

Cloud Computing: Analysis of Top 5 CSPs in SaaS, PaaS and IaaS Platforms

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Abstract—The Cloud computing refers to manipulating, configuring and accessing the applications as utilities over the internet. It involves online data computation, storage, infrastructure and application, and hence it is highly essential to make a smart decision, when and how computing, storage and network resources be distributed and allocated to users to utilize, manage and consume them. In this paper first architecture of cloud computing, characteristics of service models and services provided by CSPs are discussed, then after analyzed growth rate and market share of top five CSPs in cloud service models, i.e Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).
Keywords: cloud computing, cloud models, cloud architecture, cloud services model-IaaS,PaaS,SaaS

I. INTRODUCTION

In long established model of computation inputs and software's are remain totally resident on user's computer while in cloud computing almost no or minimal data or software stored on user's system [1]. The cloud computing is new technology and has a technology connection with parallel computing, Distributed computing, Grid computing and Utility computing [7]. The word 'cloud' refers to a network or internet which allows to create, configure and customize the applications therefore it refer to dispatching of computing, storage, databases, networking, software analytics services through internet[1,2]. This new technology is based on five attributes:

- Multi-tendency:** This attribute ensures resources in business model must be shared at network level as well as application level i.e. varied customers use same resource.
- Scalability:** Indicating capability to scale up to thousands of systems as well as scaling up the bandwidth of various networks and storage space.
- Elasticity:** This attribute ensures users or organizations can quickly add or remove computing resources as per needs.
- Pay as you use:** This attribute ensures users to pay only for resources & time period they have actually used.
- Self provisioning:** Indicates providing or making something available to users so that they can

use additional capabilities of system in terms of processing, software, storage and network.

The logical structure of cloud computing architecture compose of a front and back end. The front end focuses on service delivery, programming required for working of cloud system while the back end focuses on system architecture, particular technology and design that makes the cloud provide better services to multiple customers [1, 3].

II. CLOUD SYSTEM COMPONENT

The concept of Cloud computing was launched in 2006, with the appearance of Amazon's Elastic Computing Cloud (EC2). Generally an open source cloud system has the following components.

A. Hardware and Operating System

The hardware & operating systems are backbone of any physical machine. The OS handles the link between hardware, CPU, memory, network and other devices [2,4]. Some of the popular cloud operating systems are -TRANSOS, HPCLOUD, MIRAGE, MEGAHA etc. Virtualization is a concept, which is popularly used in cloud computing to provide virtual storage, computing and network to the cloud clients. It allows creating a virtual image of something such as server, operating system, storage devices or networking resources so that a large number of users can use virtual images on multiple machines simultaneously.

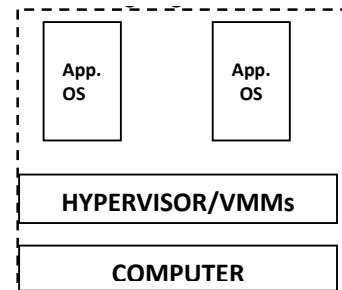


Fig. 1: Virtualization: Multiple OS images share the hardware Resources (CPU, Storage, RAM, Network) managed by Hypervisor/VMM

A hypervisor, also called Virtual Machine Monitor (VMM), consists of a VM management open source software (Xen, KVM, Microsoft Hypervisor-V) to create a virtualization management platform that translates the request received

from VM to the linked hardware component (CPU, memory, hard disk, network), so are VMs created on host hardware using software known as VM or Hypervisor [5, 6]. The concept is explained through figure 1.

B. Network

A cloud network is an important component which contains DNS/DHCP of actual machines and virtual bridge that provides individual virtual-MAC address to one and all virtual machines. It enables remote users to connect with cloud applications (SaaS) and/or cloud infrastructure (IaaS). Network resources may include virtual routers, firewalls and network management software and tools necessary for the cloud environment [2, 4].

C. Disk Image

A disk image is a copy of the entire content of a storage device. In traditional computing there is an exclusive VM on an alone physical machine, however in cloud computing there are several VMs that are integrated on a single disk. Making a full copy of an operating system on a remote disk in a short period of time is impractical because of this cloud computing has source disk images that contain images of entire disks, which can be easily copied to any VM. There are two categories of images - template images & runtime disk images. Template images are those which are stored in disk images and can be used for creating varied VMs while runtime disk images are created at the time of application execution [3, 4].

D. Front-End/Back End

The architecture of cloud computing consists of numerous loosely coupled units, which can be broadly categorized into front and back end. The front end represents the client part of the computing system and it consists of interfaces and applications which are essential to access cloud platforms. Back end refers to the cloud itself and it consists of facilities such as huge data storage, VMs, security mechanisms, deployment models, servers and others [5, 6]. A view of front and back end is provided for easier understanding in figure 2.

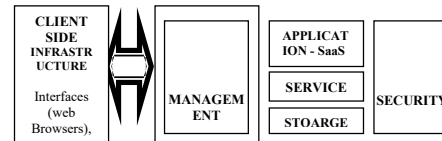


Fig. 2: Front and Back End in Cloud Architecture

III. CLOUD ARCHITECTURE

A. Cloud Models

In cloud computing several services and models are working to provide practicable and convenient solutions to customers [2]. Following two are blueprints of cloud computing [1, 4].

B. Deployment Models

The cloud deployment model shows a distinct type, cloud framework, access, size, focus, security & ownership. There are four categories of cloud: Public, Private, Community and Hybrid, which are summed in table 1.

TABLE 1: DISTINGUISH CHARACTERISTICS OF CLOUD MODELS

Attributes	Public	Private	Community	Hybrid
Scope of Service	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 community users that have shared concerns (mission, security, policy etc.)	Open for general public & licensed users
Owned by	Always Third Party i.e CSPs	Single organization/ lessened users	Several Organizations	Organization and Third Party(CSPs)
Size of Data Centre	~50,000 Server	~5,000 Server	~15000(Depends on number of orgns)	Less than public but more than private
Security	Low: because of its openness i.e E-mail	Very High: because of its private nature	High	Medium
Location	Off-Premise	off or on Premise	off or on Premise	Off and on Premise
Managed by	Only Third Party(CSPs)	Single organization or CSPs	Several Organizations and CSPs	Both(organization and CSPs)
Cost of Implementation	No-Initial Cost	High-Initial Cost	(Depends on number of organizations)	Medium

C. Service Models

The cloud service or delivery models represents a set of pre-packaged union of IT resources provided by cloud service providers [1]. Cloud models come in three types and are listed as below:

- *Infrastructure as a Service (IaaS)*: In this CSPs provide a set of virtualized computing resources (processing, storage, and network). Therefore IaaS offers the access of essential resources alike virtual storage and network.
- *Platform as a Service (PaaS)*: In this CSPs provide the run time environment for applications, development and maintaining couple, i.e system software (OS) and computing resources. The clients can model, design, develop & test applications directly on cloud and control SDLC of products
- *Software as a Service (SaaS)*: In this model CSPs provide the software and cloud infrastructure to run and maintain application software, operating system and computing resources. The clients can run & make use of software's provided by CSPs but have no control on physical infrastructure like operating system, network and storage.

TABLE 2: RELATIONSHIP BETWEEN DEPLOYMENTS AND SERVICE MODELS

Deployments Model	Service Model
Private, Community & Hybrid	Software- as-a Service (SaaS) [Use it-Licensed Software on Demand] Users: End Users Services: E-Mail, Google, Doc, Finance, Games, Virtual Desktop, CRM, Communication-Face book
Public, Community & Hybrid	Platform-as-a Service (PaaS) [Build with It-Software can be develop and deployed] Users: Application Developers Services: Execution, Messaging, App Development, Integration, Database-MySQL, Oracle, Web Server- Tomcat development tools, RedHat
Private, Public,& Community	Infrastructure-as-a Service (IaaS) [Move to It-Computer Resources & Network] Users: Infra and Network architect Services: VMs, Storage, Servers, Networking, Load Balancers, System Management

TABLE 3: GROWTH (%) OF SERVICE MODELS IN 2018–19

Models	Revenue (Billion in US Dollar) in 2018	Revenue (Billion in US Dollar) in 2019	Growth %
SaaS	80.0	94.8	18.5
PaaS	15.6	19.0	21.7
IaaS	30.5	38.9	27.54

Source: <https://www.gartner.com/>

All of service models are growing rapidly in IT industry. Gartner [] conducted a survey on service model and found that although SaaS incurred highest expenditure, IaaS was in highest demand among organizations and recorded a growth rate of 27.54% during 2018-19. Conclusions of Gartner's findings have been tabulated in table 3.

IV. TOP 5 SERVICE PROVIDERS IN IAAS

Now a day's there are many cloud service providers that are providing virtual computing resources over the Internet. Presently approximately 90% of international organizations are using cloud infrastructure. The top 5 service providers in IaaS are:

A. Amazon EC2

Amazon Elastic Compute Cloud (EC2) is one of the most popular Amazon Web Services (AWS) offerings. This service let to developers to demand computational resources from Amazon, later services are delivered via AWS dashboard [20].

B. Microsoft Azure-IaaS

It is also top cloud service provider, its offerings are best ranked services for infrastructure as a service by Newsweek. It has more than 54 data centres and servers worldwide. Azure allows professionals to establish flexible virtual machines with up to 128 virtual CPUs and 6 TB of memory [15].

C. Alibaba

Alibaba Group, has been popular in market share for IaaS and IUS (Infrastructure Utility Services). This has shown a strong presence in Asia Pacific zones mainly Hong Kong, China,, Australia, Malaysia,, India and Japan. It has local servers in Malaysia & Indonesia.

D. Google Compute Engine

The Google Compute Engine is an IaaS solution provider through Google Cloud Platform. In this cloud services are provided by using virtual machines running on Google's worldwide data centre networks. This offers several pre-made configurations such as virtual machines, etc.

E. IBM Cloud

This vendor offers public and private cloud services by using the suite of data analytics and Artificial Intelligence tools. This platform offers more than 170 products and services worldwide including virtual servers. The users can have the choice to deploy IBM servers in their home infrastructure or use a hybrid cloud.

The market share and growth of above CSPs as IaaS during 2018-19 as provided by Gartner is tabulated in table 4 and a corresponding π chart is also provided for clarity.

Table 4: Top 5 CSPs in Infrastructure as a Service (IaaS)

Name of CSPs	Amazon Elastic Compute Cloud (EC2)	Microsoft AzureIaaS	Ali-Baba	Google Compute Engine (GCE)	IBM	Others(Linode, Digital Ocean, RackSpace Open etc)
Market Share (%)	47.8	15.7	7.7	4	1.4	23.2
Growth (%) (2018-19)	26.8	60.9	92	60.2	24.7	11.1

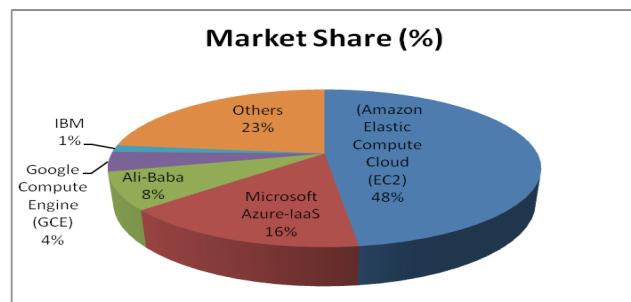
Source: <https://www.gartner.com/>

Fig. 3: Market Sharing of Top-5 CSPs in (IaaS)

V. TOP 5 SERVICE PROVIDERS IN PAAS

The platform as service makes the big difference for developers. It allows developers to focus on code and data. The worlds top 5 PaaS service providers are mentioned below:

A. Amazon Web Services (AWS)

It is one of the top PaaS providers and providing services to enhance computing power, database storage capabilities, and content delivery. As part of subscription AWS offers clouds for PaaS, such as AWS Elastic Bean stalk, AWS Lambda service,.

B. Oracle Cloud Platform (OCP)

The Oracle Corporation was established in 1977 and it is the key player in IT industry. The 'Oracle Cloud Platform is an open source platform and it is very helpful in vice technology and oracle Technology. It allows integration and migration of data in encrypted form by using single platform. It helps programmers to use Oracle autonomous transaction processing database as well as Oracle autonomous data warehouse services. This offers access of Oracle services like Java Cloud, MySQL Cloud, Application Builder Cloud Service etc.

C. Google Cloud Platform (GCP)

It is a provider of computing resources for deploying and operating applications on the web. It provides the platform services with Google App Engine (GAE) and Google Anthos. The GAE uses same infrastructure as used by Google Search Engine (GSE) and supports platform of Java, Python, PHP, Ruby, Node.js,.Net, etc. GCP offers high-quality security solutions for organizations such as firewall, SSL/TLS certificates, Google Cloud SDK, cloud deployment manager etc.

D. Microsoft Azure

MS Azure is provides deployment of provisioned and managed infrastructure services to institutions by using PaaS solution. PaaS includes all the standard features such as, infrastructure, servers, storage, networking, security solutions, and many more. It laos supports many programming languages including virtual labs in current COIVID-19 pandemic times. It supports.NET, Node.js, PHP, Python, Java, Ruby and many more programming languages [9].

E. IBM Cloud Services

IBM cloud offers services to deploy and access resources such as storage networking and compute power. There are several tools which help the customer to gain deep industry expertise. IBM also offers services that are helping home appliances, manufacturers, retailers, and medical supply businesses [13].

The market share and growth of above CSPs as PaaS during 2018-19 is presented in table 5 and a corresponding π chart is also provided for clarity in figure 3.

TABLE 5: TOP 5 CSPs IN PLATFORM AS A SERVICE (PAAS)

Name of CSPs	Amazon Web Service	Microsoft Azure -PaaS	Google Cloud Platform	IBM	Oracle Cloud platform	Others(Sale force, Software-AG, VMware
Market Share (%)	34	15	8	8	5	30
Growth % (2018-19)	23.3	46.7	57.9	19.5	32.6	14.6

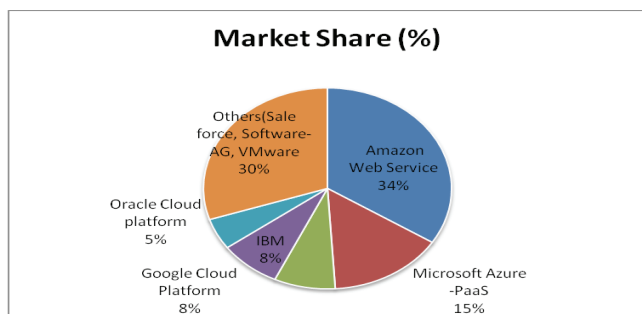
Source: <https://www.gartner.com/>

Fig. 4: Market Sharing of Top-5 CSPs in PaaS

VI. TOP 5 SERVICE PROVIDERS IN SAAS:

Many of cloud service providers giving application software and services i.e CRM, ERP as service to customers through internet. The company products are accessible from a browser and may be B2B or B2C. The Top 5 SaaS companies according to the market share as well as growth rates are listed below.

A. Top 5 Market Share Holder Service Providers in SaaS

- Microsoft:** it is largest SaaS Provider Company and has more than 100 products installed on more than 1 billion devices. It has 630 billion users and company providing services like Office-365, Dynamic CRM, share point collaboration, SQL Server Database to users [8, 9].
- Salesforce.com:** It has almost 58 products in SaaS and has approx 2.5 million users. It is a leader in CRM and provides the help to manage the customer relationships integrate with others systems and build new apps. It has large share of CRM market but getting the challenges from oracle and SAP's new products [8, 19].
- Adobe:** Adobe has more than 50 products and 2.3 million paying subscribers in its board to Creative Cloud. It has focus on image editing, audio, video tools, and web development, and pdf services from any text editor [8, 18].
- SAP:** It has 263,000 customers in 188 counties and about 309 products. It aimed to larger to mid sized business and it suite 'SAP is a complete, integrated suite which can run whole enterprise – financials, human resources module, sales module and supply chain ERP module.
- Oracle:** This serving about 400,000 customers and focusing on sell of engineered systems rather than commodity hardware. The oracle has strong presence for public as well as retail sectors world wide & provides lots of power in marketing CRM, ERP and HCM and other ERP modules [14].

The market share and growth of above CSPs as SaaS during 2018-19 as provided by Gartner is tabulated in table 6 and a corresponding π chart is also provided for clarity

TABLE 6: TOP 5 CSPs IN PLATFORM AS A SERVICE (SAAS)

Name of CSPs	Microsoft	Sales force	Adobe	SAP	Oracle	Others (Google, IBM, C/C, workday etc.)
Market Share (%)	17	12	10	8.3	6	46.7
Growth % (2018-19)	34	21	29	NA	29	NA

Source: <https://www.gartner.com/>

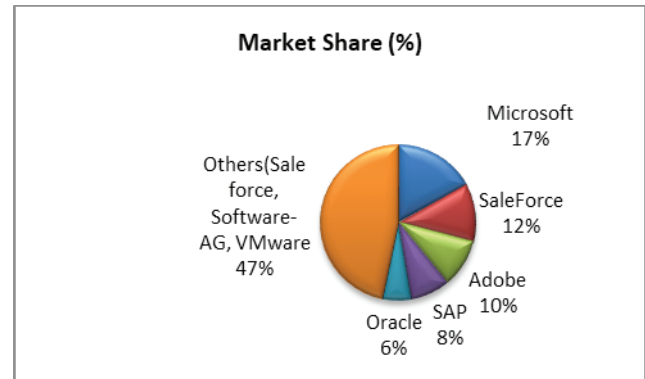


Fig. 6: Sharing of Top-5 CSPs in (SaaS)

B. Top 5 Fastest Growing Companies-SaaS Companies in 2018-19

A special survey conducted by the cloud service provider, Okta [7] has observe the growth rate of SaaS company's products during the past one year of the Yr2018-19). The outcome of this is shown in table below as:

TABLE 8: FASTEST SAAS GROWING COMPANIES IN 2018-19

Company	Focus	Growth %
KnowBe-4	IT Security (phishing, ransom ware attacks)	178
LastPass	Password Management	132
ProofPrint	Cyber Security Company(Protect business data)	122
JamF	Gives very simple IT solutions for Apple devices	120
Zoom	Providing tools for video conferencing	107

Source: www.okta.com

VII. CONCLUSION

The top five CSPs in IaaS,PaaS and SaaS sharing 76.8%,63.4% and 53.3% market respectively. Amazon Web Service (AWS) on top in IaaS(47.8%) as well as in PaaS(34%) while in SaaS Microsoft is on top with 17% market share.

It is also observed that in IaaS, Ali-Baba is fastest growing company with rate of 92% followed by Microsoft-Azure and Google approx 60% growth in 2018-19, while in PaaS Google is fastest growing with approx 58% of rate followed by Microsoft with 47.8%.

In SaaS fastest growth(34%) is noticed in Microsoft followed by Adobe and Oracle about 29% in 2018-19.It also noticed about 47% market now sharing by other than top 5 companies and top 5 whose growth noticed very fast are KnowBe-4(178%), LastPass(132%), ProofPrint(122%) JamF(120%) and Zoom(107%) during 2018-19.

In terms of expenditure SaaS is largest market but the growing rate of IaaS is very fast it seen approximately 27.54 growths in 2018-19.This indicate that IT organizations are more investing in Infrastructure as a Service (IaaS) which is one of the major cloud computing technology.

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