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Cloud Systems and Applications : A Review

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ABSTRACT

Cloud computing has become a buzz word over the last decade. It has continued to attract businesses due to its on-demand service, applications and cost-effectiveness. There exist different Cloud Computing service providers today with inherent ambiguity of services and billing structure. To overhaul these ambiguities, in this paper, we discussed an overview of cloud computing, evaluated and diagrammatically stratified the Cloud Computing stack with their examples and their common elements. Further, the biggest Cloud Computing service providers are Amazon Web Services (AWS), Google App Engine and Microsoft Azure. We selected the service providers to analyse critically, compare and contrast their services, billing, performance and functionalities.

Keywords: Cloud Computing, Service Provider, Cloud Computing Stack, Cloud Platform

I. INTRODUCTION

The concept of Cloud computing is a paradigm swing from the on-premise computing practice and utilization of resources to a pool of virtualized realm of computing services. The concept leverages on the pervasiveness of the internet to offer utility computing and flexible consumerization of resources such as: applications, hardware, network and storage. Further, the computing concept comprises a stack of service models namely: Software-as-a-Service, Platform-as-a-Service and Infrastructure-as-a-Service. Service providers can deploy cloud computing in private, public, community and hybrid domain. The private service deployment models are exclusively for an organization managed by third parties or the organization itself. Organizations restrict resources in this model.

Conversely, the public service deployment model is more popular because it extends resources outside the organization. Furthermore, community service deployment models entail joint construct of cloud computing by two or more organizations with similar service offerings. The community deployment model involves sharing of resources, policies and benefits amongst partner organizations. Furthermore, Hybrid service deployment models is a combination of different cloud deployment models. This can include private, public or community deployment models.

Furthermore, the characteristics of the cloud computing stack include on-demand self-service, broad network, resource pooling, rapid elasticity and measured services, which makes it attractive to consumers. As Cloud computing is a new concept with wealth of applications, researchers and businesses have different views on its adoption. According to Tak et al. (2011), the concept is only suitable for small and growth hampered company. However, investments in cloud computing will worth $150 billion by 2014 (Gartner Research (no date) cited by Martson et al 2010). Further, according to another research, Cloud compuitng will take over 24% of the IT market by 2020 (Dempsey and Kelliher 2018). To prove these predictions, technologies such as blockchain applications which has become popular in recent times utilizes cloud computing concept. A recent research by Yaqoob et al. (2021), predicted that blockchain adoption will lead to cost savings of 100-150 billion per year across industries due to protection against data breach in the cloud. These predictions mean Cloud computing is a promising paradigm for businesses. Hence it is important to bring to the fur an overview of this computing paradigm. The next section evaluates the Cloud computing stack. Section III we examined examples of the cloud computing stack. Section IV critically analyzed the three biggest cloud computing platforms and section VI presents a conclusion of this research.

II. EVALUATION OF CLOUD COMPUTING STACK (SaaS, PaaS and IaaS)

Cloud computing offers the opportunity to render information technology services to users in a flexible manner. It also proffers economic consumption of applications, data management and infrastructure. Cloud computing consists of a stack of service models such as SaaS, PaaS and IaaS. Layered on PaaS is SaaS and PaaS on IaaS. Figure 1 shows the CC stack. The definition of the different components of the stacks is as follows (Godse and Mulik 2009):

Software-as-a-Service (SaaS)

SaaS is "the capability provided to the consumer is to use the provider's applications running on a cloud infrastructure (Godse and Mulik 2009)." The evolution of SaaS has made companies focus on business aspect of organizations instead of worrying about the technological aspect, which supports the business. Although SaaS has experienced increased adoption over the last decade but service interrupt and ineffective SLA continue to be the problem of this service model. In 2014, Gartner affirmed that 60% of the companies, which adopted SaaS, experienced service interruptions (Araujo et al. 2014). However, SaaS continue to receive attraction as CIOs see the concept of SaaS as a profitable paradigm. In fact, Gartner predicted that 30% enterprise resource planning application will be deployed on SaaS platform by 2016 (Araujo et al. 2014). Also, the SaaS business is increasing by 50% each year (Choudgar 2007 cited by Tan et al. 2013). From the foregoing, SaaS is a paradigm that will continue to attract companies.

Platform-as-a-Service (PaaS)

PaaS is "the capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider (Godse and Mulik 2009)."

The PaaS does not have a consensus for evaluation this is the reason for variations of evaluations of PaaS. One of such research is the evaluation of High-Computing Power of PaaS using Microsoft Azure and Amazon EC2 as a benchmark (Roloff et al. 2012). These researchers concluded that there is no perfect PaaS model as they both complement each other in terms of efficiency, cost and performance. According to some researchers, PaaS was researched by deploying existing application to the cloud using Amazon EC2 as a benchmark. The research

confirmed that PaaS is a cost-effective way of leveraging computing resources (Delman et al. no date cited by Roloff et al. 2012). The study further states that many computer clusters are idle because they are not utilized and they quickly degrade hence the PaaS concept helped to eliminate these problems as PaaS vendor take the responsibility of upgrading the infrastructure. These results show that adoption of PaaS will help companies to convert capital expenditure to operational expenditure therefore saving money for companies and to also focus on operational and business aspect of the company.

Infrastructure-as-a-Service (IaaS)

According to Godse and Mulik (2009), IaaS "is the capability provided to consumers to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications" IaaS does not have a "one size fit all" benchmark to evaluating the infrastructure. There exist several criteria to evaluating IaaS one of such the novel work of Lee et al. (2010), which evaluated the CPU and storage capability of different PaaS. Whereas, Lenk et al. (2011) postulated that there is no particular standard to measure the performance of PaaS and that the available standards are insufficient to measure PaaS performance. They also said although the price of different PaaS services differs, the standard of measurement of the performance of PaaS is still subject for further research.

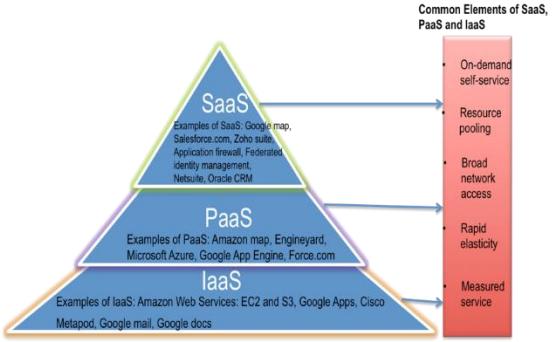

Fig 1. Stack of Cloud Computing paradigms with Examples and their Common Elements.

III. EXAMINING EXAMPLES OF THE CLOUD COMPUTING STACK

Some examples of the Cloud computing stack in Figure 1 have dual functionality. For example, Microsoft Azure renders PaaS services to developers to build applications in different programming languages without dealing with the infrastructure management. Whereas, on the IaaS side, Microsoft Azure provides virtual machines, where consumers can install software such as operating systems as well as management of the underlying infrastructure of the virtual machine. Preconfigured Azure virtual machines make it easy to deploy. Consumers can also configure the virtual machine to suit their requirements. Microsoft Azure in some cases deliver services outside PaaS and IaaS platforms resulting to SaaS offering. Example of such Microsoft offering is the office 365 which is an embodiment of OneDrive, PowerPoint, word, excel etc. further, Amazon offers AWS, EC2/S3, Elastic Beanstalk as SaaS, IaaS and PaaS respectively.

IV. CRITICAL ANALYSIS OF THE THREE CLOUD PLATFORM

In the beginning, there were physical machines, which were expensive and were also loaded with multiple applications to save costs. This caused no end of conflicts, unexpected bugs, and low utilization of machines until the advent of Cloud computing. AWS, Microsoft Azure and Google Cloud Platforms are the biggest competitors in Cloud computing practices (Zahariev 2009). The following describe the capabilities, functionalities and deficiencies of the cloud platforms:

Amazon Web Services (AWS)

Amazon was no exception to the above challenges; scaling and agility was key to their DevOps practices to effectively serve their growing customer base.

AWS is an IaaS which comprises of Elastic Compute Cloud (EC2) and Simple Storage Service (S3). Other services include Dynamo, Queuing services, CloudFront and database management system called SimpleDB. AWS on-demand characteristic and its cheap price attracted more customers making AWS the leading IaaS provider. Jeff Bezos met with AWS executives in 2003. The leaders identified the core strengths of the company. The outcome of the meeting resulted to the development of Amazon's robust infrastructure services, which gave the company a competitive edge (Brandt 2011). In 2006, AWS commissioned this platform. AWS released Simple Storage Service (S3), Elastic Compute Cloud (EC2) and Simple Queue Service (SQS) after the commission.

AWS as a pioneer of Cloud computing continues to expand the breadth and depth of their cloud offerings and data center footprints. Before competition became fierce, they have combined learning from failures and customer feedbacks to build an enterprise-friendly service pool, which appeals to customers. In addition, AWS ranks high in security and reliability, ease of platform configuration, and they have a large ecosystem of partners and developers that have built third-party applications to form the AWS Marketplace. AWS can support large organizations and covers more regions. The flexibility of AWS allows organizations to mix-and-match services that best suit their architectural designs. This is the main reason TfL (Transport for London) chose AWS (over Azure) to power its Journey Planner platform. AWS weaknesses are in the areas of hybrid cloud (Chabanon and Tysons 2013). More so, the scale of AWS product suite and services is enormous. While this feature may be good for sales and marketing, it can be overwhelmingly difficult to navigate the entire product suite. AWS does have some opportunities to make the portal easier to navigate, especially for beginners.

Microsoft Azure

Microsoft has a long and successful history of on-premise deployment compared to AWS and Google. Azure, therefore, seamlessly integrates with on-premise systems such as Active Directory, Windows Server, IIS and System Center.

Furthermore, of all three vendors, Microsoft Azure's core strength is in the area of its IaaS offerings, especially in private and hybrid cloud; this is due to Microsoft 's pre-existing footprints in .Net and operating systems technology stack. A recent study suggests that Microsoft Azure is a leader in Cloud IaaS (Copeland et al. 2015). People perceived Microsoft Azure to be an anti-open source platform. This perception is changing as Microsoft is heavily investing in the open source technology stack. For this reason, most companies that use open source technologies tend to go for AWS or Google Cloud Platform. Microsoft has contributed immensely to the open source community in attempt to change people's mindset with regards to its history of Microsoft centric applications. Azure supports Ruby on Rails, Java, Python, .Net core (which has been open sourced) running on Linux in its web application platform. It is also reported that Azure has less uptime compared to AWS. Downtime analysis of public IaaS vendors in 2016 by Gorbenko et al. (2012) shows AWS had the least amount of downtime in comparison to major cloud vendors.

Google Cloud Platform

Google App Engine is a PaaS. In 2008, Google commissioned this platform. The structure depends on a sandbox. Google Cloud platform is competitively priced compared to AWS and Microsoft Azure.

Further, Google has an excellent record of cloud-centric innovations - this makes it attractive for trending organizations, because of its portability and open source community. This platform also offers more flexible contracts and discounts. Again, It's AI

platform, called TensorFlow is also gaining popularity. TensorFlow powers some Google Home devices. However, while Google Cloud Platform appears attractive to small and medium-sized companies, the platform is struggling to win over big enterprises as it has fewer services, fewer data centers and its late entrance into the market. This is due to Google's legacy strategy of carving out a small niche within the enterprise, rather than becoming a de-facto long-term partner for all things cloud in the enterprise. Google App Engine often encounter failures due to exceeded quota, offline slave applications, or loss of connectivity (Prodan et al. 2012). Google Cloud Platform has the smallest datacenter of all the big three vendors. This makes it less attractive to organizations outside of the EU and US.

V. SIMILARITIES AND DIFFERENCES BETWEEN THE THREE CLOUD PLATFORMS

AWS, Microsoft Azure and Google Cloud Platform offer similar capabilities and features around serverless computing, networking, IoT, Machine learning, Docker containers and storage. Again, they all share a common norm of auto-scaling, security, identity management, compliance and analytics features. For example, Microsoft Azure provides HDInsight, AWS provides a similar service called Elastic Map Reduce, and Google offers Dataproc. The similarities and differences between the cloud platforms are in the table below. Due to the similarities in these three vendor offerings, selecting one over the other depends on the use cases, and most times, existing legacy technology stack of customers. Most organizations are also adopting a multi-cloud strategy to blend the pros from two or more cloud vendors. Google Cloud Platform tends to have an advantage in storage and network performance, while Amazon Web Services has an advantage in cloud features and points of presence around the globe (Kaufmann and Dolan 2015).

The following further compares the most dominant vendors:

Pricing

Google cloud platform is the simplest among AWS and MS Azure. Google subscribers pay for on-demand service every month with minimum time of 10 minutes. The more you subscribe the more discounts you get. On the contrary, AWS offers a variety of pricing and payment options. AWS rounds off on-demand pricing to the nearest hour. Another option is the reserved instance where customers have to pay for VM instance for a period of one or three years. AWS gives discount based on upfront payment. However, Microsoft Azure offers per minute billing as well as contractual pricing on a long-term basis. Services can be prepaid or on monthly basis (Sysfor Technologies 2014).

Scalability

Google cloud platform allows users to scale up and down with fluctuating prices. Users can scale down and pay less and can also scale up and pay more. Again, Google instances are not restricted to regions. AWS have fixed price for per VM instance utilized. Conversely, Microsoft Azure is similar to Google cloud platforms, allows for scaling in/out helping consumers to save money.

Storage and Coverage

On the average, AWS and Microsoft Azure tend to have more coverage in terms of regions than Google Cloud Platform. AWS promises more availability compared to Google Cloud Platform and Microsoft Azure. Table 1 summarizes object store, Storage costs, egress costs, availability and the regions for data center for AWS, Microsoft azure and Google cloud regions.

Block Storage

Amazon offers block storage between 4GB to 16GB whereas, with a maximum throughput of 320 MB/s per volume whereas, Microsoft azure offers 1GB to 1TB with maximum throughput of 60MB/s throughput per disk. Google offers 1GB to 64TB with maximum throughput for 180MB/s for writing and 120MB/s for reading.

TABLE I. COMPARISM OF THE THREE CLOUD PLATFORMS

Functionalities	**Amazon AWS**	**Microsoft Azure**	**Google App Engine**
Scalability	Auto scaling	Auto scale	Auto scaler
Backup options	Amazon glacier	Azure backup	Google cloud storage
Disaster recovery planning	None	Azure site recovery	None
Object storage	Amazon S3	Tables, blobs, queues, files	Cloud storage
Database options	Amazon redshit relational database service	Azure SQL database	Cloud spanner
NoSQL options	Amazon DynamoDB	Azure DocumentDB	Cloud Bigtable and cloud datastore
Administration and security	AWS directory services AWS identity and access management	Azure active directory	Cloud Identity and Access Management
Multifactor-authentication	AWS multifactor authentication	Azure multifactor authentication	Cloud identity-aware proxy Security key enforcement
Search services	Amazon cloud search	Azure search	None
Email services	Amazon simple email services	None	None

Notifications	Amazon simple notification service	Azure notification hub	None
Pricing	Varies	Varies	Flexible and easier to follow
Network	AWS Elastic load balancing	Azure load balancer	Cloud load balancing

VI. CONCLUSION

Cloud computing is beginning to receive popularity but has inherent complexities making the computing paradigm difficult to measure, compare, and contrast performances. Also, the advent of different providers raised different services and billing schemes. The aforementioned challenges often times, make adopters confused about the choice of platforms to adopt. To overhaul these challenges, in this paper, we gave details of the components that make up the Cloud computing stack, their common characteristics and examples were also defined and evaluated. Furthermore, we identified the three big Cloud computing providers, compared and their differences were also pointed out. Cloud computing is still developing and has no consensus on evaluation technique. Hence industry professionals and academia should encourage research to proffer a common evaluation framework for cloud computing. except for short minor words as listed in Section III-B.

VII. REFERENCES

[1]. Araujo, V. M., Vázquez, J. A., & Cota, M. P. (2014). A framework for the evaluation of SaaS impact. arXiv preprint arXiv:1406.2822.

[2]. Brandt, R.L., 2011. One click: Jeff Bezos and the rise of Amazon. com. Penguin.

[3]. Chabanon, D. (2013). How capacity issues in large urban commuter networks in Europe are addressed by implementing modern train control systems. In 2013 Rail ConferenceAmerican Public Transportation Association.

[4]. Dempsey, D., & Kelliher, F. (2018). Cloud Computing: The Emergence of the 5th Utility. In Industry Trends in Cloud Computing (pp. 29-43). Palgrave Macmillan, Cham.

[5]. Godse, M. and Mulik, S., 2009, September. An approach for selecting software-as-a-service (SaaS) product. In Cloud Computing, 2009. CLOUD'09. IEEE International Conference on (pp. 155-158). IEEE.

[6]. Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J. and Ghalsasi, A., 2011. Cloud computing—The business perspective☆. Decision Support Systems, 51, pp.176-189.

[7]. Roloff, E., Birck, F., Diener, M., Carissimi, A., & Navaux, P. O. (2012, June). Evaluating high performance computing on the windows azure platform. In 2012 IEEE Fifth International Conference on Cloud Computing (pp. 803-810). IEEE.

[8]. Sikeridis, D., Papapanagiotou, I., Rimal, B.P. and Devetsikiotis, M., 2017. A

Comparative Taxonomy and Survey of Public Cloud Infrastructure Vendors. arXiv preprint arXiv:1710.01476.

[9]. Tak, B.C., Urgaonkar, B. and Sivasubramaniam, A., 2011, June. To Move or Not to Move: The Economics of Cloud Computing. In HotCloud.

[10]. Tan, C., Liu, K. and Sun, L., 2013. A design of evaluation method for SaaS in cloud computing. Journal of Industrial Engineering and Management, 6(1), p.50.

[11]. Lee, V. W., Kim, C., Chhugani, J., Deisher, M., Kim, D., Nguyen, A. D., ... & Dubey, P. (2010, June). Debunking the 100X GPU vs. CPU myth: an evaluation of throughput computing on CPU and GPU. In Proceedings of the 37th annual international symposium on Computer architecture (pp. 451-460).

[12]. Lenk, A., Klems, M., Nimis, J., Tai, S., & Sandholm, T. (2009, May). What's inside the Cloud? An architectural map of the Cloud landscape. In Proceedings of the 2009 ICSE Workshop on Software Engineering Challenges of Cloud Computing (pp. 23-31). IEEE Computer Society.

[13]. Prodan, R., Sperk, M., & Ostermann, S. (2012). Evaluating High-Performance Computing on Google App Engine. IEEE Software, 29(2).

[14]. Gorbenko, A., Kharchenko, V., Mamutov, S., Tarasyuk, O. and Romanovsky, A., 2012, May. Exploring uncertainty of delays as a factor in end-to-end cloud response time. In Dependable Computing Conference (EDCC), 2012 Ninth European (pp. 185-190). IEEE.

[15]. Copeland, M., Soh, J., Puca, A., Manning, M. and Gollob, D., 2015. Microsoft azure and cloud computing. In Microsoft Azure (pp. 3-26). Apress, Berkeley, CA.

[16]. Yaqoob, I., Salah, K., Jayaraman, R., & Al-Hammadi, Y. (2021). Blockchain for healthcare data management: Opportunities, challenges, and future recommendations. Neural Computing and Applications, 1-16.

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