azure to Microsoft Azure, one of the top cloud computing services known today.

In 2008 Google launched App Engine, which was an PaaS cloud service model. Initially, it launched privately for some developers to review. After that Google made the service for more developers with the passage of time until the number become 75,000 and 80,000 on the waiting list. After that, Google noticed that it should make the service for everyone. In 2011 Google left the preview label on App engine. At that time, many developers criticized Google engine because it does not support many programming languages like Java. In 2009 Google gradually added support to several programming languages that are requested by the users, and in the following year Google launched the second cloud computing services which made Google enter the laaS market. Until now, Google never stops expanding and improving Google Cloud Platform (GCP) to provide services at a lower price point to the market.

2.0 Comparative Evaluation

Currently, there are 3 global corporations that stand-out as being the most prominent cloud computing service providers. Namely, Amazon EC2 provided by Amazon.com Inc, Google Cloud Platform provided by Google LLC, and Microsoft Azure provided by Microsoft Corporation. Being a smart consumer and aspiring IT professional, it is crucial to be able to compare and evaluate thoroughly the main selling points as well as shortcomings of services provided by each of them, therefore determining which is the most suitable to be chosen and implemented according to user needs. In the following section, each service providers will be evaluated and compared based on several aspects like service model, virtual machine and cloud storages, cloud security and many more.

2.1 Service Model (IaaS, PaaS, SaaS)

Emerging in the 2010s as a popular computing model, *Infrastructure as a Service*, or simply "*IaaS*" is a cloud computing's offering that serves with fundamental computing, networking and storage resources over the internet to users on demand under a payment basis.

Software as a Service or *SaaS* is a Cloud Computing's offering that refers to model of software distribution where a provider hosts the applications and then make those available to users on the Internet.

Platform as a Service or *PaaS* is a type of cloud computing's offering where a provider provides a platform to clients, in which the clients can manage, develop and run business applications without the necessity of building and maintaining the infrastructure that such software development processes usually require.

Amazon EC2	Microsoft Azure	Google Cloud Platform
Amazon Elastic Compute cloud or EC2 does the networking, storage, server and virtualization and user can manage the Operating System, data and application. So, it is IaaS (Infrastructure as a Service)	Microsoft Azure is a Cloud that provides storage, application, computing services. So Azure is both (PaaS) and (IaaS).	Google Cloud's App Engine is P*latform as a Service* (PaaS). By this App Engine, Google manages the resources for the users. Again, Google Compute Engine or GCE of Google Cloud is a *IaaS* component of Google Cloud. It is built on the global infrastructure that runs Google's search engine, Gmail, YouTube and other services.

2.2 Virtual Machine

Cloud Computing also provides Virtual Machine. A virtual machine or VM is the virtualization of a computer system so that a user can use any other operating system simultaneously he wants. A VM app creates a virtual environment that acts just like a separate computer system. The VM runs as a process in a window on the current operating system. In the VM, the actual operating system that is running on the computer is the host and any operating system that's running inside the Virtual Machines are called guests.

Amazon EC2	Microsoft Azure	Google Cloud Platform
Usable for micro, small, medium and large VMs. It limits up to 256 vCPUs and 24000 GB RAM. It also offers a MAC-based VM.	Usable for micro, small, medium and large VMs. It limits up to 416 vCPUs and 11400 GB RAM. It also offers an "economic" VM.	Usable for all micro, small, medium and large VMs. Google Compute Engine VMs limit up to 416 vCPUs and 11776 GB RAM. It also offers low end VMs for free.

2.3 Storage

Cloud storage is a model of cloud computing that stores data on the internet by a provider that handles data as a service. In cloud storage, data is managed and backed up remotely so that users can update their contents easily, save it and rescue data when needed. Cloud storage utilizes data centers with huge computer servers that generally store data and make accessible in online.

Benefits of cloud storage in cloud computing:

- Worldwide availability
- Usability and accessibility
- Backups and archives
- Less-expensive disaster recovery

Amazon EC2	Microsoft Azure	Google Cloud Platform
Amazon EC2 provides user with adaptable, financially savvy and simple to utilize data storage for user instances. These storage options can be utilized freely or in combination with the needs of the user. A square-level storage volume made for single-occurrence connection and up to **16 TB** of storage space. Useful for successive updates(database).	The Azure Storage stage is Microsoft's distributed storage result for digital data storage situations. Core storage services give a hugely adaptable item store for data-objects, disk-storage for Azure virtual machines, a document system service for cloud, an informing storage for dependable data and a NoSQL store. Microsoft Azure storage can store up to **500 TB** of data.	Google Cloud Storage is a Restful online document storage web administration for storing and getting information on Google Cloud Platform system. The assistance joins the presentation and versatility of Google's cloud with cutting edge security and sharing capacities. There is maximum limit of **5 TB** for individual objects stored in Google Cloud Storage.

2.4 OS Environments offered

Amazon EC2	Microsoft Azure	Google Cloud Platform
Amazon EC2 uses Linux Kernel and various other Operating Systems. Here users can also upload their own operating system.	Microsoft Azure supports Linux, Ubuntu. Since Microsoft owns Windows, it supports Windows Operating Systems.	Google Cloud has CentOS which is a free operating system platform and is a Linux distribution.

2.5 Security

Cloud security is the consolation of data stored in online through cloud computing platforms. Strategies for giving cloud security incorporate firewalls, entrance testing, jumbling, VPN and evading public web associations. Security in cloud computing is very important to protect user data.

Security of cloud computing services:

Amazon EC2	Microsoft Azure	Google Cloud Platform
By using AWS, client will obtain the control and conviction they need to safely keep up their business with the most versatile and secure cloud computing environment open today. As an AWS customer, user will benefit by AWS information workers and an organization modeler to make sure about their information, characters, apps, and contraptions. With AWS, client can improve their ability to meet focus security and consistence necessities for instance, data locale, affirmation and protection with organizations'	**Azure** offers user one kind of security points of interest got from worldwide security insight, complex client confronting controls and a secure solidified framework. This amazing combination ensures user applications and information, uphold their consistence endeavours, and give financially savvy security to associations of all sizes. Microsoft uses a wide assortment of physical, framework and operational controls to help secure Azure. Among the Azure Security Center, utilize Azure Defender to	**The Google Cloud platform** system uses numerous layers of security. Since excess is incorporated into the progressive layers of security, nobody incident can bring down the Google Cloud foundation. Google Cloud security layers includes everything from actual security at data centres to probably the most developed cybersecurity technology and experts accessible in the world. Google uses a few layers of **encryption** to ensure user information very still in Google Cloud Platform items. Google

Amazon EC2	Microsoft Azure	Google Cloud Platform
comprehensive administrations and features. AWS licenses client to **robotize** manual security endeavours with the goal that they can move their focus to scaling and upgrading the business. What's more, client pay only for the administrations that they use. All clients benefit by AWS being the solitary business cloud that has had its administration commitments and related store network assessed and recognized as secure enough for exceptionally secret excess weights.	ensure their hybrid cloud outstanding burdens. Ensure data, applications, and foundation quickly with **built-in** security services in Azure that incorporate unrivalled security knowledge to help identify rapidly advancing occurs early so that user can react quickly.	Cloud Platform encrypts user content put away very still, with no activity needed from the user, using at least one encryption components.

2.6 Performance, Scalability, Auto-Scaling and Elasticity

As the business grows, more resource had to be consumed by the system to handle increasing client requests. Therefore, a cloud computing service must be highly scalable to handle varying amounts of load by increasing or removing resources from the system to remain performant to the clients. For example, horizontal scaling groups multiple independent computing instances together to provide more processing power for handling heavy load. **(Amro Al-Said Ahmad 2019)** It is important that when the application had expanded or was having a traffic spike, the cloud service is able to detect the increasing load, and automatically take corresponding actions like distributing the incoming traffic across virtual machines or increasing system resources to mitigate the problem and avoid application crashing, as business downtimes can be expensive. This is called **Auto-Scaling** or **Elasticity**.

Amazon EC2	Microsoft Azure	Google Cloud Platform
User is able to build their own scaling plans that will automate the response of resource groups when the demand changes. AWS Auto Scaling will monitor the application continuously and increase the available constrained resource to ensure optimal service experience. Predictive Scaling is also available which scale the resources using Machine Learning technology. **(AWS Auto Scaling n.d.)**	Azure Autoscale is a feature to automatically scale the application as needed. User is able to use scheduled autoscale to automatically scale the resources on specified time, or to save the operation costs by scaling down when demand drops. **(Azure Autoscale n.d.)**	GCP users can create an autoscaler, which at least one autoscaling policy must be specified. The policy can be based on CPU utilization, serving capacity, monitoring metrics or simply scheduled autoscaling. The autoscaler will act based on the policies assigned by the user. **(Load Balancing and Scaling (GCP Documentation) n.d.)**

2.7 Pricing Model

For a business that relies on cloud services, pricing is an important factor to consider so to ensure that the cost required to achieve the objective is minimized. Bills should always correspond to how much cloud resources had been used by users and shall never overcharge.

Amazon EC2	Microsoft Azure	Google Cloud Platform
All Amazon EC2, Microsoft Azure as well as GCP adapt Pay-as-you-go pricing model, which the client is charged according to the virtual machine instances, network utilizations and storage capacity used. For example, virtual machines are charged based on the total uptime per month as well as the specifications and model of the virtual machine. However, there is still minor differences		

Billing are calculated on hourly basis, rounded up. Provides on demand, spot and reversed pricing model	Billing are calculated on a minute-by-minute basis, rounded up. Provides on demand, short term commitments pricing model	Billing are calculated on a minute-by-minute basis, rounded up. Provides on demand, sustained use pricing model

2.8 Monitoring tools/ Service Provided

Monitoring tools are used to constantly monitor the status of the resource being used, to have the latest warning of crashes, defects or issues and insights to improve them. Every cloud service provider has monitoring tools for their servers, networks, security, performance, internet usage and applications. In cloud computing, monitoring tools generally monitors the data and analytics.

Amazon EC2	Microsoft Azure	Google Cloud Platform
AWS monitoring tools includes, **SolarWinds® AppOptics. ™**, SolarWinds Papertrail. ™	Microsoft Azure monitoring tools includes, Serverless360, Site24*7	Google Cloud monitoring tools offer cloud (Artifact Registry, Cloud Build, Cloud Core, Cloud SDK, Cloud Tasks) monitoring system.

3.0 Opinion

After research and discussion, we were able to analyze the advantages and disadvantages of the three most popular cloud service providers, as shown in table below:

	Amazon EC2	Microsoft Azure	Google Cloud Platform
Advantages	• Has no capacity limits. It can launch instances of any size and can also be resized as however the user wants. • It provides users with servers within minutes just according to the requirement. A user can quickly deploy his/her application. So, it provides speed, agility and flexibility; • Provides security and protect the privacy of the user by storing those in AWS data centers irrespective of the size.	• Microsoft Azure efforts a high accessibility in data centers on a worldwide range. • It has a great concentration with security, maintaining a standard security model of Detect, Measure, Stabilize and Cease. • It makes very simple to scale process power up or down with just the snap of a catch.	• Google cloud Features with easy-to-use interface which help users to use it without any complications. • It also provides very big capacity with low cost. • It gives simple, user-friendly services for expanded security. • It has different types of storage (Cold line storage, regional storage, line storage and multiregional storage) for the Backups archives.
Disadvantages	• Because of so many features it becomes difficult for beginners to use. Beginners may easily make serious mistakes like leaving open ports or deleting any instance without realizing it. • AWS limits some of its security features which are unchangeable like the EC2 Classic, EC2 VPC etc.	• Dissimilar to SaaS platforms where the end-user is devouring data, IaaS (Azure) moves business' process power from data center to the cloud. Microsoft Azure should be properly led and obeyed that incorporates patching and monitoring the server.	• Compared to AWS, Google Cloud Platform still lack in some features that was yet to be integrated. • GCP is relatively new compared to Microsoft Azure and Amazon EC2. As a result, Google is more immature in the cloud service providing industry.

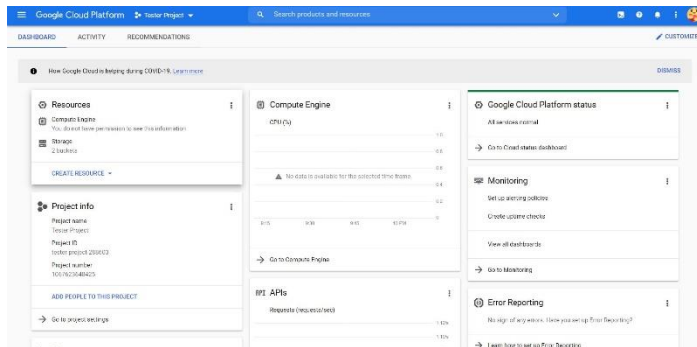|	• It charges for any sort of immediate support and the pricing list or fee structure is not efficient for all users.	• Azure expects expertise to ensure all moving parts cooperate proficiently.	

Figure 1-Example Dashboard of GCP

With this, we all had agreed to choose **Google Cloud Platform (GCP)** as our ideal cloud service provider for software development. Although GCP was relatively late to the market compared to Microsoft Azure and Amazon Web Services (AWS), Google was able to quickly catch up and became one among the top competitors in cloud service providing market. Compared to Microsoft Azure and Amazon EC2, GCP provides with a much more user-friendly interface which is intuitive for beginners like us. In terms of crucial aspects like Security, Monitoring, Scalability and Elasticity, GCP does not seem to fall behind the other cloud service providers. Every service provided by GCP are well documented and goes into detail so that even beginners were able to follow along with ease. **Firebase** was a great example of cloud service backed by GCP which was a Backend as a Service (BaaS) that benefit developers by avoiding complex backend logics and focus more on their development. Also, Google frequently organizes events like last year's **#GCPBoleh** which encourages people in Malaysia to be exposed towards Google's cloud technology. Therefore, we had made our conclusion to select Google Cloud Platform (GCP) as it does not lose to other cloud service providers in terms of the services provided but also proven to be more universal and beginner friendly as it was willing to take initiative in promoting their cloud services.

4.0 Conclusion

Cloud computing plays a major role in Industrial Revolution 4.0. With cloud computing becoming more accessible, developers are able to focus more on integration of their projects instead of worrying about handling hardware specifications like setting up and maintaining a server, as it was all handled by the cloud service provider. It also allows companies to save cost, as bills are charged based on how much they use. Scalability and Elasticity help companies to tune down the resources during off peak times as well as avoid server downtimes. Therefore, future IT professionals must be equipped with adequate cloud computing knowledges to be able to adapt to this ever-changing technology industry.

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