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Faculty of Engineering & Computing Sciences, Teerthanker Mahaveer University, Moradabad, India

Cloud Computing: Comparison and Analysis of Cloud Service Providers—AWS, Microsoft and Google

Dr. Manish Saraswat[1] and Dr. R.C. Tripathi[2]

[1]*Department of MCA, Geetanjali Institute of Technical Studies, Udaipur, Rajasthan-India*
[2]*Faculty of Engineering & Computing Sciences, Teerthanker Mahaveer University (TMU), Moradabad, UP-India*
E-mail: [1]manishsaraswat24@gmail.com, [2]rctripathig@gmail.com

Abstract—**The cloud computing refers to network that enables to distribute processing, application, storage capabilities among many remote located computer systems. In cloud computing platform the IT resources are utilized and released as per the requirement by using internet. It is a better option to organizations and ordinary users to utilize services (IaaS,PaaS ,SaaS,DaaS etc) as provided by cloud service providers and need pay as use. Currently a large number of service providers in market and due to diversity of features and services, it very difficult to find suitable provider for s for long term needs. As per market share top three providers are Amazon, Microsoft and Google. In this paper we will analysis some of the tools such as compute, storage space management and performance offered by AWS, Azure and GCP which are the top three market leaders in cloud computing technology. In this paper, we will summarize and compare the features of AWS, Azure & GCP to provide help to organizations and users to choose the suitable features which will fulfill the long term requirements of the users.**
Keywords: Cloud Computing, CSP, AWS, MS Azure, GCP, cloud computing platform, IaaS,PaaS, SaaS and, DaaS

I. Introduction

In current era almost all organizations are need computerization, it is not possible to make large investment in infrastructure, IT resources (powerful network, server, software and memory) and IT staff to manage them. Cloud computing is provides an Internet based platform to collect, utilize and manage computer resources automatically [1]. The cloud computing is providing a large number of services to users and organizations through it's equipped data centres with tightly coupled resources and available resources can be dynamically provisioned to end users to fulfill their needs. The users or organization can consume all the available computation resources from large pool without thinking the resource limitations, source and scalability of cloud resources. Thus the users and organization has complete relief from initial investment to use cloud resources, and they have to payonly for the services to which they have used [1, 2, 3].

During the last few years' tremendous growth have been seen in field of cloud computing, according to gartner[12] public cloud is expected $411 million till end of 2020. As more and more organizations are eternalized towards cloud services, it is becoming difficult to select appropriate service provider among a large pool of CSPs for long terms of suitability. Now a day a large number of cloud providers have been emerges, but there no universal standard and development of these providers in parallel directions many providers focusing on computational capability and provide CPU, storage, Database and networking services to end users. Some of the services providers focus in reducing the cost of the service, while others focus on un- interrupted service delivery and scalability factor for service delivery. These diversified dimensions have made it very difficult to choose a suitable service provider based on the requirements of the individual user or organization. This paper presents a comparative feature study of top three cloud service providers-AWS, MS Azure & Google's cloud computing platform to resolve the above dimensions. The next section in this paper will explain the fundamentals of cloud computing and cloud computing architecture [4, 9, 13].

II. Fundamentals of Clou Computing Architecture

The cloud computing is gaining attention and popularity within computing industry. The Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources which is rapidly provisioned and released with minimal effort's. This is the definition of cloud computing as per the National Institute of Standards and Technology (NIST) taxonomy. There are five essential characteristics, three service models, and four deployment models in the cloud computing platform provided by AWS, MS Azure and GCP. All these are mentioned in the following table no-1:

TABLE 1: NIST BASED CLOUD MODELS AND CHARACTERISTICS [1,2,3,9]

Service Models		
SaaS	**PaaS Build with:**	**IaaS**
Use: It is a licensed Software on Demand Used by: End Users Services: E-Mail, Google Doc, Finance, Games, Virtual Desktop, CRM, Communication-Face book	This software can be develop and deployed, Users: Application Developers Services: Execution, Messaging, App Development, Integration, Database-MySQL, Oracle, Web Server- Tomcat development tools, RedHat	Use: It is collection Computer Resources & Network's Users: Infra and Network architect Services: VMs, Storage, Servers, Networking, Load Balancers, System Management

Deployment Models			
Public	**Private**	**Hybrid**	**Commun**
Open for General Public and Large Industrial group : system and services are easily accessible to general public on demand	Open for licensed users, single organization: services & accessibility of cloud infrastructure is exclusively available within organization or owned persons	Open for general public & licensed users	ity Open for communit y users that have shared concerns (mission, security, policy etc.)

ESSENTIAL CHARACTERISTICS OF CLOUD COMPUTING
a) ON DEMAND SELF SERVICE: This characteristic can be explained as providing computer related services, such as E-mail, Applications software, Network for Server etc. It is provided by AWS, IBM, Saleforce.com, MS Azure etc. on demand without interaction with each service provider.
(b) BROAD NETWORK ACCESS: In this all cloud capabilities are provided available over the network. It can be accessed by using dedicated broad band network and by using the heterogeneous client's devices such as mobile phones, laptop's and desk top computers.
(c) RESOURCE POOLING: In this method the resources of all the service providers are pooled together to serve the multiple customers having different physical and virtual resources. In this setup the customer generally has no control or knowledge over the exact location of the provided resources. The customer may be able to specify location at a higher level of abstraction; It includes resources like storage, processing, memory, and network bandwidth.
(D) RAPID ELASTICITY: In this capabilities are provided to users in elastic manner and with provision of grab and released. The dynamic allocation helps to scale rapidly outward and inward bound data with demand.
(E) MEASURED SERVICE: In this method the service provider and user can monitor, control, and measure all the resources to which they are sharing. For example: storage, processing, bandwidth, and active user account at a particular time can be monitored.

There are several concepts, technologies, characteristics which combine together to make the cloud computing flexible and convenient for the user's. We will discuss some of the important computing technologies in the section below:

- **Utility Computing:** It is the fundamental concept where computing resources like storage, network, CPU etc. are provided to end users as utility service.
- **Service Oriented Architecture:** Here data centers in cloud provide resources as web services (software, infra, platform) and heterogeneous system incorporate each other.
- **Scalability:** The term scalability means ability to expand without limitations. This feature provides large scale of solutions in cloud computing; for example Amazon, Google, and Microsoft etc. have hundred thousands of servers in worldwide. The service providers can extend the nodes and servers to meet the growing demands of software & infrastructure for the world- wide users.
- **Reliability:** The cloud uses multiple redundant computational nodes which ensure high guaranteed availability of services this make the cloud more reliable than local computers.
- **Versatility:** This characteristic ensures that cloud computing is not aim for certain specific applications. A lot of applications can be run and supported by cloud in parallel.
- **Virtualization** This enable's execution of multiple user's requests on single physical platform. The cloud uses hypervisor software which virtually isolates the physical resources from the users by using virtual machine instance.
- **Autonomic computing** This ensure self management of cloud systems by allowing automation in various tasks such as resource provisioning, capacity management, service measurement and disaster management etc.
- **Maintainability** The maintenance of resources is responsibility of service providers so it is easy to maintain in minimum cost [3, 10,11].

III. LITERATURE REVIEW

Zhong et al.[5] studied features of major cloud service providers' i.e AWS, Google, and Microsoft and concluded that existing service providers offering diversified features therefore end users force to use more than one service provider for business. *Noman Islam et al.[8]* presented a comparative study on various service providers and concluded that there are two directions of providers, one focusing on reliability of service and another focusing on cost reduction. Privacy and security issues are totally ignored. *Buggya et al.[6]* compared the features of AWS, GCP, Microsoft live mesh, sunnetwork.com and found service providers features are not comply with market needs and suggested more research is required to introduce new models. *Hofer et al.[7]* conducted a study on AWS, GCP, and Microsoft and concluded that interoperability is major issue it must be address.

IV. MAJOR CLOUD SERVICE PROVIDERS

In present time's a lot of cloud vendors are there in the market. Some of popular vendors are mentioned below:

a. Amazon Web Service (AWS): It was launched in year 2006.
b. Microsoft Azure: It was launched in year 2010.
c. Google Compute Engine: It was launched in year 2008.
d. Sale force: It was launched in year 2012.
e. Alibaba: It was launched in year 2009.
f. Rackspace: It was launched in year 2008.
g. IBM It was launched in year 2011
h. Oracle: It was launched in year 2012, & many more…

In this paper our focus is only on the products and characteristics of top three vendors; such as, Amazon, Google and Microsoft that are proving extensive cloud services. The information about products, features of these vendors have been collected from provider's website.

A. Amazon Web Service (AWS)

The Amazon is one of the pioneer and oldest cloud service providing company, which has started its cloud based services in year 2006. It has allowed cloud users to perform and manage the server's instances on data centers from its inception. It is the one of top CSPs in IaaS (market share: 47.8%) and PaaS (market share: 34%) till the end of 2019. It is offering cloud based storage, computation and others functionalities which can be accessed by cloud users to set up applications and services on demand through the REST and SOAP protocol over the HTTP [4,5,19].

B. Microsoft Azure

The Microsoft is a pioneer company to provide cloud services and holding top place in SaaS (17% of market Share) and second in PaaS and IaaS where it sharing approximate 15.5% market till the end of 2019. The Microsoft Azure, allows clients to use the cloud services purely on the cloud, or on combination of any existing applications, data centre or infrastructure. It is an ideal vendor for hybrid cloud combination model. The MS Azure uses following three principles to provide the cloud services

- Windows based environment that is used to run applications and store at data-centers
- SQL-Azure offers data services based on SQL server & (iii).Net services which provides the distributed services as infrastructure for local as well as cloud based applications. [7,8,15]

TABLE 2: RANK OF MAJOR CLOUD VENDORS

Criteria	Rank-1	Rank-2	Rank-3
Entered in Market	AWS	GCP	AZURE
Availability Zones	AWS	AZURE	GCP
Market Share	AWS	AZURE	GCP
Growth Rate	GCP	AZURE	AWS

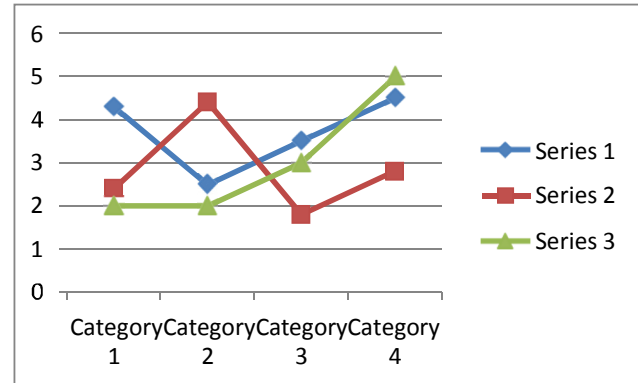|			
Number of services	AWS	AZURE	GCP
Numbers of Data Centers	AWS	AZURE	GCP
Integration tools on-premise service	AZURE	AWS	GCP

Fig. 1: Performance Chart of all the Cloud Vendors

The Fig 1 explains the comparative performance chart of all the cloud technology vendors. The above analysis shows that MS Azure is the best among all the cloud computing service providers in present time.

C. Google Cloud Platform (GCP)

The Google is one of the fastest growing company in IaaS and PaaS with growth rate of 60.2% and 57.9% respectively till end of 2019. It joined the cloud market in year 2008 by simply providing E-mail, Calendars, online documentation. GCP is the goggle's hosting service for web application, it uses pre-defined runtime environment for development and deployment of cloud based applications by applying java and Python. The primary drivers behind the GCP popularity are its scalability, user's based infrastructure and payment. The comparison of various criteria's among AWS, Azure and GCP is tabulated as [10,17]:

V. METHODOLOGY

Before moving on cloud the customer must analyze and review several points like objective to moving on cloud, ideal deployment and service model because each model has different level of controls, offerings, need of application migration on cloud, security and cost management. There are a lot of parameters which must be understood by customers to choose right service providers to fulfill their needs. The parameters are:

- infrastructure & computing services
- network technologies services
- storage technologies
- data base support
- back-up services
- key tools. On the basis of stated parameters,

The cloud service providing companies such as Amazon, Microsoft and Goggle are providing various products which are tabulated below [8,10],:

TABLE: 3 SUMMERY OF TECHNICAL PARAMETERS OF AWS, AZURE AND GCP[6,812,14]

Parameter	Amazon Web Service	Microsoft Azure	Google Cloud Platform
Infrastructure (IaaS) collection of hardware/ software elements/ interf ace to enable/access cloud computing services/ virtualized resources.	Amazon- EC2(Xen virtualization Engine	Microsoft common language run time(CLR) (Hypervisor-V)	Google Cloud Platform (GCP)
Computing Services (PaaS) : Provide the IT as service over the internet or	AWS Beanstalk, Amazon Lightsail, AWS Batch, AWS	Platform-as-a- service(PaaS) Function-as-a- service(FaaS) Service Fabric Azure Batch	Google App Engine; Graphic processing unit; Docker Container;
network with delivery on demand and price as –use.	Fargate,		Compute Engine; &
Network Technologies: It allow to access the network infra- structure directly and securely.	Amazon allows VPC services; Amazon Route 53 services, The Cloud Front service, & AWS-Direct Connection.	It provides branch cache, direct access for services, It helps in core Network Guide framing, DNS Service, and load balancing	Cloud Interconnect, Cloud VPN, Carrier Peering, and Direct Peering
Storage technologies : maintain and manage the data and makes the accessible on network on demand)	Following services of Amazon can be availed such as simple storage service, Amazon Glacier, Amazon Elastic Block Store, & Amazon Elastic file System.	Azure It allows scalable object store It can store text and binary data. Azure Files: It manages file's for cloud for on- premises deployments. Azure Queues: A messaging	Data Store, Blob store Google cloud, SQL
Relational Data Base Support: allow to users to access the database without installing software/setting- up environment	Amazon- RDS, SQL, MySQL and Oracle	Azure SQL, Azure-SQL- DW	Cloud-SQL, Cloud- Spanner
Back-Up Services: restore/backup of data or application remotely or online.	Glacier	Archival storage, Recovery backups, Site recovery	Near-line, Cold-line are frequently used to access data
Key Tools: for AI/IOT/ serverless	AI/ML:, Machine Learning, Translate, Deep Lens, Deep Learning, Apache IoT: Core, Free RTOS, Device Defender, IoT Device Management. Serverless: AWS-Examples are	AI/ML: Machine Learning, Azure Bot Service & many more can be availed IoT: IoT Hub ,IoT Edge, Stream Analytics, Time Series Insights Serverless: This Functions can also be	AI/ML: The Cloud service helps in Machine Learning, Cloud Natural Language, Cloud Speech NLP, The Cloud Translation API, For Cloud Video, Intelligence, & Cloud Job Discovery IoT: Cloud
	Lambda, Serverless Application Repository.	availed here,	IoT Core can be managed Serverless: Cloud Functions are available

Thus we analyzed several parameters of AWS, Azure and GCP which may be useful for cloud users to choose appropriate service provider for their business or organization. Studied parameters are listed as:

TABLE 4: SUMMERY OF GENERAL PARAMETERS OF AWS, AZURE AND GCP[13,17,18,19]

Parameter	Amazon Web Service (AWS)	Microsoft Azure	Google Cloud Platform (GCP)
Type of Service Model	All computing models- IaaS, PaaS,SaaS but major in IaaS a,PaaS	All three computing models- IaaS,PaaS,SaaS but major in SaaS	All three computing models- IaaS,PaaS, SaaS but major in PaaS
Focus	Enterprise Friendly offering s and Public Cloud (off Premise)	Microsoft tools Integration, Open Source and Hybrid Cloud(on/off premise)	Open Source & Portability and Hybrid Cloud (off premise)
Availability Regions & Range of services	66 It is extremely wide	54 It is wide	20 It is just Limited but is expandable
Unique Selling Point of cloud computing: Ability to quickly respond	This provides Tight security system	This Integrated with Microsoft tools	It helps in Top-notch data & analytics tools

Security	Moderate	Moderate	Moderate
Nature of services	It provides Enterprise- centric services	It is Not totally 'enterprise- ready'	It is Designed for cloud- based businesses
Reach	It is an Established global presence	It is Expanding gradually	It is New to the market
Major drawback	It is Difficult to use, options may seem confusing	The Management tooling is inefficient	It has Limited data centers across the world
Price and Payment	Free, Commercial (Pay-as-you-go) ($0.11/Hour- (roundup) Subscription: Hourly/ Monthly	Commercial (Pay-as-you-go),($0.02/Min utes) (roundup-commitment Subscription: Monthly	Free, Commercia l (Pay-as- you-go) ($0.02/Min utes) (Minimum 10 minutes) Subscriptio n: Hourly/Mo nthly.

VI. CONCLUSIONS

The selections of vender depend on business needs and technical requirements of particular company. During the study it is observed certain organizations need a specific cloud service provider while others need the guidance to choose most appropriate vender for business or to provide the services to customers. The conclusions for AWS, Azure and GCP are as given below:

A. AWS

- More Global reach: it has a lot of Data Centers.
- Wider. Stable, Reliable lot of Services: It has large number of products.
- Need a Public solutions
- You are a larger company: Its pricing policies move towards enterprise level companies where need versatile solutions even expensive.

B. AZURE

- Migrating on cloud first time
- Most of Applications/solutions are Microsoft/ Windows based.
- Need a Hybrid deployment Mode/solutions
- You are a Developer

C. GCP

- Focusing on container based model(containers are types of software that can share OS Kernel virtually without
- need of virtual machines)
- Focusing on web based applications
- Flexible pricing You are already digital organization and now moving on to develop & deploy cloud based apps
- and soft wares

Therefore **AWS** is best when you are looking for a platform with broadest reliable and stable services and pricing is not a major challenge when the if business servers are running on windows then **Azure** is best because it offering windows platform integrated services. If you are a start-up and medium-sized company and rapidly scaling up with large volume of user data, innovations and resources then **GCP** is ideal.

REFERECNES

[1] Cloud Computing by A. Srinivasan, Pearson India ISBN: 9789332537439 Cloud Computing: Concepts, Technology & Architecture, Prentice Hall Service Technology Series 1st Edition, and ISBN-10: 9780133387520

[2] Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS),ist Edition, Wiley by J.Kavis, ISBN-10: 1118617614

[3] Eissa Alreshidi, "Comparative Review of Well Known Cloud Service Providers", Sci.Int(Lahore).31(1)B.65- 170,2019,ISSN-1013-5316

[4] Q Zhing,L Cheng," Cloud Computing: State of Art and research challenges",journal of International Services and Applications,Vol-1,issue-1,2010.

[5] R Buyyaa,Yeoa, "Cloud Computing and Emerging IT Platform", Future Generation Computer Systems, vol 25,2009,pp-599-616.

[6] C.N Hofer and Karagiannis,"cloud computing services: Taxonomy and comparison", Journal of Internet services and Applications, Vol-2, 2011, pp-81-94

[7] Noman Islam and Aqueel ur Rahaman,"A Comparative Study of Major Cloud Service providers for Cloud Computing", IEEE 4th International Conference on Computer and Communication Systems (ICCCS); 2019

[8] Cloud Computing Vendor & Service Provider Comparison, Crisp Vender Universe, Research Report-2108

[9] Rajendran and Swamynathan, "Parameters for Comparing cloud service Providers: A Comparative Analysis", DOI: 10.1109/ CESYS.2016.7889826, IEEE Xplore: 30 March 201711.Dutta and DUtta, "Comparative Study of Cloud Services offered by Amazon, Microsoft,and Google, International Journal of Trends in scientific Research and Development(IJTSRD),Vol-3,issue-3, April-2019

[10] Sajay and Suvanam, "A Study of Cloud Computing Environments for High Performance Applications", Proceedings of 2016 International Conference on Data Mining and Advanced Computing (SAPIENCE)-2016.

[11] Almishal and Youssef, "Cloud Service Providers: A Comparative Study, International Journal of Computer Applications & Information Technology Vol. 5, Issue II April May 2014 (ISSN: 2278-7720)

[12] https://www.gartner.com/, Accessed 31 January, 2020

[13] http://cloudcomputing.bestfind.com/, Accessed 11 February, 2020 15.https://www.azure.microsoft.com/Solutions/, accessed 11 February, 2020

[14] 16.https://www.gartner.com/reviews/customers- choice/,accessed 18 February, 2020 [3]

[15] .https://cloud.google.com/gcp/, Accessed 02 March, 2020 18.https:// azure.microsoft.com/en-in/free/cloud- services/,Accessed 06 March, 2020

[16] 19.https://aws.amazon.com/, Accessed 10 March, 2020