Cloud Computing:
The Sky Has No Limit

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1 Introduction

Cloud computing is increasing in popularity these days especially during this pandemic season due to the fact that most activities, transactions and businesses are now conducted online. More companies have begun to see the potential of cloud technologies such as Amazon Web Services(AWS), Google Cloud and Microsoft Azure to boost their companies' efficiencies and sales in order to increase the companies' revenue. According to CloudTech, in 2019, the growth for public cloud spending has reached US$229 billion and in 2023 is expected to grow up to US$500 billion with yielding a compound annual growth rate (CAGR) of 22.3% [19].

According to InfoWorld, there are two meanings to describe cloud computing. The first meaning explains that cloud computing allows users to perform tasks online in a commercial provider's data centre, another name for it is the "public cloud" model. The examples for public clouds are Amazon Web Service (AWS) and Microsoft Azure [21]. The second meaning of cloud computing is it acts as a versatile platform that provides all forms of computing resources to users, such as services, databases, software, storage, networking, analytics and intelligence. The companies are only required to pay for the cloud services after that they could access them all. Cloud computing is currently very welcoming as it is convenient, speeds up innovation, flexible and reduces cost. [24].

Thus, there are a few important fundamentals about cloud computing that have been broken down by EXIN. Firstly is the building blocks of cloud computing, which includes Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), where these are the 3 standard models that are offered by the cloud computing providers. Secondly is the role of IT. Thirdly is the benefits of cloud computing, which are able to reduce the IT infrastructure costs. The fourth fundamental is risk assessment, as some companies are worried about their companies' documents being leaked. Hence, the cloud computing providers are well-aware that the security and encryption should be secured and strong in order to protect the users' privacy. The fifth is governance, where it is the responsibility of the private cloud owner, service provider and service consumer of public cloud to monitor the industry standards. Lastly is competencies where the cloud engineers and IT workers are required to equip themselves with competent programming skills and frequent training is needed in order to keep up with the latest technologies and bugs [10].

2 Comparison

Amazon Elastic Compute Cloud, also known as Amazon EC2, by Amazon Web Service is an Infrastructure as a Service (IaaS) by Amazon. Microsoft and Google also provide IaaS through their respective product. Microsoft Azure is Microsoft's IaaS meanwhile Compute Engine by Google Cloud is an IaaS by Google. IaaS is a service models in which users have direct on-demand access to virtual machines as well as a suite of related services to automate common tasks. There is also another service model called Platform as a Service (PaaS). PaaS is a service model where the user will be provided a platform to develop and manage software without having to worry about the underlying complexity of the infrastructure. Each company has their own service regarding PaaS. AWS Elastic Beanstalk is a PaaS provided by Amazon in which user can simply upload your code and Elastic Beanstalk automatically handles the deployment, from capacity provisioning, load balancing, auto-scaling to application health monitoring [3]. App Service by Microsoft Azure is a PaaS provided by Microsoft with features such as fully managing platform with built-in infrastructure maintenance, security patching, and scaling; and also, Integration with virtual networks and ability to run in an isolated and dedicated App Service

environment [23]. Lastly, App Engine by Google Cloud is a PaaS provided by Google. App Engine allows customers to build highly scalable applications on a fully managed serverless platform [12].

Virtual machines are one of the types under Infrastructure as a Service (IaaS). VM instance types offered by Amazon, Microsoft and Google have a variety of predefined instance configurations with specific amounts of virtual CPU, RAM, and network. Amazon EC2 and Microsoft Azure refer to these configurations as instance types meanwhile Google Cloud Platform (Compute Engine) referred as machine type. All 3 of the products share few similar features such as create instances from stored disk images, launch and terminate instances on demand, manage your instances without restrictions, tag your instances, and install a variety of available operating systems on your instance. Predefined instance types are categorized by their intended usage. The first type is 'general purpose' which provide balanced CPU-to-memory ratio and for testing and development, small to medium databases, and low to medium traffic web servers [4][25]. Secondly is 'compute optimized' which has high CPU-to-memory ratio and is good for computationally intensive applications that do not have unusually high memory needs. Some examples include data transformation software (e.g., video encoding), simulation software for science and engineering, and high-traffic web servers. Thirdly is 'memory optimized' which has high memory-to-CPU ratio and is great for memory intensive applications that are not computationally demanding. Some examples include high-performance database applications, applications that must keep large caches of data, and any large, data-driven applications such as enterprise management systems. Next is 'GPU' which is specialized virtual machines targeted for heavy graphic rendering and video editing, as well as model training and inferencing (ND) with deep learning and is available with single or multiple GPUs [14].

Storage is one of the most important services in cloud computing. Amazon EC2 provides Amazon Elastic Block Store (EBS) as a storage option which is flexible, cost effective, and easy to use data storage. EBS is just one of the options in their range of storage options. Meanwhile, Microsoft Azure has more specialized solutions like Data Lake that is specifically designed for data rich applications. Microsoft Azure provides the largest array of databases and offers a dedicated storage option called Blob Storage which is reserved for unstructured REST-based object warehousing. Google's Cloud Storage is quite basic, but they are unified and targeted, and offer both SQL and NoSQL support [11]. As for backups, Amazon only has Glacier, while Google Cloud Platform has no backup option. Azure is the best with backup because of providing several backup solutions including archival storage.

Operating system offered by Amazon EC2, Microsoft Azure, and Google Cloud Platform includes the common OS such as Linux and Windows. But some of the service supports more and some support less. Amazon EC2 offers support for Amazon Linux, Ubuntu, Windows Server, MacOS, Red Hat Enterprise Linux, SUSE Linux Enterprise Server, Fedora, Debian, CentOS, Gentoo Linux, Oracle Linux, and FreeBSD. Microsoft Azure offers a limited amount of OS which are Windows Server and Linux which consists of few distributions such as CentOS, Debian, Ubuntu LTS, Oracle, SLES and RHEL. Compute Engine from Google Cloud offers OS support for CentOS which is derived from the sources of Red Hat Enterprise Linux (RHEL), Container-Optimized OS (COS) which is optimized for running Docker containers, Debian, Fedora CoreOS, Red Hat Enterprise Linux, SQL Server, SUSE Linux Enterprise Server (SLES), Ubuntu LTS, Windows client, and Windows Server [15].

One of the top concerns when choosing a cloud computing provider is security. There are three aspects to be put in consideration which is physical security, infrastructure security, and data and access security but cloud providers do not have too much control on the third one as it is mostly the user's responsibility [27]. In contrast to their rivals, AEC2 had more versatility in the design of its offering by effectively designing the cloud from the ground up [5]. They have also done a good job of pinning identity across the platform as the prime control mechanism. Moreover, to make its security stronger and better, AEC2 has started to add functionality to such identity controls [5]. About Microsoft Azure, a strong suit of Azure is its use of encryption by default. It supports many models of encryption. They provide encryption on the server side using service-managed keys, Key Vault customer-managed keys, or customer-managed keys on customer-controlled hardware [1]. Keys can be handled and maintained on the premises or in another secure location with client-side encryption. While some cloud security features of Google Cloud are quite strong, overall, security remains very much a work in progress compared to AWS and Azure. Many security services are released in beta mode. permissions and granularity can be frustrating, another challenge with Google Cloud [22]. As users want to restrict permissions and are thwarted by the services of a cloud, they may eventually stop trying. And when they stop trying, they start over-per missioning and security suffers [16]. The greatest security controls in the world are not any good if users cannot get them to work.

Performance and scalability are quite important for cloud computing clients as they want to it to be as efficient as possible. They all are pretty good in terms of performance and scalability as they are pretty big companies. Scalability is done to maintain good performance. They all also offer a service called autoscaling which is to monitor your applications and automatically adjust capacity to maintain steady, predictable performance at the lowest possible cost. Locations of cloud data centers also impact network latency. In Asia,

GCP and Azure exerts more network performance stability than AWS, which measured 35 percent less network performance stability than GCP and 56 percent less than Azure [1].

Pricing can be a concern for client to choose their cloud computing platform. For pricing of each platform, AEC2 and Azure have almost 6 times higher pricing than Google Cloud Platform. AEC2 and Azure have almost same pricing due to same free tier offerings and additional pricings. As for serverless computing, Google Cloud Functions turns out as the cheapest provider due to its very low compute price($0.0000025) compared to AWS and Azure [17].

Auto scaling is a cloud computing feature that allow platforms to automatically scale cloud services, like virtual machines and server capacities, up or down, depending on the particular situation (e.g., CPU utilization). Auto-scaling make sure that new instances are increased during demand spikes and decreased during demand drops, enabling consistent performance for lower costs. Amazon EC2, Azure and Google Cloud Platform all has autoscaling in their platform. In AEC2, the feature is called Auto Scaling groups [6], while In Google Cloud, the equivalent feature is called instance groups [11] and in Azure, it is called Virtual Machine Scale Sets [24].

Cloud monitoring is a method of reviewing, observing, and managing the operational workflow in a cloud-based IT infrastructure. Manual or automated management techniques confirm the availability and performance of websites, servers, applications, and other cloud infrastructure. All three-cloud computing platform has its own monitoring tool, but clients can use third party software for monitoring as well. For AWS(EC2), its monitoring tool is called Amazon CloudWatch [2]. It monitors your resources and the application the clients run on EC2 in real time. With CloudWatch, you gain system-wide visibility into resource utilization, application performance, and operational health. For Microsoft Azure, its monitoring tool is Azure Monitor [24]. Azure Monitor helps you maximize the availability and performance of your applications and services. It delivers a comprehensive solution for collecting, analyzing, and acting on telemetry from your cloud and on-premises environments. For Google Cloud Platform, it is called Cloud Monitoring [13]. Cloud Monitoring collects metrics, events, and metadata from Google Cloud, Amazon Web Services (AWS), hosted uptime probes, and application instrumentation. It features SLO monitoring, custom metrics, Google Cloud integration and a bunch of other features. Despite having its own monitoring tools, clients can use third party software to monitor their cloud as well. For example, Google cloud can be monitored using ManageEngine by Zoho Corp.

3 Analysis and Opinions

As we have gone through all the features presented by the respective cloud-based application, it is also crucial to analyse their pros and cons on every aspect despite various opinions from the users. The analysis will allow us to decide which platform is the best for certain types of groups based on their current needs. Although the cloud-based platform seems to be more beneficial compared to its weaknesses, we must be very cautious on the user agreement and policies provided in order to reduce any extra charges fined by the cloud-based companies. This section will mostly be explained based on users' overall views and does not depend on any of our personal thoughts.

Starting from Microsoft Azure, it is well-known as one of the most user-friendly platforms due to its scalability. Users are allowed to choose any programming languages to start their businesses as they implement the terms "pay for what you used only". This means users are given freedom to pay the service based on what they want to use instead of buying a whole set which is more costly [24]. Microsoft Azure is also an effective platform for starters as it provides low-cost services [24]. Nonetheless, users' information will be well-protected by Azure Security Centre to prevent any unauthorised access. On the other hand, the basic fundamentals of Azure might be very complex for beginners [7]. Thus, they need to hire experts to guide them which would increase their budget for a couple of their starting months. Moreover, the platform is very demanding in terms of hardware [7]. One might need to upgrade their PC in order to utilise their services efficiently.

Moving on to Amazon Elastic Compute Cloud (EC2), it is also as scalable as Microsoft Azure. Since it is based in the United States, the features provided are mostly and specifically for the Americans with other users around the globe are allowed to use limited features [8]. The best thing about using Amazon EC2 is that it is a really convenient cloud-based platform with low cost and high efficiency. However, many users and experts complained about this Amazon service. One of them is Amazon EC2 seems to mine users' data and sell them to third parties [8]. Moreover, the platform is bound to Data Loss Prevention Policies where it compensates the customers with service outages especially when there is data loss occurring [8]. Sometimes there are several users complaining about the monthly or annual bill provided by Amazon [8]. This means that their charges fluctuate massively due to the background features which might seem to be less useful to certain people.

The third cloud-computing platform is Google Cloud. This service has an excellent integration with other Google services and at the same time, the features made are all available across the region which means equality in services [18]. It is also very cost-effective compared to other products due its user-friendly pricing. For starters, especially, they will get a free credit around 300 USD for their project which could be the key factor of

attracting more fresh businesses. Furthermore, it has different storage classes for each necessity which can increase the hospitality of the platform. Oppositely, Google Cloud is very limited in terms of the programming languages and has a very complex pricing scheme [18]. Nonetheless, the users may find it costly in terms of downloading the data from the cloud.

Throughout the analysis of all three cloud-computing services, we have decided to choose Microsoft Azure for software development purposes. This is because Azure provides a more formal, secure and yet convenient environment for everyone to work with. During the pandemic COVID-19 where everyone needs to practise social distancing, Azure allows remote features which grant no loss or risk by working from home. Although the other cloud-service providers have their own specific features, Azure serves a lower pricing compared to Amazon EC2. Other than that, we will also be given the opportunity to work with Artificial Intelligence (AI) [20] which could prove to ease our burden. In terms of safety, we would not be worried to work since we are glad that our data and information are well-protected. The most interesting part is Azure wills to fund the project with 200USD free credit in the first 30 days trials whether or not our software development will be fully functional. Hence, we believe that the risk working on this platform will be as minimal as possible as it provides some custom-made solutions of basic projects for references.

4 Conclusion

In sum, cloud computing contributes a lot of benefits to users due to its myriad of advantages. The use of cloud computing has eased the community, benefitted the schools, and helped many businesses to grow and sustain. In light of the Covid-19 pandemic, the world has switched to using cloud computing. Not to deny the fact that cloud computing has played an important part in allowing companies and schools to continue to function properly by enabling them to complete the given tasks at remote places due to the stay-at-home orders [9]. With the service available in cloud technology, users no longer have to worry about the costs, security, privacy, inconvenience, and maintenance. These are the reasons why cloud computing is the new buzz in the market and getting recognition as a digital transformation engine. Recently, the most significant and increasing popularity in cloud computing is customer relationship management (CRM). Cloud-based CRM enables companies to engage with their customers and provide excellent customer service which may result in boosting the companies' revenues [26]. In the future, cloud technology will continue to develop, accelerate, and improve so that it is able to cater the needs of the community. Competition between cloud service providers will also become even more intense as they have to compete to be the top in the cloud industry.

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