Cloud Computing – Research Issues, Challenges, Architecture, Platforms and Applications

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***Abstract*-- Cloud computing is a recent development in the world of Information Technology offering IT capabilities as services. It involves parallel computing, distributed computing, grid computing, and virtualization technologies. In this research paper, the concepts of cloud architecture and platforms. The various applications of cloud computing and their unique characteristics are differentiated on how they work on different platforms. Like any other technology with shortcomings, the challenges of using cloud interoperability and cloud computing adoption perspectives are also highlighted. Issues of security, compliance, reliability, legal issues and privacy that present a primary barrier to users are also discussed.**

Index Terms – Cloud computing, architecture, Nimbus, Eucalyptus

I. INTRODUCTION

Cloud computing is a new generation technology that provides users to access storage, infrastructure, software and environment deployment. Despite the many definitions of the term Cloud Computing, the National Institute of Standards and Technology (NIST) is the accepted general definition of the concept [1] NIST definition is "Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction." Cloud computing (CC), therefore provides parallel computing, distributed computing, grid computing, and virtualization technologies [2]. The technology delivers the service as a software, platform, and infrastructure as a service in a pay-as-you-go model to consumers. It is a combination of several architectural components including Virtualization, Utility computing, SaaS, IaaS, Daas, and PaaS. With the enormous benefits of cloud computing, the research further looks into the popular cloud computing platforms. Application of cloud computing are based on the type of information used by individuals and companies. Some of the applications looked into in the research include data storage, and data sharing, reliability of use of the internet.

II. ABBREVIATION ON ACRONYMS

SaaS – Software-as-a-Service

IaaS- Infrastructure-as-a-Service

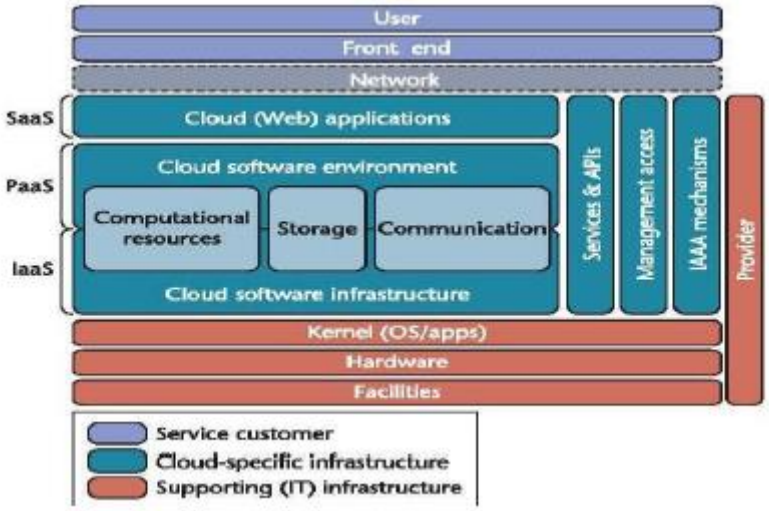
PaaS- Platform-as-a-Service

CSP – Cloud Service Provider

OS – Operating System

III. ARCHITECTURAL COMPONENTS OF CLOUD COMPUTING

The cloud service model is commonly divided into SaaS, PaaS, and IaaS to make up a cloud infrastructure. Figure 1 shows a cloud reference architecture that includes the most important security-relevant cloud computing components. A good cloud computing system must have a customer service interface, the cloud-specific infrastructure, and the supporting IT infrastructure. Under the customer service, there are users, front end, and network [1]. As seen in Fig.1, supporting infrastructure include OS, Hardware, and facilities. The cloud specific infrastructure that comprises the SaaS, PaaS, and IaaS; form the most crucial parts of the system.



The functionalities of the three architectural components is as discussed below.

Infrastructure-as-a-Service (IaaS)

The IaaS refers to the hardware infrastructure such as network, storage, and compute resources. These resources are used with virtualization technology. The virtualization technology is essential in IaaS cloud as it integrates or decompose some physical resources in an ad-hoc manner thus shrinking or expanding resource demand from cloud consumers [3]. For the IaaS to work, independent Virtual Machines (VM) are isolated from both the underlying hardware and other VMs. Some of the features of IaaS include a virtual computing environment, configurations of CPU, memory, storage and networking capacity, secure login information, persistent storage volumes, multiple physical locations, a firewall, metadata, and static IPv4 addresses [3]. An example of an effective IaaS used at corporate level is the Amazon's EC2. The Amazon Elastic Compute Cloud (Amazon EC2) provides scalable computing capacity in the Amazon Web Services (AWS) cloud [4].

Platform-as-a-Service

PaaS is a development platform that has the capability to provide consumers with cloud infrastructure consumer-created or acquired applications. The PaaS also supports the "Software Lifecycle" that provide opportunities for cloud consumers to establish cloud services and applications such as SaaS directly on the PaaS cloud. PaaS therefore offers a development platform that hosts both completed and in-progress cloud applications. For effective hosting and support, development infrastructure such as programming environment, tools, configuration management among other features [3]. An ideal example of PaaS cloud model is the Google AppEngine that hosts web applications in Google-managed data centers. It acts as a platform for applications such as Python, Java, Go, and PHP.

Software-as-a-Service

SaaS is a model that deploys software whereby an application is hosted as a service provided to consumers across the internet [14]. SaaS enables cloud consumers to access networks from other clients such as Web browser and PDA. Cloud consumers do not have control over the cloud infrastructure as it utilizes a multi-tenancy system architecture. Different cloud applications are organized in a single logical environment in the SaaS to provide users with economies of scale and optimal speed, security, availability, maintenance and disaster recovery mechanisms. A popular SaaS is the Microsoft Office 365 which expands the Office suite's parameters enabling users to create, edit, and share content from any PC, Mac, iOS, Android or Windows device in real-time.

IV. CLOUD COMPUTING PLATFORMS

Abicloud

Abicloud is a cloud computing platform that builds, integrate and manage private and public clouds in a homogenous environment. users under this platform are able to deploy and manage the server, storage system, network, virtual machines, and applications. A distinguishing factor from the other platforms is that Abicloud is powerful web-

based management function [5]. The powerful trait can be illustrated by how a user can finish deploying a new service by only dragging a virtual machine with a mouse unlike other platforms that use command lines. Based on users' requests, the platform can also deploy and implement private and hybrid clouds. Resultantly, Abicloud can also be packed and redeployed on any other Abicloud system making it flexible and easy to use [11].

Nimbus

Nimbus is an open tool set and cloud computing solution that majors on IaaS. As a platform for IaaS, it permits users to lease remote resources and build a computing environment by deploying virtual machines. The functional components of Nimbus are divided into three categories. The first category is the client-supported models to support all applicable clients; a context client models, cloud client models, and reference client models all fall in this category [2].

OpenNebula

The second grouping is the Open Nebula which is an open source cloud service framework that allows users to maneuver and manage virtual machines on physical resources by setting user's data centers to the virtual facilities adaptable to changes on the service load. Unlike OpenNebula, the Nimbus platform launches a remote interface based on EC2 or WSRF from which a user process security related issue [2]. Open Nebula can be used to synchronize storage, network, and virtual techniques thus users can dynamically use services on the distributed infrastructure in accordance to the allocation techniques from the data center and remote cloud resources.

Eucalyptus

The Elastic Utility Computing Architecture for Linking Your Programs to Useful Systems (Eucalyptus) is a platform used to develop open-source private cloud platform. It connects users' programs to the essential systems [2]; [10]. It is an open-source infrastructure that applies clusters or workstations that are elastic, utility, cloud computing and a computing standard enabling users to lease networks for computing capabilities [2]. Eucalyptus is compatible with EC2 of Amazon and any other client's systems with minimum modifications and extensions.

In Table 1 below, a comparison of how the four cloud computing platforms operate is provided.

Table 1: The Comparison of Cloud Computing Platforms

	Abicloud	Eucalyptus	Nimbus	OpenNebula
Cloud Character	Public/private	Public	Public	Private
Scalability	Scalable	Scalable	Scalable	Dynamic, Scalable
Clouds form	IaaS	IaaS	IaaS	IaaS
Compatibility	Not support EC2	Support EC2, S3	Support EC2	Open, multi-platform
Deployment	Pack and redeploy	Dynamical deployment	Dynamical deployment	Dynamical deployment
Deployment Manner	Web interface drags	Command line	Command line	Command line
Transplant-ability	Easy	Common	Common	Common
VM support	Virtual Box, Xen, VMware, VM	Xen, VMware, KVM	Xen	Xen, VMware
Web interface	Libvirt	Web service	EC2, WSDL, WSRF	libvirt, OCCI, EC2, API
Structure	Open platform encapsulates core	Module	Lightweight components	Module
Reliability	-	-	-	Rollback host and VM
OS support	Linux	Linux	Linux	Linux
Development language	Ruby, c++, python	Java	Java, python	Java

Source: [2]

V. APPLICATIONS OF CLOUD COMPUTING

Cloud computing as a recent technological development is widely used in forms that even users may not realize they are using. From government agencies to non-profit organizations, cloud computing is used for every sort of reason especially by the fact that it allows users access files anywhere as long as there is internet connection. The technology provides reliable and secure data storage centers for organizations and individuals. Another application is its capabilities

to realize sharing data between different equipment. As another application to cloud computing, users are able to use the internet thus applicable by organizations that post information and data mostly retrievable on the internet [2]. Cloud computing is used by organizations as a disaster recovery plan for crucial information. In businesses, cloud computing is used to keep track of resources, obtain decision-making insights, review and update budget plans through office applications, emails, and past and present activities integrated within the systems [7].

VI. RESEARCH ISSUES IN CLOUD COMPUTING

Organizations and individuals have adopted cloud computing for storage of crucial information and this has led to raising concerns about the safety on the environment. some of the issues identified include:

a) Privacy and Security: Cloud computing uses virtual computing technology which can jeopardize users' personal data in the various virtual data centers. Users may manipulate the systems and leak hidden information when they access cloud computing services. Researching through cloud computing is therefore sensitive in terms of violating privacy other users' confidential information [6].
b) Reliability: cloud servers at times experience downtimes and slowdowns in the local servers thus cannot be relied up on at those specific times [8].
c) Compliance: there are regulations that require users to comply with especially when storing and using data [8]. Regular reporting and audit trails must be complied with and some users may lack adequate knowledge on these compliances. Resultantly, customers are subject to requirements necessitated at data centers [9].
d) Legal Issues: there are concerns on the safety measures and confidentiality of individuals attended to at legislative levels [10].
e) Freedom: Cloud computing users are not allowed to physically possess the storage of data thus leaving data storage in the hands of cloud providers [10].
f) Long-term Viability: As a researcher, you have to rely on the cloud providers that ensure data is put into the cloud and will not become invalid when there are changes in management or downfalls in the organization [10].
g) Issues in Cloud Interoperability[14].

As cloud computing is evolving, customers do not want to be locked into a single cloud provider and desire to get freedom to move among clouds as their demands grow or shrink [9]. When customers decide to move an application between clouds, there are challenges experienced. They include: Rebuilding application and application stack in the target cloud; setting up the network in the target cloud; setting up security to match capabilities; managing the application running in the target cloud; and handling data movement and encryption of data when in transit [10]. To offer solutions to the interoperability issue, the following interventions are provided:

a) **Intermediary layer:** In recent developments, interoperability is perceived by users leading to provisions of intermediary layer between cloud consumers and cloud-specific resources such as Virtual Machines.
b) **Open standard:** Standardization of cloud applications by vendors and providers reduces the issue of interoperability.
c) **Open API:** Organizations such as SUN have launched the Sun Open Platform under the Creative Common license through API. API defines clearer and easy-to-understand RESTful Web service interfaces enabling customers to create and manage resources [10].
d) **SaaS and PaaS Interoperability:** The three solutions tackle IaaS interoperability issues. To solve SaaS interoperability issues, data mining standards on the cloud by focusing on use of statistical algorithms, reliable production deployment of models, and integrating predictive analytics are recommended [13]. PaaS interoperability, on the other hand, is not well established as it involves development of a life-cycle on the cloud which is difficult to reach standardization.

VII. CONCLUSION

Cloud computing has been reviewed where the research has focused on the architectural components, the platforms, different applications, challenges in research and among users. It can be concluded that Cloud Computing is mainly divided into three types of cloud services; IaaS, SaaS, and PaaS. The three are differentiated by the form of

control users have and their dependability on other cloud services. The different platforms such as Abicloud, Nimbus, and Eucalyptus are also discussed in details and how users relate with them. Applications of Cloud Computing discussed include how it is used in data storage, data sharing and usage of the internet. Issues of security and privacy are highlighted. The challenge of interoperability of cloud services among users is also discussed and some solutions provided to deal with interoperability. The research indicates that CC is dynamic and in future more research studies will address upcoming issues.

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