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ARCHITECTURE LEVEL MAPPING OF CLOUD COMPUTING WITH GRID COMPUTING

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ABSTRACT

Cloud computing provides on demand large scale hardware and software services over the internet. It is a group of virtual servers available for general public through payment. On the other hand, grid computing is a collection of heterogeneous distributed resources to solve large scale problems with intensive resources. Grid computing allows an application to run on different machine and utilize the grid resources. This paper describes the layered architectures of two computing models, mapping of layers in terms of services and their functionality differences. The audience of this paper is academia.

KEYWORDS: *Cloud Computing, Grid Computing, Architecture, Mapping, Computing Models*

I. INTRODUCTION

Cloud computing has become a popular computing model [9] to handle large scale on demand services over Internet [2]. It is a collection of dynamically managed, monitored and maintained collection of virtual servers which work together through Internet [4]. It offers hardware and software services provided by the data center. Software as Service (SaaS) is the delivery of application as service over the internet in this computing model. Cloud computing does not include private cloud; which refers to internal data center of an organization which are not accessible to the public [6][8].Public Cloud is available for the general public as pay-for-use model [1]; hence utility computing. So cloud computing is a combination of SaaS and utility computing [8].

Grid computing provides the platform to solve large scale resource intensive problems. It integrates widely distributed heterogeneous computational resources (like PC, workstations and clusters), data sources, storage systems, etc. and presents them as unified resource [21]. Grid computing allows to run an existing application on different a machine to exploit the underutilized grid resources, to aggregate the machine's unused storage. In case of unexpected peaks of activity grid provides the load balancing of wider resources. Collaboration among wider audience is an important feature of grid computing and it can be achieved by organizing grid users dynamically into virtual organizations each having its own policies. Resources are shared by these virtual organizations [22].

The perspective of this paper is to map the layers of cloud architecture with grid architecture in terms of their services and also to find out their functionality differences. This approach could be beneficial for academia for better understanding of these computing models.

II. CLOUD COMPUTING ARCHITECTURE

We are using four-layered cloud computing architecture [5], for the software which require on demand services over Internet. Figure 1 shows different layers of cloud architecture.

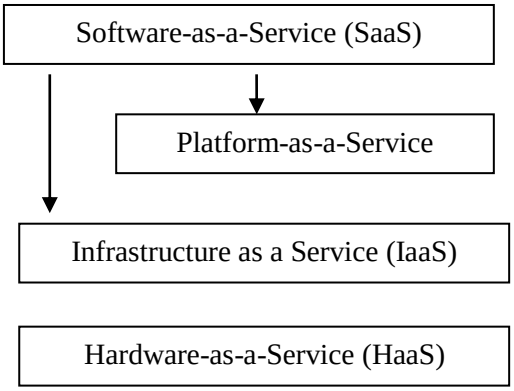

Figure 1: Cloud Architecture

Hardware-as-a-Service (HaaS): HaaS is a backbone of the cloud comprising of actual hardware. Large enterprises are responsible to operate, manage and upgrade the hardware [15].

Infrastructure as a Service (IaaS): IaaS delivers hardware components (like server and storage) and software as services [12]. Here usage-based pricing model allows the public to use infrastructure for computation and storage purpose [2]. Cloud software Infrastructure layer is composed of computational resources, storage and communication described as follows [15].

Computational Resources: This layer has become more efficient due to virtualization which allows higher utilization of resources [16]. Virtualization also protects the physical infrastructure of the data centers [15].

Storage: Data-Storage as a Service (DaaS), allows the user to remotely store and access the data anytime from anywhere. Cloud application scale extends beyond their limited server because of DaaS [15].

Communication: To achieve Quality of Service (QoS); service oriented, configurable, reliable, schedulable and predictable communication capability is provided by the cloud system [15]. Along with above communication capabilities, Communication as a Service (CaaS) allows the customers to practice cost effective enterprise level VoIP, VPN, PBX and unified communications without managing the expensive infrastructure [23].

Platform-as-a-Service (PaaS): Cloud application developers are the users of this layer [15]. Platform as a Service (PaaS) offers a sophisticated environment (comprising well defined APIs for interaction between environment and cloud application, to accelerate the deployment and support the scalability [15]) to cloud applications' developer to develop, test and deploy custom application [2]. Automatic scaling, load balancing and integration with other services (e.g. email services) are the major benefits to cloud application developer [15].

Software-as-a-Service (SaaS): Cloud SaaS provider hosts the software or an application and provide to the customer through Internet [17] with a usage-based pricing model [2]. It eliminates the burden of the customer from installation of the software on the local disk and reduces the purchase and maintenance cost of the customer [17]. Applications can be updated by the provider without shipping the updated versions to the customers. Customer of network-based application is completely dependent on the underlying network. In case of network failure user is unable to perform any work with application [16].

III. GRID ARCHITECTURE

Five layered grid protocol architecture [2] is being used to describe protocols and services provided by the grid. Fig. 2 describes the different layers of grid protocol architecture.

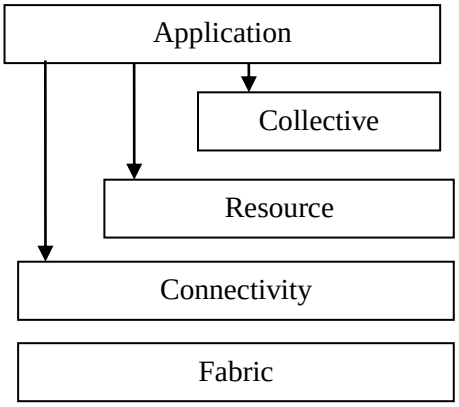

Figure 2: Grid Protocol Architecture

Fabric Layer: It is the lowest layer of grid architecture. To define the interface to local resources is the responsibility of this layer [10]. It includes all physical computational devices, storage system, and networks required by the user [18]. Grid network uses grid protocols for resource control [20].

Connectivity Layer: It contains communication and authentication protocols for successful and secure grid specific network transactions. Communication between fabric resources is possible due to communication protocols while authentication protocols provide the secure mechanism to identify the users and resources [18].

Resource Layer: Resource layer protocols offer secure initiation, monitoring, auditing and payment for sharing operation of single resource [11]. Handling a single resource is its main function [10].

Collective Layer: Collective layer is responsible for overall resource management and interaction across the collections of resources. Resource layer and connectivity layer protocols are used for communication [10].

> "Examples of collective services include directory and brokering services for resource discovery and allocation; monitoring and diagnostic services; data replication services; and membership and policy services for keeping track of who in a community is allowed to access resources." (Ian Foster)

Application Layer: At the top of the grid system, user application in virtual organizational environment can be constructed according to layer defined services [11].

IV. MAPPING

Table 1: Architecture Level Mapping

Service	Cloud Computing		Grid Computing	
	Layer	**Liability**	**Layer**	**Liability**
Hardware	Hardware-as-a-Service (HaaS)	Large Enterprises	Fabric	Grid Protocol
Communication	Infrastructure as a Service (IaaS)	Communication as Service (CaaS)	Connectivity& Collective	Connectivity and Resource Layer Protocol
Data Storage	Infrastructure as a Service (IaaS)	Data-Storage as a Service (DaaS)	Fabric	Interface to local Resources
Develop & Deploy Application	Platform-as-a-Service (PaaS)	Cloud Application Developer	Application	Virtual Organizational Environment
Pricing / Payment	Infrastructure as a Service (IaaS) & Software-as-a-Service (SaaS)	Cloud IaaS & SaaS Provider	Resource	Resource Layer Protocol

Application	Software-as-a-Service (SaaS)	Cloud SaaS Provider	Application	Virtual Organizational Environment

The above table describes the services offered by different layers of cloud architecture which lie on top of the services provided by various layers of grid architecture. It also depicts the enterprises, service providers, software and protocols which are responsible to offer these services.

V. FUNCTIONALITY DIFFERENCES

- Cloud based application can be used on any computer which has access to the Internet. Updated versions of the applications would be available to the user when accessing them on the cloud [7].
- User of grid computing has to first establish his identity on the grid and then he can install grid software on his machine to use the grid as well as donating to the grid [22].
- In contrast with the traditional software where user pays one time for unlimited use, cloud computing user has to pay the provider according to the consumption [2].
- Users of the grid can outline the capacity and availability of their resources and can set up grid credits and utilize them when they require additional resources [22].
- Users of cloud computing can store and access the data to and from remote storage disks [15].
- Every machine shares some quantity of its secondary or primary storage with the grid [22].
- Virtualization in cloud computing makes it possible to run multiple virtual machines on the same resource; by doing this higher utilization of resource can be achieved [15]. Since virtual machines are completely isolated with one another, so the applications based on different operating systems may be executed on the same physical resource [3].
- In grid computing, collaboration of geographically distributed individuals or institutes with common goal or objective as a single unified organization known as virtual organization [18].
- UCSB-IBM cloud computing classification model [15] depicts that the hardware, computational resources, storage, communication, software environment and applications are delivered as services to the users.
- Grid computing allows to exploit underutilized resources (e.g. run an existing application on idle machine, to aggregate the unused storage, load balancing on the resources),CPU intensive grid application to run on multiple CPU and to utilize the additional resources like special equipment, software, licenses and other services.

VI. CONCLUSION

This paper shows the overlapping of different layers of cloud and grid computing models in terms of their services. It is also found that these two models are different with each other in the use of application, price / brokering, data storage, computation, virtualization concept, providing services to the users and resource utilization.

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