



## A Review of Service Models in Cloud Computing

<sup>1</sup>Muhammed Kuliya, <sup>1</sup>Ahmed Abdulrazaq Bello, <sup>1</sup>Ikenna Chukwuka Onuorah, <sup>1</sup>Khalil Sani Ibrahim, <sup>1</sup>Aisha Adam Bappa, <sup>2</sup>Ahmad Auwal

<sup>1</sup>Department of Computer Science, Federal Polytechnic Bauchi

<sup>2</sup>ICT/MIS Unit, Federal Polytechnic Bauchi

### ABSTRACT

*Cloud computing has emerged as a ubiquitous term resonating across industries worldwide. Contrary to a common misconception that views the cloud as a uniform concept applicable to all, this study endeavors to delve into the diverse and established cloud service models presently prevalent in the market. The exploration encompasses an in-depth analysis of the factors contributing to the widespread adoption of cloud service models in the industry, shedding light on the diverse solutions available. Furthermore, the study delves into the myriad benefits offered by cloud services, emphasizing their significance in the contemporary business landscape. In addition, it critically examines the major issues and challenges that pose obstacles to the seamless functioning of cloud services, providing a comprehensive overview of the landscape. Through this exploration, the aim is to offer a nuanced understanding of the intricacies surrounding cloud computing and its service models, contributing to a more informed discourse on this transformative technology.*

### ARTICLE INFO

Article History

Received: August 2023

Received in revised form: September, 2023

Accepted: October, 2023

Published online: November, 2023

### KEYWORDS

Cloud, Cloud service, Computer, Internet, Technology

### INTRODUCTION

In recent years, the worldwide usage of computers and smartphones to surf the web at homes, and do businesses online has risen significantly. With this growth, businesses need to expand their services to meet the growing demand for quality and affordable services. Cloud computing has taking up the challenge to provide digital businesses their platform to access IT infrastructures on demand. According to Forrester (2017), there will be more than 50% adoption rate of cloud computing services which will in effect change the way businesses compete for clients. This will no doubt bring competition among the prominent cloud service providers in the world such as Amazon, Microsoft, Salesforce, and Google.

Cloud computing offers a value proposition that is different from traditional

enterprise IT environments. By providing a way to exploit technologies such as virtualization, application containers, and serverless computing which aggregate and share computing resources, cloud computing can offer economies of scale that would otherwise be unavailable. With minimal upfront investment, cloud computing enables global reach of services and information through an elastic utility computing environment that supports on-demand scalability. Cloud computing can also offer pre-built solutions and services, backed by the skills necessary to run and maintain them, potentially lowering risk and removing the need for the organization to retain a group of scarce highly-skilled staff (Standards & Council, 2017).

Cloud computing is a style of computing where computing resources are easy to obtain and access, simple to use, cheap, and

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved



just work (Rajan & Shanmugapriyaa, 2012). Cloud computing offers a flexible and powerful computing environment to provide on-demand, subscription-based online services over the Internet to host applications on a pay-as-you-go basis. The various cloud providers such as Microsoft, Google and Amazon make extensive use of Cloud Data Centers (CDCs) to fulfill the requirements (memory, data, compute or network) of the digital world. To reduce the service delay and maintain the Service Level Agreement (SLA), fault tolerance should be provided through replicating the compute abilities redundantly (Gill & Buyya, 2015).

### Definition of Cloud Computing

According to the United States National Institute for Standards and Technology (NIST) "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Miha et al, 2010; Sanaei et al, 2014). It is obvious NIST definition of cloud computing has gained more recognition over the year. Other definitions are given in table 1.

**Table 1: Definitions of cloud computing**

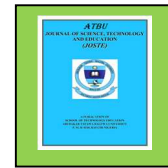
Definition	Author
"Internet-based computing service"	Yang, H., Tate, M(2012)
CC refers to computing services that are provided within a cloud infrastructure and accessed on demand by customers, so that the customers do not have to be concerned with the details of service provisioning.	Jose & David (2015)
Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements (SLA) established through negotiation between the service provider and consumers.	Buyya, et al (2009)
Cloud computing is a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet.	Foster et al (2008)
It can be defined as computing model which offers computing as a utility to meet the requirement of users at very low cost based on pay as per use manner.	Mell (2009)
Cloud Computing is an internet-based architecture which creates a computing environment to provide availability, scalability and flexibility of computer infrastructures at different level of abstraction.	Mohammad & Rafiqu (2018)

Corresponding author: Ahmed Abdulrazaq Bello

✉ [aabello.cs@fptb.edu.ng](mailto:aabello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved



### **Characteristics of Cloud Computing**

According to NIST, it identifies five distinct features of cloud computing as given below:

*On-demand Self-service:* A cloud's subscriber can access resources such as computing capabilities, storage etc. anytime when needed without a need of service provider.

*Broad Network Access:* Any device such as smartphones, laptop, workstations etc. can be used to access the resources available over the internet.

*Resource Pooling:* Computing resources can be accessed by more than one user at a time using multitenant architecture. However, users are not familiar with the exact location of provided resource but in the case of higher level of abstraction such as datacenter location may need to be specified.

*Measured Service:* Cloud systems provides pay as per use service which monitors and control resource usage to provide transparency for both user and service provider.

*Rapid Elasticity:* The services of cloud computing are so elastic that one can add resources when needed and release them once they finish. In addition, resources are accessible to users in unlimited quantity at any time.

### **LITERATURE REVIEW**

Buyya (2009) states that cloud computing is the fifth utility closely coming after water, electricity, gas, and telephone. As these utilities are essential and accessible, so is cloud computing services becoming instantly obtainable on demand.

According to Carolan et al (2009), the crucial thing about cloud computing is the services offered to its growing clients by the cloud service providers: software as a service

(SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS).

The SPI models comprising SaaS, PaaS and IaaS are the most prominent cloud service models cloud computing technology brought for seamless access to cloud services (Jose & David 2015; Zissis & Lekkas, 2012).

David (2015) claims that as an alternative to investing in new IT systems, Cloud computing is fast becoming the popular choice. This is obvious in the developed countries where most companies are now adopting cloud service models because of its numerous benefits.

Furthermore, Hoefer and Karagiannis (2011) stated that most of the software industry's players, such as Microsoft, and other leaders in Internet technology, including Google and Amazon, are joining cloud services development. Several businesses, also those not technically oriented, want to explore the possibilities and benefits of cloud computing. However, there is a lack of standardization of cloud computing services, which makes interoperability when working with multiple services or migrating to new services difficult. Further, there is a big marketing hype around cloud computing, where online service providers rebrand their products to be part of the cloud movement. The great amount of different cloud computing services makes it is hard to compare the offers and to find the right service.

Software as a service (SaaS) is a cloud service model through which the cloud provider makes available software applications for the consumers. The cloud provider is also responsible for the maintenance of the software (May et al, 2013).

Platform as a service (PaaS) offers the clients a platform and environment to develop and build applications online using the internet. PaaS is a service model which offers users a platform to build and run applications through a programming interface provided and supported by cloud service providers (Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi, 2011).

---

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved

Therefore, the issues of scalability, high server speed and storage capacities are addressed under PaaS. Hence, PaaS users can build, run, and deploy their own applications using remote IT platforms. However, users do not have absolute control over the core cloud platforms such as servers, operating systems or storage (Sultan, 2010).

## CLOUD COMPUTING ARCHITECTURE

Cloud computing architecture environment consist of four layers which comprises the hardware layer, the infrastructure layer, the platform layer and the application layer, as shown in Fig. 1.

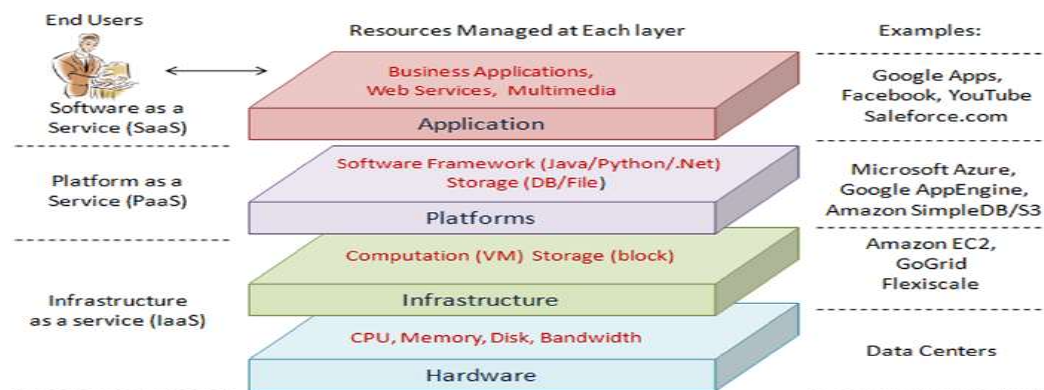


Figure 1: Cloud Computing Architecture

*The hardware layer:* Usually, the hardware layer is implemented in the data centers and contains thousands of servers organized in racks and interconnected by switches, routers or other fabrics. The hardware layer manages the cloud's physical resources, including physical servers, routers, switches, power and cooling systems (Mahmoud & Xia, 2019; Hofer & Karagiannis, 2011, Zhang et al, 2010).

*The infrastructure layer:* The infrastructure layer also known as virtualization layer uses virtualization technologies to create a pool of storage and computing resources. Being one of the most essential components of cloud computing, the infrastructure layer main features encompass dynamic resource assignment, are only made available through virtualization technologies (Mahmoud & Xia, 2019; Hofer & Karagiannis, 2011, Zhang et al, 2010).

*The platform layer:* The platform layer consists of operating systems and application frameworks, built on top of the infrastructure layer. The platform layer's purpose is to minimize the burden of direct deployment of applications in VM containers. Google App Engine, for example, operates on the platform layer to support APIs to implement typical web applications ' storage, database and business logic (Mahmoud & Xia, 2019; Hofer & Karagiannis, 2011, Zhang et al, 2010).

*The application layer:* The application layer is made up of the actual cloud applications at the highest level of the hierarchy. Cloud applications, unlike traditional applications, can leverage the automatic scaling feature to improve performance, availability, and lower operating

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved

costs (Mahmoud & Xia, 2019; Hofer & Karagiannis, 2011, Zhang et al, 2010).

services. NIST (Mell, 2009) revealed that Cloud service delivers three major types of service delivery models which comprises SaaS, PaaS and IaaS as can be seen in figure 2.

### Cloud service Models

Cloud computing technology facilitate the provisioning of numerous types of cloud

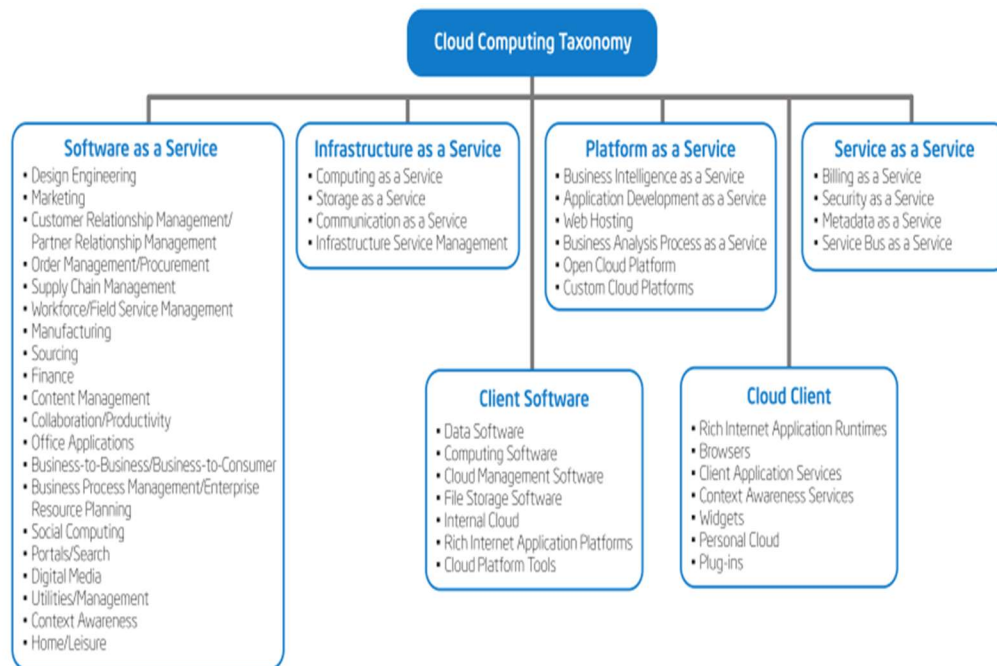


Figure 2: Intel cloud computing taxonomy(Technology & Computing, 2010)

### Software as a Service (SaaS)

SaaS is a model of software deployment in which an end user or enterprise subscribes to software on demand. SaaS applications are built with shared back-end services that enable multiple customers or users to access a shared data model (Technology & Computing, 2010). SaaS is simply having a software system running on a computer that doesn't belong to the customer and isn't on the customers' premises. It is based on the concept of renting an application from a service provider rather than buying, installing and running

software yourself (Rajan & Shanmugapriya, 2012). A SaaS provider gives subscribers access to both resources and applications as seen in figure 3. SaaS makes it unnecessary for you to have a physical copy of software to install on your devices. SaaS also makes it easier to have the same software on all of your devices at once by accessing it on the cloud. In a SaaS agreement, you have the least control over the cloud (Huth & Cebula, 2011). well suited to cases where the enterprise wants to avoid the costs and risks of developing custom applications, where standard off-the-shelf cloud services provide the required

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved

business capabilities (Standards & Council, 2016).

In the software as a service model, the same software is provided to different customers via Internet. The software no longer resides on the consumer's workstation. Under the SaaS model, the software provider is responsible for the creation, updating, and maintenance of software, including the responsibility for licensing the software. Customers usually rent the software on per usage basis. A good example could be web-based email running on a cloud infrastructure. Typical examples for SaaS offerings are Google Apps such as Google Mail and Google Docs and Spreadsheets and

Salesforce.com (Jain & Kumar, 2014). SaaS involves the acquisition of a complete application or business service running as a cloud service. It is the cloud computing equivalent of buying a packaged application; one that typically requires minimal configuration before it is ready for use. SaaS allows businesses to benefit from the "pay-as-you go" concept in addition to being highly scalable, offering flexibility to companies to provision and de provision based on business needs. This consumption based model for software eliminates many of the high start-up costs for initial licensing and installation of software delivered in a traditional model (Standards & Council, 2017; Hemant, 2019).

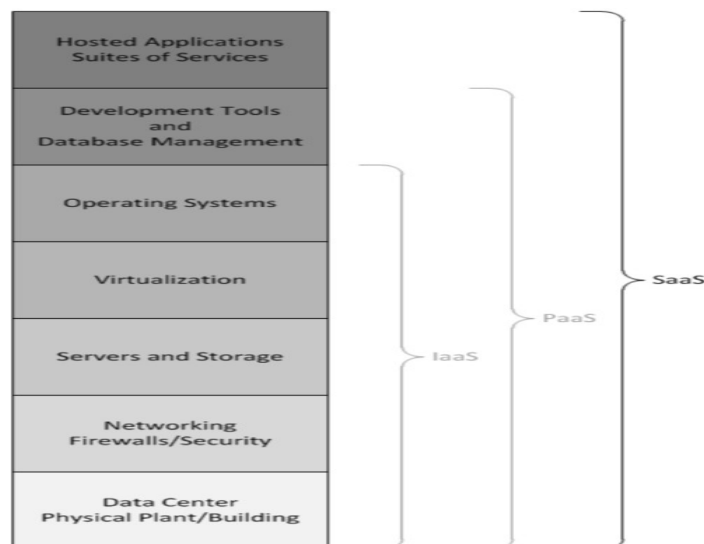


Figure 3: SaaS Variations

### Platform as a Service (PaaS)

PaaS provides an integrated development and runtime platform for creating, deploying, and managing custom applications in a cloud service. Based on the standardization and automation of a common set of topologies and software components, the platform provides elasticity, efficiency, and automated workload

management (Standards & Council, 2017; Hemant, 2019). A PaaS system goes a level above the Software as a Service setup. (PaaS) is the delivery of a cloud computing platform for developers. It facilitates development and deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers as seen

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved

in figure 4. PaaS provides all the facilities required to support the complete life cycle of building and delivering Web applications and cloud services over the Internet (Technology & Computing, 2010). A PaaS provider gives subscribers access to the components that they require to develop and operate applications over the internet (Huth & Cebula, 2011). PaaS has the infrastructure, which is a part of the service offered to the user. The Pure PaaS is offered only to the user-level middleware and at the end it has to have a virtual or physical infrastructure. It is similar with SaaS, but out of this is also providing to the customer software applications that can help the business in creating customized services (Catalina, 2015).

PaaS providers offer a managed higher-level software infrastructure where customers can build and deploy particular classes of applications and services using the tools and programming languages supported by the provider. The offers include the use of the

underlying infrastructure, such as servers, network, storage or operating systems, over which the customers have no control, as it is abstracted away below the platform. Platform services are aimed at specific domains, such as the development of web applications, and are dependent on the programming language. Customers get a separated environment to test and develop or to permanently deploy their applications. Google's App Engine is targeted at traditional web applications offering a Java or Python environment. For small non-scaling applications the Google App Engine is free. On Microsoft's Azure platform applications can be developed using the .NET libraries. Microsoft uses their cloud offers to promote their own software packages. Bungee Connect is specifically designed for cloud application development and deployment. A PaaS of a different domain is Force.com, which allows companies to develop customized business applications (Hoefler & Karagiannis, 2011)

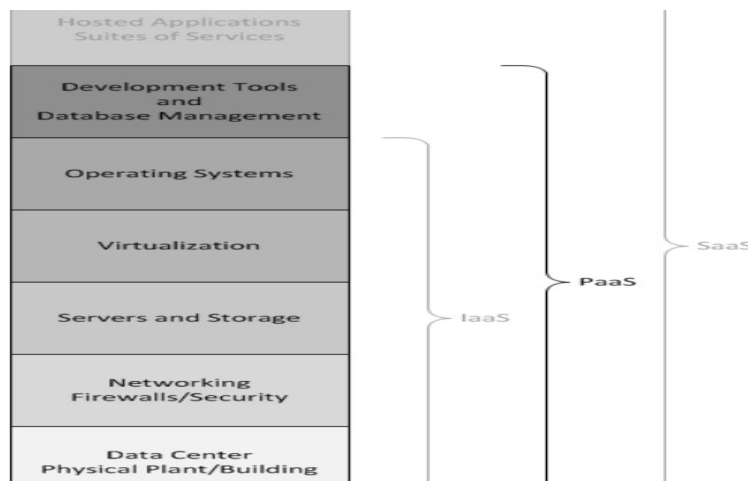


Figure 4: PaaS Variations

**Infrastructure as a Service (IaaS)**

The incentives for an organization to transition to an IaaS environment differ based on the size and Information Technology (IT) maturity of the organization. For Small and Median Businesses, the primary motivation for

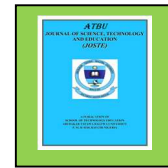
considering IaaS is capital expense reduction and access to IT capacity that would otherwise not be available. For large organizations with potentially several data centers and departmental silos in different geographical locations, there are additional incentives for considering a move to

Corresponding author: Ahmed Abdulrazaq Bello

[abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved



IaaS. Incentives include addressing low server utilization, high administrator-to-server ratios, data center sprawl, proliferation of ad-hoc IT solutions, and desire for improved, more centralized control of IT assets (Standards & Council, 2017; Hemant, 2019). The consumer uses "fundamental computing resources" such as processing power, storage, networking components or middleware. The consumer can control the operating system, storage, deployed applications and possibly networking components such as firewalls and load balancers, but not the cloud infrastructure beneath them (Miha Ahronovitz, Dustin Amrhein, Patrick Anderson, Andrew de Andrade, Joe Armstrong, Ezhil Arasan B, 2010). In the infrastructure as a service model, the consumer can provision fundamental computer resources such as processors, storage, and networking resources. An infrastructure provider (IP) makes an entire computing infrastructure available "as a service". Rather than purchasing servers, data storage, and networking equipment, customers rent these resources provisioned over a network. Infrastructure services are built on top of a standardized, secure, and scalable infrastructure. Amazon Web Services with its Elastic Compute Cloud (EC2) for processing and Simple Storage Service (S3) for storage and Joyent who provide a highly scalable on-demand infrastructure for running Web sites and rich Web applications are examples of IaaS (Jain & Kumar, 2014; Hemant, 2019).

Infrastructure as a service helps companies to move their physical infrastructure to the cloud with a level of control similar to what they would have in a traditional on-premise datacenter. IaaS provides the closest resemblance to the in-house datacenter compared to other services types. Core datacenter infrastructure components are storage, servers (computing units), the network itself, and management tools for infrastructure maintenance and monitoring see figure 5 (Gorelik, 2013). IaaS is a service model around

servers (compute power), storage capacity, and network bandwidth (Rajan & Shanmugapriya, 2012).

Cloud infrastructure services typically offer virtualization platforms, which are an evolution of the virtual private server offerings that are already known for years. The customers buy the resources, instead of having to set up servers, software and data center space themselves, and get billed based on the resources consumed. They deploy their own software on the virtual machines and control and manage it. The virtual instances can be rented for as long as necessary, which can be as short as an hour. The number of instances can be scaled dynamically to fulfill the customers' needs. Billing is based on this amount, the duration and additional services used, such as additional storage space. Providers often have data centers in multiple locations to offer quick access all over the world. Web interfaces allow monitoring of the cloud service. A pioneer in virtualization and computing power offerings is Amazon. The Amazon Elastic Compute Cloud (Amazon EC2) is one of the most widely used infrastructure platforms. Further popular virtualization services include ServePath's GoGrid and the Rackspace Cloud. Other services are the IBM Smart Business cloud solutions, Oracle Cloud Computing, GigaSpaces, RightScale and Nimbus. Online storage and backup services fall in the category of IaaS. Like most virtualization platform, there are several storage solutions intended for corporate use, but there are also special services for private individuals. Corporate services range from temporal to permanent and from general additional storage space to extend the company's internal capabilities, to storage services aimed at database structured information.

These latter services are billed based not only on the amount of storage space used, but also on the number of queries on the data. Further, there are specially designed services to extend the storage amount offered with standard

---

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved



virtualization instances. For private individuals more and more cloud storage and backup services are offered. Laptop and netbook manufacturers, as well as, operating system providers advertise for additional web-storage. Files can be stored on the provider's servers as backup or to synchronize multiple workstations and can often be retrieved from different locations, as the services are often accessible also with a web-browser, such as Rackspace's CloudFiles. Rackspace offers online storage for

corporate and private use. Another storage provider is Nirvanix. Amazon offers data storage facilities either in combination or separate from their EC2 instances, called Amazon Elastic Block Store (EBS) and Amazon Simple Storage Service (Amazon S3), respectively. Amazon also provides special database solutions, such as the Amazon SimpleDB (Hofer & Karagiannis, 2011),(Gorelik, 2013), (Rajan & Shanmugapriya, 2012).

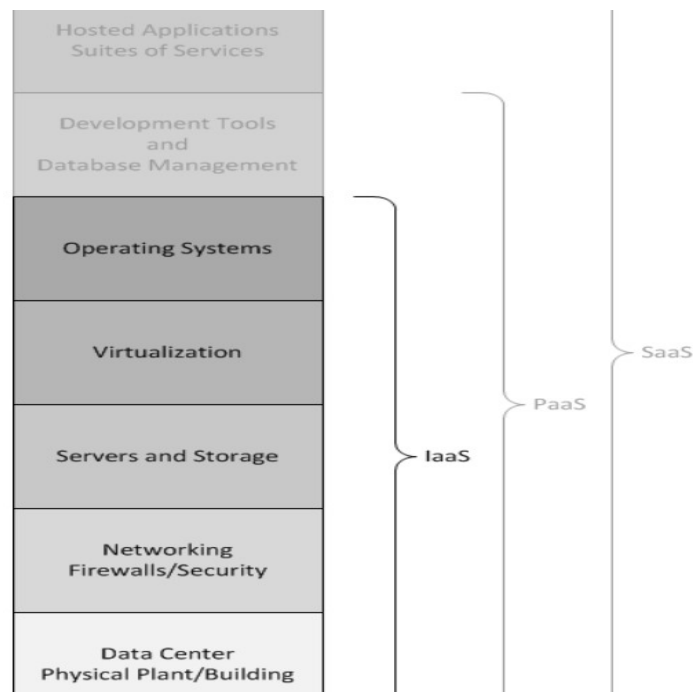


Figure 5: IaaS Variations

Other emerging cloud service models are:

#### **Security-as-a-Service (SEaaS)**

SEaaS is a new instance of a cloud service model that delivers security solutions to enterprises by means of cloud-based services from the cloud. These services may be delivered in different forms, and Authentication-as-a-Service (AaaS) is one of the variants. AaaS is the

new form of user authentication that cloud users should embrace for mitigating the risk of compromising sensitive information (Lim, Kiah, & Ang, 2017).

#### **Network as a Service (NaaS)**

Network as a Service (NaaS), along with Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved

(SaaS), is sometimes listed as a separate cloud provider. As shown in the figure 6 below, this factors out of IaaS networking, firewalls, related

security and so on. NaaS can include Virtual Private Network (VPN), flexible and extended bandwidth on demand, custom routing and so on.

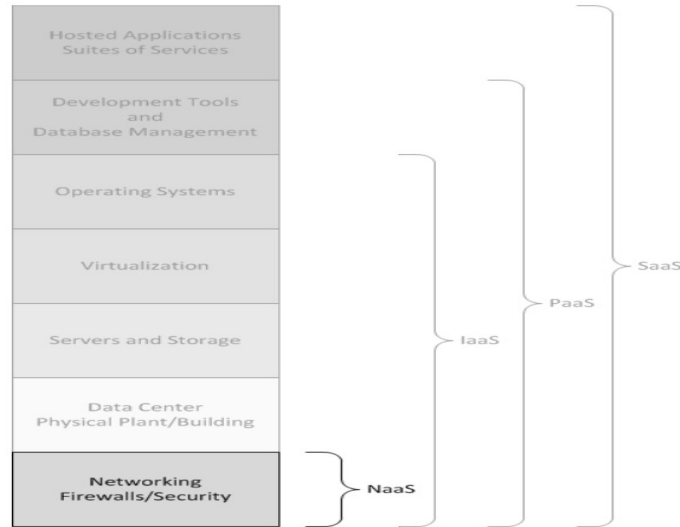


Figure 7: NaaS Variations

**Communications as a Service (CaaS)**

Communications as a Service (CaaS) provides communications software as a service (SaaS). What is included in CaaS is not standard specification. Implementations are different.

CaaS could include unified communications, broadcasting, individual calls (voice and video), voice and video conferencing, voice over IP (VoIP), messaging, and so on

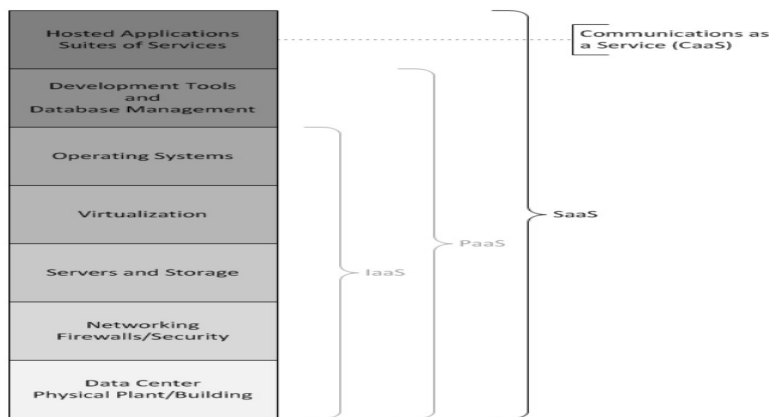


Figure 8: CaaS variations

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved

### Comparison between the cloud service models

Figure 9 clearly showed the major differences between the three major cloud service models: SaaS, PaaS and IaaS.

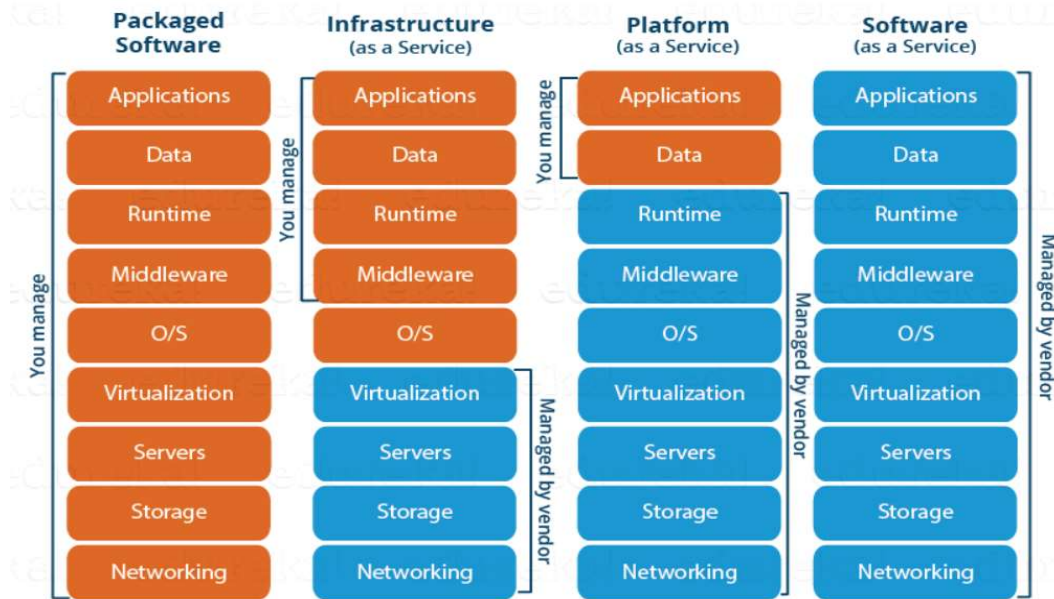


Figure 9: Difference between SaaS, PaaS and IaaS

### Benefits of Cloud Services

Standards & Council (2016) states the benefits of cloud services as:

**Flexibility** – Elasticity requirements must be considered when assessing public and private cloud usage. Seasonal demand for services, such as Black Friday ecommerce activity, drives a significant increase in capacity requirements for a short period of time.

**Security** – Security and privacy are major considerations when evaluating application and data deployment and the data being used.

**Speed and Automation** – The ability to quickly deploy applications and satisfy business needs is a major consideration when making deployment decisions. The immediate availability of

resources and capabilities in public cloud services makes this model desirable when fast deployment is required.

**Cost** – The cost associated with hosting the application over the term of usage is a key factor when considering application and data deployment. Thorough understanding of private cloud services costs (e.g., monthly server cost) and understanding public cloud variable costs, such as outbound internet bandwidth usage, is critical to establishing an apples-to-apples comparison.

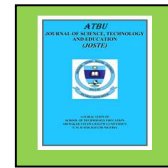
**Locality** – The location of application and data must be considered when deploying services to public and private cloud. Locality considers latency of services to end users (includes application and data integration) to ensure a great user experience.

Corresponding author: Ahmed Abdulrazaq Bello

[aabello.cs@fptb.edu.ng](mailto:aabello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved



*Service Levels* – Service levels associated with mission critical applications are a major consideration when assessing application deployment - including availability, response times, throughput, etc.

*System Interdependencies* – How dependent is a system on other systems in your organization?

### ISSUES AND CHALLENGES

The security requirement becomes more complex with flexible content processing and sharing among a large number of users through cloud- based applications and services. When clouds contain applications from multiple organizations on a single managed infrastructure, application data is vulnerable not only to external attacks, but also to attacks from other organizations sharing the same infrastructure (Lim et al., 2017).

There are three major types of service models supported in cloud computing as a service, including software, platform and infrastructure. But in current mobile cloud computing, there are few implementations because majority of mobile devices has insufficient storage capacity, power of the battery, poor display and computing power. Absence of norms acute shortage or lack of open norms is an another barrier for mobile cloud computing that may lead to problems such as restricted scalability, unreliable availability of service and service supplier lock-in (Basha, Umar, & Abbas, 2014).

Cloud users are forced to adhere to specific cloud service provider(s). However, standardization efforts like the Open Virtualization Format (OVF) are emerging to alleviate problems and facilitate the deployment of virtual appliances in various clouds (Sanaei et al., 2014).

### CONCLUSION

Users subscribe to this virtual infrastructure on demand as opposed to

purchasing servers, software, data center space, or network equipment. Billing is typically based on the resources consumed. Software as a service provide scalable internet-based applications on cloud and offered as services to the end user. Platform as a service allowed cloud service subscribers to design, develop, builds and test applications. Infrastructure as a service enables cloud end users to use storage, databases management systems, and network services on demand.

### REFERENCES

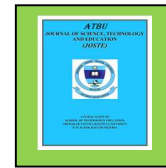
- Bakde, K. G., and Patil, B. M. (2016. )"Survey Of Techniques and Challenges for Load Balancing In Public Cloud", *International Journal of Technical Research and Applications*, 4(2), pp.279-290.
- Basha, A. D., Umar, I. N., & Abbas, M. (2014). Mobile Applications as Cloud Computing : Implementation and Challenge. *International Journal of Information and Electronics Engineering*, 4(1), 36–40. <http://doi.org/10.7763/IJIEE.2014.V4.404>
- Buyya, R., Chee, S. Y., Srikumar, V., James, B. and Ivona, B. (2009). Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing As the 5th Utility. *Future Generation Computer Systems* (Elsevier Science Publishers B. V.) 25, No. 6, 599-616.
- Catalina, I. S. (2015). *Title: Cloud computing - impact on business.*
- Douglas, K. B. (2013). Cloud Computing: Cloud Computing Definitions. Accessed 1<sup>st</sup> April from [https://www.service-architecture.com/articles/cloud-computing/cloud\\_computing\\_definition.html](https://www.service-architecture.com/articles/cloud-computing/cloud_computing_definition.html)
- Foster, I., Yong, Z. R. and Lu, S. (2008). "Cloud Computing and Grid Computing 360-Degree Compared", Grid Computing Environments Workshop.
- Forrester (2017). Predictions 2018: Cloud Computing Accelerates Enterprise Transformation Everywhere. Accessed 1<sup>st</sup> April, 2019 from

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved



- <https://www.forrester.com/report/Predictions+2018+Cloud+Computing+Accelerates+Enterprise+Transformation+Everywhere/-/E-RES139611#>
- Gill, S. S., & Buyya, R. (2015). A Taxonomy and Future Directions for Sustainable Cloud Computing : 360 Degree View.
- Gorelik, E. (2013). *Cloud Computing Models*.
- Hemant, S. (2019). What Is Cloud Computing? Retrieved 30<sup>th</sup> March from <https://www.edureka.co/blog/what-is-cloud-computing/>
- Höfer, C. N. and Karagiannis, G. (2011). Cloud computing services: taxonomy and comparison. *Journal of Internet Service Application* (2011) 2:81–94. DOI 10.1007/s13174-011-0027-x
- Huth, A., & Cebula, J. (2011). The Basics of Cloud Computing, 1–4.
- Jain, A., & Kumar, R. (2014). A Taxonomy of Cloud Computing, 4(7), 2–6.
- Jose, M. and David, H. (2015). Review and Analysis of Networking Challenges in Cloud Computing, *Journal of Network and Computer Applications*, <http://dx.doi.org/10.1016/j.jnca.2015.11.015>
- Lim, S. Y., Kiah, M. L. M., & Ang, T. F. (2017). Security Issues and Future Challenges of Cloud Service Authentication, 14(2), 69–89.
- Mahmoud, M. S., and Xia, Y. (2019). Cloud Computing. *Networked Control Systems*, 91–125. <https://sci-hub.tw/10.1016/B978-0-12-816119-7.00011-3>
- May, A., Shaikha, A., Sabika, B. and Imtiaz, A. (2013). *International Journal of Grid and Distributed Computing* Vol.6, No.5 (2013), pp.93-106 <http://dx.doi.org/10.14257/ijgdc.2013.6.5.09>
- Mell, P. and Grance, T. (2009). "Draft NIST working definition of cloud computing. V15", pp.1-3, 2009.
- Miha Ahronovitz, Dustin Amrhein, Patrick Anderson, Andrew de Andrade, Joe Armstrong, Ezhil Arasan B, J. B. (2010). *Cloud Computing Use Cases A white paper produced by the.*
- Mohammad, H. and Rafiqul, Z. K. (2018). A Systematic Review on Cloud Computing. *International Journal of Computer Sciences and Engineering Open Access Review Paper*, Vol.-6, Issue-11, E-ISSN: 2347-2693
- Rajan, R. A. P., & Shanmugapriya, S. (2012). Evolution of Cloud Storage as Cloud Computing Infrastructure Service, 1(1), 38–45.
- Sanaei, Z., Abolfazli, S., Gani, A., & Member, S. (2014). Heterogeneity in Mobile Cloud Computing : Taxonomy and Open Challenges, 16(1), 369–392.
- Standards, C., & Council, C. (2016). *Practical Guide to Hybrid Cloud Computing*.
- Standards, C., & Council, C. (2017). *Practical Guide to Cloud Computing*.
- Strauch, S., Kopp, O., Leymann, F., Unger, T., Strauch, S., Kopp, O., ... Unger, T. (2011). Institute of Architecture of Application Systems A Taxonomy for Cloud Data Hosting Solutions A Taxonomy for Cloud Data Hosting Solutions. *IEEE Computer Society*, 577–584. <http://doi.org/10.1109/DASC.2011.106>
- Technology, I. I., & Computing, C. (2010). *Intel Cloud Computing Taxonomy and Ecosystem Analysis*.
- Zhang, Q., Cheng, L. and Boutaba, R. (2010). Cloud computing: state-of-the-art and research challenges. *Journal of Internet Service Application*, 1: 7–18. DOI 10.1007/s13174-010-0007-6
- Zissis, D., & Lekkas, D. (2012). Addressing cloud computing security issues. *Future Generation Computer Systems*, 28(3), 583–592. <http://dx.doi.org/10.1016/j.future.2010.12.006>.

Corresponding author: Ahmed Abdulrazaq Bello

✉ [abello.cs@fptb.edu.ng](mailto:abello.cs@fptb.edu.ng)

Department of Computer Science, Federal Polytechnic, Bauchi.

© 2023. Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. All rights reserved