A Comparative Analysis of Cloud Computing Service Providers

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1. Introduction

Cloud computing is a concept that in recent years has gained common use in an organization and gain more attention worldwide. The cloud computing works on a similar concept as we-based email clients, by enabling users to access all the system's functionality and data without having to keep the bulk of the system on their own machines. Currently, without even realizing it, most individuals do use a range of cloud computing services. These cloud-based applications include Gmail, Google Drive, TurboTax, and even Facebook and Instagram. In fact, 94% of workloads and compute instances will be processed through cloud data centers by 2021, compared to only 6% by traditional data centers, according to research by Cisco.[1] The main objectives of this paper are to give a comparative study of different cloud computing service providers and evaluate the advantages and disadvantages of different types of cloud platforms. This paper is organized into 4 section. The first section outlines the background of cloud computing. The second section describes the deployment models of cloud. The third section is about the comparative evaluation of the most prominent cloud computing service providers. Finally, the last section is the top choice for software development.

2. Background of Cloud Computing

The concept of Cloud Computing was first publicly suggested by John McCarthy in year 1961 based on what he said in his speech, “Computation may someday be organized as a public utility.” However, it spent up to 50 years to take this technology to reality.[2] National Institute of Standards and Technology, USA proposed that cloud computing is a model for allowing global, convenient and on-demand network to get access to computing resources that can rapidly supplied and released with less management effort or service provider communication.[3] While according to I.Ahmad et al, cloud computing is a developing technology which is able to execute all computational tasks over the Internet by virtualization techniques at the same time it remains isolated from the complex hardware and software.[4] On the other hand, Swati I. Bairagi et al defined cloud computing as a gathering of IT services supplied to the user over a network together with the ability to scale up down the service requirements.[5] Actually, it is undeniable that cloud computing has rapidly become one of the most popular technologies nowadays with the offer of a wide range of services and opportunities that would able to help the organisations to improve their business by optimising the use of technologies. It brings a lot of business advantages in the aspect of cost savings, quality control, loss prevention, sustainability, security, mobility and much more. [6]

3. Cloud Model Deployment

Cloud deployment models including private cloud, public cloud, hybrid cloud and community cloud shows the way how the cloud services are offered to the users. Private cloud is built and managed by a single group of organization and is not accessible to public. It is more pricey than public cloud but more secure and reliable. On the other hand, public cloud is available to public or external parties to use over Internet. It is built to provide unlimited memory storage and expanded data transmission through the Internet to all organisations. Apart from that, hybrid cloud is combination of private and public cloud while community cloud is collaborative platform which shared by several organisations with similar core of business, project or the demand of infrastructures.[7]

4. The Most Prevalent Cloud Computing Service Providers

Amazon EC2, Google Cloud Platform and Microsoft Azure offer Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). When we compare these Cloud Computing service providers based on virtual machines, we can clearly see a difference in what they provide us with. Based on storage, Amazon EC2 provides the largest number of choices for its users compared to Google Cloud and Microsoft Azure. However, the choices provided by the latter provides as much usefulness as Amazon EC2. For Operating System (OS) environment offered, all of these Cloud Computing service providers are compatible with Linux and Windows, while only Amazon EC2 is compatible with Mac.

Based on security, each one of these Cloud Computing service providers have their own unique tools, with Amazon EC2 having AWS Security Hub, Google Cloud having Cloud Security Command Centre, and Microsoft Azure having Azure Security Centre. Performance efficiency is the ability of workload to meet the demands that were placed on user effectively while scalability is how well a system can handle increase load.[8]

Performance and scalability are measured based on resource usage such as CPU load, memory usage, Disk I/O and read or write database queries as well as application statistic which consists of number of requests and response time.[9] However, they are not much difference between three of the service providers. Thus, we compare their performance and scalability based on server computing and networking. By this comparison, we found that EC2 have greater performance because EC2 has been tested that its standard deviation is 30 percent higher than GCP and Azure.[10]

Each of the cloud computing has its own pricing model. Amazon EC2's pricing model is similar with Microsoft Azure and only one model is different between them which are saving plan is provided by EC2 while commitment consumption- based plan is launched by Azure. However, Google Cloud platform only provide one pricing model which is usage-based. All of the cloud computing service providers have auto-scaling which is used to maintain application availability. All the service providers have its own auto-scaling in different form except scheduled scaling.

Every cloud computing service provider has offered monitoring tools in order to maximize their performance. Google Cloud Platform and Microsoft Azure have similar monitoring tools while Amazon EC2's monitoring tool has divided into two parts which are automated and manually.

Table 1. Comparative evaluation of the most prominent cloud computing service providers

Services	Amazon EC2	Google Cloud	Microsoft Azure
Service Model	• Infrastructure as a Service (IaaS) • Platform as a Service (PaaS) • Software as a Service (SaaS)	• Infrastructure as a Service (IaaS) • Platform as a Service (PaaS) • Software as a Service (SaaS)	• Infrastructure as a Service (IaaS) • Platform as a Service (PaaS) • Software as a Service (SaaS)
Virtual Machine	• On-Demand Instance • Reserved Instances • Spot Instances	• Standard Machines • High-memory Machines • High-CPU Machines • Mega-memory Machines	• General Purpose • Compute Optimized • Memory Optimized • Storage Optimized • GPU • High-performance Compute
Storage	• Simple Storage Service (S3) • Elastic Block Storage (EBS) • Elastic File System (EFS) • Storage Gateway • Snowball • Snowball Edge	• Cloud Storage • Persistent Disk • Transfer Appliance • Transfer Service	• General-purpose v2 Accounts • General-purpose v1 Accounts • BlockBlobStorage Accounts • FileStorage Accounts • BlobStorage Accounts

	• Snowmobile		
OS Offered	• Linux, Windows and Mac	• Linux and Windows	• Linux and Windows
Security	• AWS Security Hub	• Cloud Security Command Centre	• Azure Security Centre
Performance and Scalability (Serverless Computing)	• Lambda • Serverless Application Repository	• Google Cloud Functions	• Functions
Performance and Scalability (Networking)	• Virtual Private Cloud (VPCs)	• Virtual Private Cloud (VPC)	• Virtual Network (VNET)
Pricing Model	• On-Demand Instance • (Pay-as-you-go) • Reserved Instance • Spot Instance • Dedicated Host • Saving Plan	• Usage-based • (Pay-as-you-go)	• On-demand • (Pay-as-you-go) • Reserved capacity • Spot capacity • Dedicated Host • Commitment consumption-based plan
Auto-Scaling	• Scheduled • Dynamic • Predictive	• Scheduled • Cloud Monitoring Metrics • Serving Capacity of External • HTTP(S) Load Balancer • CPU Utilization	• Scheduled • Host-based metric
Monitoring Tool	• Amazon CloudWatch	• Google Cloud Monitor	• Azure Monitor

5. Advantages and Disadvantages of The Service Providers

Amazon Elastic Compute Cloud (Amazon EC2) is the largest cloud computing service provider which was launched in 2006.[11] It provides the secure, scalable compute capacity that can fulfil our requirement to uphold the workload. [12] Petters has stated that the kinds of services which are offered by Amazon EC2 are developer, engagement and management tools, machine learning and predictive analysis, database and storage solutions, business productivity tools, app integration and compute.[13] The main reason that contributes to the strength of Amazon EC2 is at dominant market position because it is highly available and durable as well as it has many data centres over the world compare to the others. EC2 also has a great performance for any workload, virtually unlimited scale and provides broadest range of features and services to the users. [14] However, Amazon EC2 does not have hybrid cloud which are provided by its competitor, Azure. The wide variety of offerings by EC2 become overwhelming and cause difficulty to use for some users as well as leading to a confusing and complicated billing. Another disadvantage of EC2 is its networking is not as flexible as other service providers.

The Top 2 cloud computing service provider which is Microsoft Azure has released since 2010. Azure is a public cloud platform that enable user to store data, establish, design and deploy the web application.[11] As an user, we can utilize several types of services such as big data and predictive analytics, game and app development, scalable data warehousing, blockchain technology, DevOps and IoT integration via Microsoft Azure to enhance our cloud computing experience.[13] Azure can act as a second larger service provider globally because it has a better integration with Microsoft tools and software, provides wide range of features

and offers with hybrid cloud.[14] On the contrary, the weaknesses of Azure are lacking in area of DevOps, require expertise when using the services and do not have assistance when handling a data centre dependent on the cloud. Azure also supports only limited operating systems which are Linux and Windows.

Google cloud platform consists of a combination of physical assets such as computers and hard disk drives as well as virtual resources which are virtual machines (VMs) that are involved in Google's data centres globally. [15] It contains a plenty kind of services such as computing and hosting, storage, databases, networking, big data and machine learning.[16] Google cloud platform has deep investments in analytics and machine learning, so it is expertise in DevOps. Then, the strengths of Google Cloud are offer flexible pricing and discounts as well as provide live migration of virtual machines. Moreover, it also has a great reputation in the open-source community because open source has been a part of Google's foundation. [17] Despite the advantages that given by Google Cloud platform, it is lacking in storage solution and less data centres over the world compare to EC2 and Azure.

Figure 1. Magic Quadrant for Cloud Infrastructure and Platform Services

6. The Top Choice for Software Development

In our opinions, Google Cloud Platform (GCP) will be our choice for software development. One of the big strengths of GCP would be big data and analytics. Its BigQuery analytics engine provides features such as BigQuery ML, BigQuery GIS and BigQuery BI Engine which analyse petabytes pf data using ANSI SQL with fast speed and zero operational overhead. While data can be very important for a software development, we would believe BigQuery will offer a great help. Besides, Google Cloud Platform also leads at the field of machine learning and AI and provides a series of ML tools. For instance, GCP provides Google Cloud Learning Machine whereby the developer can simply build and run superior machine learning model. Nevertheless, GCP also offers AI Platform which is a hosted repository of plug-and-play AI components. We can easily deploy Google Cloud AI for any experimentation and production in Google Cloud and hybrid infrastructure and this will definitely ease our job for any software development. It is also expertise in DevOps and provide world-class infrastructure. In this case, GCP provides a variety of development tools such as Google App Engine. Its key features enable to build application using popular programming language including Node.js, Java, Ruby, C#, Go and Python. Furthermore, it is open and flexible as well as providing a fully managed environment. GCP's open-source platform gains a great reputation too. The open source can preserve our control over where we deploy our IT investment and definitely will help especially in software development. Apart from that, it also costs less since it gives a lot of discounts for long term used. It provides flexible contracts and we only need to pay for the service we need.

7. Conclusion

This paper evaluates about the cloud computing in terms of background and cloud deployment models. We have given a comparative evaluation of each most prominent cloud computing service providers based on the aspect of service model, virtual machine instance types offered, storage, OS environment offered, security, performance and scalability, pricing model, elasticity and the monitoring tools. We also had done the research of the advantages and disadvantages of the three service providers. In the future, cloud computing will be becoming more demand and it is important to us to know about the cloud computing.

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