Cloud Computing – Recent Research Trends and Developments

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***Abstract*: Cloud computing has been a trending revolution for the next-generation computing and rapidly becomes the most important topic in the field of IT. Its research has attracted tremendous interest of many researchers in recent years. In this paper, we focused precisely on the current open challenges and issues of Cloud computing. This paper was classified into 3 main sections where in the first discussion related to cloud computing architecture was presented. Secondly various security issues in cloud computing were addressed based on its service layer. Finally, many challenges in Cloud computing security and its future implications were presented. Finally, we discussed different privacy issues in cloud computing while comparing different cloud simulators.**

***Index Terms*: Cloud Computing, Architecture, Challenges, Research, Development**

I. INTRODUCTION

Latest never ending technical revolution in the IT industry known as cloud computing has led to an innovative way to provide a best answer to the present and future information and communication technology (ICT) requirements [1]. It gives an adaptable platform which encourages the strength to handle any expanded volume of real-time problems without having any minute adverse effect on the execution of the Cloud framework. It is very much attractive to entrepreneurs as it eliminates the requirement for users to plan ahead for provisioning, and allow various service and product oriented enterprises [1] to support the increasing service demand. Promoting and elaborating the expansion of cloud environment offers made a vast scope around the cloud that led to user expectation pressure.

Over the recent years, several technologies such as virtualization, grid computing, and service-oriented architecture (SOA) [3] have grown significantly and contributed for the vast visibility of cloud computing [5]. On the other hand, cloud computing in the initial stage experienced absence of institutionalization in many aspects. In current scenario, most cloud service providers proposed their own business solutions for accessing the resources and other services which lead to the raise in barriers to cloud realization. As cloud infrastructure is vastly used, security is the major problem for many cloud service providers. This sharing of framework together have raised huge security problems. The clouds have a different architecture based on the solution of the cloud service providers.

This paper focusses mainly on the current key patterns in the space of Cloud computing and presents researching space for future amendments of this technology. Key elements of opportunity in cloud research are noted, and each one of them explained in detail. The rest of the paper is organized as follows. Section II presents a study on the cloud computing architecture and highlights the recently available latest computing tools. In section III, we list out various security and privacy issues in cloud computing. Next, we discuss the open challenges and its future implication in section IV. Finally, in Section V, we conclude the paper.

II. CLOUD COMPUTING ARCHITECTURE

The US National Institute of Standards and Technology (NIST) has proposed full idea that blankets the generally concurred parts of cloud computing. It defines cloud computing as, a model for enabling 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 [8].

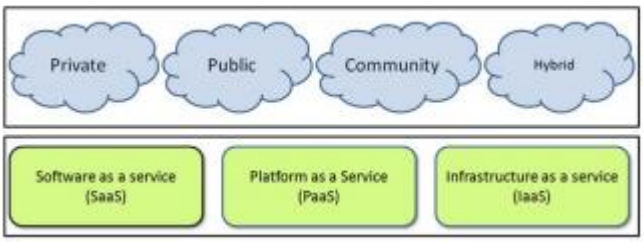

Figure: 1: Cloud Deployment & Service based Architecture

Characteristics of Cloud Computing

• Self-demand service: Cloud administration suppliers is useful to gain cloud resources and can be utilized without the requirement for human association. Computing aspects [4] include processing power, storage, virtual machines, etc.

• Huge network access: Previous resources could be gotten to over a system utilizing various complex gadgets, for example, laptops or mobiles telephones.

• Resource pooling [3]: Numerous clients provide various resources to be imparted which are supplied by different Cloud Administrators. This is referred to as multi-tenure service where, for instance, a physical server [7] may have a few virtual machines having a place with distinctive clients.

• Rapid elasticity [5]: A client can rapidly gain more different resources from cloud servers by scaling out and can scale back in by discarding those resources once they are utilized.

• Measured service: Resources utilization is measured by monitoring storage usage, CPU hours, bandwidth usage, etc. The said metrics are applied to all clouds, but each cloud provides users with services at a different level of abstraction, which is an alternate to an administration [6].

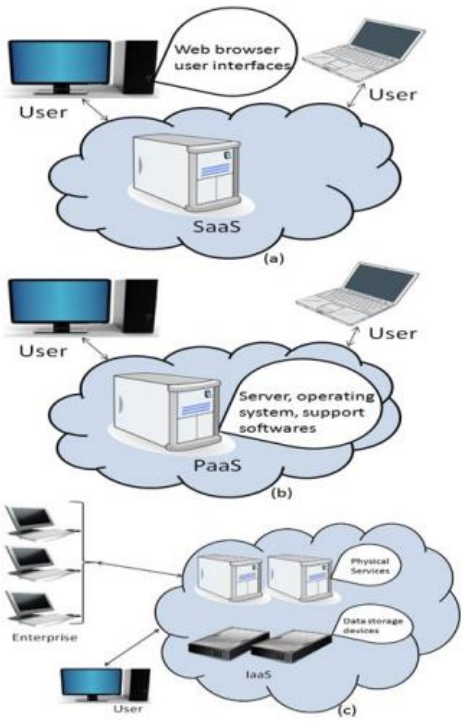

Figure:2: Cloud Service Models

Cloud Service Architecture

Software as a service (SaaS) [16]: The capability to use applications running on a cloud infrastructure is provided to the consumer which mainly depends on the web browser to access software that offer as a cloud service over the web. The consumer don't have any control on the underlying framework including system, servers, network, operating systems, storage, or even individual application capacities, with the conceivable exemption of constrained client particular application setup settings [12]. GoogleDocs1 and Salesforces2 are some of the prominent examples for SaaS.

Platform as a Service (PaaS) [26]: The capability to deploy onto the cloud infrastructure is provided for consumer created applications which are produced using set of programming languages and various cloud computing tools that are supported by the Paas provider. The consumer does not consider to control the underlying cloud framework including network, servers, operating systems, or storage, but has control over the sent applications and conceivably application facilitating environment arrangements [27]. The SaaS server clients do not have control or access to the underlying base framework being utilized to have their applications at the Paas level. Some of the examples of PaaS are Google App Engine3 and Microsoft Azure4 are prominent examples that use the PaaS model of cloud computing.

Infrastructure as a service (IaaS) 13]: It provides the consumer with the capability to provision processing, huge storage, networks, and other fundamental computing resources from an IaaS provider, which allows the consumer to deploy and run any software [20]. The client has full control over operating systems, storage, deployed applications and perhaps constrained control of select systems administration parts. Rather than the Paas model, the Iaas model is a low level of reflection that permits clients to the right of the entrance the underlying foundation through the utilization of virtual machines. Iaas gives clients more adaptability than Paas as it

permits the client to convey any product stack on top of the operating system. Examples of IaaS are Amazon Web Services [20] EC2 and S35 are prominent examples that use the IaaS model of cloud computing [12].

Cloud Deployment Models

A cloud organization model always indicates how resources inside the cloud are shared and utilized. Fig. 1, shows four different cloud deployment models: private cloud, public cloud, community cloud, and hybrid cloud. Each model has its own impact on comparing scalability, reliability, security, and cost [13].

Private cloud: It refers to a cloud that is used exclusively by one organization, company, or one of its customers. The cloud may be operated by himself or a third party, whereas private cloud offers [18] increased security at greater cost. The St. Andrews Cloud Computing Co-laboratory and Concur Technologies [7] are illustration associations that have a private cloud.

Public cloud: It is referred to as a cloud that is used by general public. Due to its openness nature the cloud may be less secure. It is the best option which is less expensive [18]. This can be a large organization [5] and can offer services. It requires significant investment and are usually owned by large corporations such as Microsoft, Google or Amazon.

Community cloud: A cloud which is shared by two or more several organizations and is usually setup for their own specific requirements [14]. This is typically for the shared concern (e.g. such as schools within a university).

Hybrid cloud: It is referred as a cloud which is setup by a mixture of two or more private, public, or community cloud [9]. It could be freely overseen yet applications and information would be permitted to move over the cloud.

Cloud Computing Features

The cloud servers [21] are now hosting wide range of large scale and small scale applications. Many organization or companies are now moving key applications from expensive internal data centers to cost effective [10] and resourceful cloud solutions.

Scalability: It is defined as a site or application's skill which uses traditional solutions on demand. This site may scale up to available additional resources which the system [8] is experiencing high user demand and later may scale down recourse when the user demand turns down. Some applications that run within the cloud are normally highly scalable. An applicant/user can manually add or remove resources or application can be configured to scale automatically.

Simulator	Base Platform	Developer	Available	Language	GUI	Energy Model
CloudSim [30]	SimJava	University of Melbourne, Australia.	Open Source	Java	No	Yes
CloudAnalyst [31]	CloudSim	University of Melbourne, Australia.	Open Source	Java	Yes	Yes
iCanCloud [33]	SIMCAN	Universidad de Madrid, Spain.	Open Source	C++	Yes	No
NetworkCloudSim [32]	CloudSim	University of Melbourne, Australia.	Open Source	Java	No	Yes
EMUSIM [34]	CloudSim, AEF	University of Melbourne, Australia.	Open Source	Java	No	Yes
GroudSim [35]	-	University of Innsbruck, Austria	Open Source	Java	Limited	No
MRCloudSim [36]	CloudSim	Seoul National University, South Korea	Not available	Java	No	Yes
DCSim [37]	-	University of Western Ontario, Canada.	Open Source	Java	No	No
SimIC [38]	SimJava	University of Derby, UK	Not available	Java	No	Rough
GreenCloud [39]	NS2	University of Luxembourg, Luxembourg	Open Source	C++, otcel	Limited	Yes
MDCsim [40]	CSIM	Pennsylvania State University, USA	Commercial	Java, C++	No	Rough
SPECI [41]	SimKit	University of Bristol, UK	Open Source	Java	-	Rough
MalStone [42]	-	University of Illinois, Chicago, USA	Open Source	Java, Python	-	Rough

Table: 1- Comparison of Cloud Simulators

Virtualizations: Virtualization is to use hardware or software to create the observation of some specific task. Server must have their own machine which is capable of running a specific operating system (OS) [15], such as Windows, Linux, or Mac OS. By using special mechanism, server can be shown as it has multiple CPUs and are running the same or different OS and the server CPU switches [11] its processing power frequently among the various operating systems.

III. Cloud Computing Security Issues

Security issues in SaaS

In SaaS, the client needs to rely upon the supplier for various efforts to establish safety. The supplier should do the work to keep numerous clients' from seeing one another's information. So it is difficult to the client to guarantee that right efforts to establish safety are set up furthermore hard to get confirmation that the application will be accessible when required [24].

The utilization of cloud computing together with the pay-as-you-go (develop) methodology helps the application administration supplier to diminish the interest in foundation benefits and empowers it to focus on giving better client administration. Over the past decade, computers have become widespread within enterprises while IT services and computing has become a commodity. Today's enterprises view data and business processes (transactions, records, pricing information, etc.) themselves as a strategic and guard them with access control [25] and compliance policies. However, in the SaaS model, enterprise data is stored at the SaaS provider's data center, along with the data of other enterprises.

Security Issues in PaaS

In PaaS, the administration supplier may give some control to the customer to manufacture applications on top of the cloud framework. However, any securities beneath the application level, will presently be in the extent of the supplier which brings to the table solid affirmations that the information stays distant between applications. It is proposed to empower designers to assemble their own particular applications on top of the platform. The vulnerabilities of cloud are connected with the web applications as well as vulnerabilities connected with the machine-to-machine Service- Oriented Architecture (SOA) applications, which are progressively being conveyed in the cloud [25].

Security Issues in IaaS

In IaaS, the developer has better control over the security & length of there should not any security gap in the virtualization director. Likewise, however in basic virtual machines may have the capacity to address these issues yet in practice there are a lot of security issues [26]. The other element is the unwavering quality of the information that is put away inside the supplier's equipment. Based on the cloud deployment IaaS inclined to various security issues. Private cloud is more protected compared to a public cloud. The most important issue is to protect the physical infrastructure of data centers [24]. It can be damage by any natural disaster or damage is acquired to the framework deliberately. Infrastructure doesn't mean the hardware where data is processed and stored, it also includes the where it is getting transmitted.

IV. PRIVACY AND SECURITY

Cloud computing can provide infinite resources on demand due to its high scalability in nature [23], which eliminates the needs for Cloud service providers to plan far ahead on hardware data allocations. Many companies, such as Amazon, Google, Microsoft and so on, accelerate their paces in developing cloud computing systems and enhancing its services by providing them to a larger amount of users. In this paper, we investigate the security and privacy issues of current cloud computing systems provided by various companies. Based on the different security and privacy concerns provided by companies which are not adequate, which consequently result in big obstacle for users to adapt into the cloud computing systems [20]. Hence, more concerns on security issues, such as availability, confidentiality, data integrity, control, audit and so on, are taken into account.

Cloud services [12] are some applications running at different locations in the cloud computing infrastructures through internal network or Internet. It allows providers to develop, deploy and run applications that can easily grow in capacity (scalability), work rapidly (performance), and never (or at least rarely) fail (reliability), without any reasons on the physical properties of the underlying infrastructures. These systems can achieve the following five goals together [2]:

1) Availability: The goal (including applications and its infrastructures) is to ensure its users can use them at any time, at any location. which enables its users to access the system (e.g., applications, services) from anywhere. This is true for all the cloud computing systems (e.g., DaaS, SaaS, PaaS, IaaS, and etc.) which requires to be accessed at any time, which should be severing all the time for all the users (say it is scalable for any number of users). Two strategies, like hardening and redundancy, are mainly used to enhance the availability of the cloud system or applications hosted on it.

2) Confidentiality: It means keeping user data secret in the cloud systems. There are two basic approaches (i.e., physical isolation and cryptography) to achieve such confidentiality, which are extensively adopted by the cloud computing vendors.

3) Data integrity: In the cloud system means to preserve information integrity. As data is the base for providing cloud computing services, such as Data as a Service, Software as a Service, Platform as a Service, maintaining data integrity is a fundamental task.

4) Control: It means to regulate the use of the cloud system, including the applications, its infrastructure and the data.

5) Audit: It monitors the latest happenings in the cloud system. Auditability could be added as an additional layer in the virtualized operation system (or virtualized application environment) hosted on the virtual machine to provide facilities watching what happened in the system [3]. It is much more secure than that is built into the applications or into the software themselves, since it is able watch the entire access duration.

Cloud Related Working Groups

A working group is an assembled, cooperative collaboration of researchers working on new research activities that would be very difficult for any member to develop alone. Working groups generally strive to create an informational document, or find some solutions for problems related to a system or network. Most often, the working group attempts to assemble experts on a topic. These are sometimes also referred to as task groups or technical advisory groups.

The Open Cloud Consortium (OCC) is divided into several different working groups [8]. Its purpose is to support the development of standards for cloud computing and to develop framework for interoperability among various clouds [19]. There is also a working group on wide area clouds and the impact of network protocols on clouds. The focus of this working group is on developing technology for wide area clouds, including creation of methodologies and benchmarks to be used for evaluating wide area clouds.

V. Conclusion

The cloud computing principle is generating a lot of interest globally because of its low cost of ownership, scalability, competitive differentiation, reduced complexity for customers, and faster and easier acquisition of services. Users come to the cloud computing topic from different points of view in spite of many advantages. Many people find the cloud as safe than their own security provisioning, especially small businesses that do not have resources to ensure the necessary security themselves. They think that they will not consider moving to cloud anytime soon because they have no good way to quantify their risks. This survey demonstrated that there are a few routes in which the cloud research group can gain knowledge from related groups. An extensive outlook on current research issues cloud computing and available platform to simulate the research idea is published. Several scientific classification of issues found here are exhibited, and the methodologies in which these issues have been handled at various levels such as operational level, client level, service level and application level, security and context-awareness are showcased.

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