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## Cloud Computing: An Overview

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**Abstract:** Cloud made it easy for an organization to increase its capability without actually adding new infrastructure, new software or updating existing technology; as it is Internet based system for providing services to the end users on pay per usage basis. Cloud computing reduces cost of computation & storage to a large extent and also improves productivity. From few days cloud has grown from a promising business application to fastest growing IT industries. Cloud offers services such as storage, computation & applications etc for different types of markets such as health care, net banking, several government organizations and other financial applications. Now many popular educational institutes and enterprises are also getting their applications and data shifted to the cloud. In this paper we summarize different classifications and service models of the cloud. In further sections major characteristics and working of cloud is discussed. Next section discusses the general implementation requirements for cloud computing. Also its comparison with the Grid computing is mentioned in next part. Like other online applications cloud computing security also has several downsides. In the last sections major benefits and downsides of cloud computing has been discussed.

**Keywords:** Cloud Computing, Security, Services, transparency, Private, Public, Community, Hybrid, Transparent, Hardware, Software, Grid

### I. Introduction

“A Cloud is a type of distributed and parallel system that consists of a collaboration of inter-connected and virtualized computers that are dynamically presented and provisioned as one or more unified computing resource(s) based on service-level agreements established through the negotiation between the consumers and the cloud service provider [1].” Saving your document to the Internet rather than saving it to computer memory is cloud computing. This will facilitate access to it from anywhere and through any device connected to the internet. A paradigm in which information is stored permanently and also replicated in servers on the Internet by the expert cloud providers and cached temporarily on clients that include entertainment centers, desktops, table computers, wall computers, notebooks, handhelds etc. In short it is model for convenient on-demand network access to sharable & configurable computing resources, such as information, services, applications, storage, and networks that can be easily released and provisioned with minimal service provider’s interaction [2]. Figure 1 shows how cloud computing can be used to access applications and data from any of the network devices.



**Figure 1:** Applications & data access from cloud through any network device.

Now cloud computing is also very successful in commerce field due to its scalability, cost effectiveness and flexibility. Cloud computing resources are provided in virtualized, massive and abstracted manner and all are managed by professional service providers in contrast to the conventional computing where everything is located at end user’s computer system and also managed by themselves [3]. So cloud computing has simplifies storage, distribution, operation and maintenance of information systems and also increases efficiency, availability and reliability of system while reducing its cost [4]. Cloud systems require less experience to work with it as they are very user friendly. It is capable of running the same program on many different connected computers at the same time.

According to [5], cloud computing is a shared pool of computing resources for on-demand networks. With minimal management efforts the resources like storage, services, servers and networks can be easily released and provisioned [6]. According to Wikipedia [7] cloud computing includes large group of computers those support Internet based computing, shares information, software, hardware and resources on demand. Cloud computing supports on demand capability, scalability and delivery of services on pay-as-you-go basis [8]. According to them cloud computing is: “A larger computing paradigm that is scalable and is driven by economies of scale, in which a pool of abstracted virtualized, storage, managed computing power, dynamically-scalable, services and platforms are delivered on demand to customers over the Internet in distributed environment”. Also cloud computing can be used to support cooperative and remote e-learning [9]. It benefits the e-learning by using centralized data storage, facilities for data access monitoring and virtualization and by directly providing educational services, platform and infrastructure to customers.

**Characteristics of Cloud Computing:**

Cloud computing implies 4 main characteristics as follows:

- The end user has “no-need-to-know” about the internal details of the cloud infrastructure. The application itself interfaces with it through the API (Applications Programming Interface).
- The Cloud is “transparent” for the end users and applications; that’s why cloud could be built in several ways. It could be on costumed hardware or software or branded products or off-the-shelf PCs. Usually, cloud is built of clusters of servers and Open Source software indulged with system software and/or in-house applications.
- The cloud provides “elasticity and flexibility” to the users to scale up and scale down in utilizing resources of all kinds (server capacity, databases, storage, load balancing etc.) according to their requirements.
- The cloud offers “Anywhere and always on” type of network based on the computing and the “pay as much as used and needed” type of utility computing to its customers.

**II. CLASSIFICATION OF CLOUD COMPUTING**

The cloud customers can access data, applications, software, servers and heterogeneous platforms as services without knowing where they are actually located [4]. It is classified on the basis of their service or deployment models. Its deployment models can be classified as private, public, community and hybrid cloud.

**A. Private Cloud:**

This type of cloud is rented and owned by an organization. The organization uses cloud resources for its private use only. These types of special clouds are personally built by an enterprise for serving their critical business processing needs.

**B. Public Cloud:**

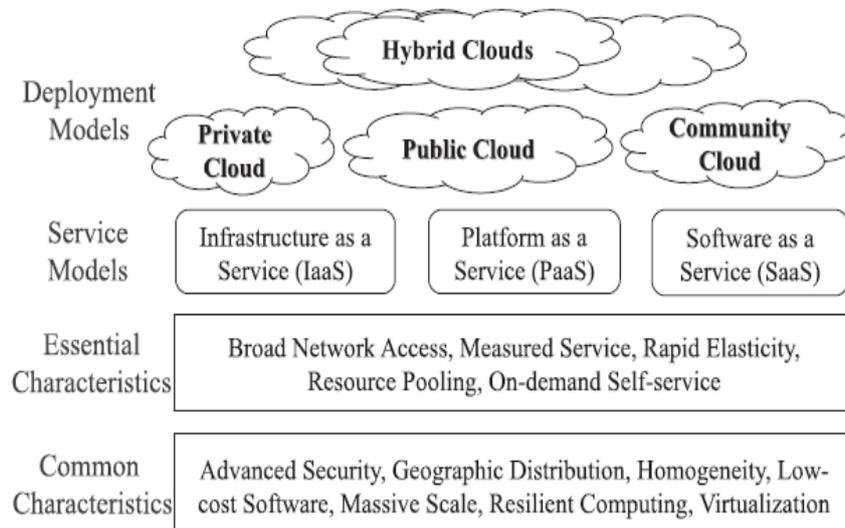
In this type of cloud all the resources are owned by cloud provider and they sell the resources to public on demand. End users can rent required resources and pay as per usage. Google, Amazon, Salesforce, Rackspace and Microsoft are some main examples of public clouds.

**C. Community Cloud:**

It is another type of Private cloud. But here cloud resources are shared among the members of a closed community having same resource requirements and interest. The *Media Cloud* is the example of community cloud setup by Siemens IT Solutions and Services [10]. This type of community cloud may be operated by collaborate efforts of all or by a third party alone.

**D. Hybrid Cloud:**

It is the collaboration of two or more above mentioned cloud infrastructures (private, community, or public). The sole purpose of hybrid cloud is to provide extra services and resources to end users to serve their high demands.



**Figure 2:** The cloud definition framework by NIST [11]

### III. Cloud Computing Service Models

All the cloud resources are provided as services to the end users. The service models of cloud computing are mainly Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

#### A. Software as a Service (SaaS):

All the applications running on the cloud are provided as the services to the end users. This eliminates the software up-gradation and software licensing investments for the clients. On the other hand cost of the cloud is rather low. Cloud also delivers business applications such as accounting, enterprise resource planning (ERP) and customer relationship management (CRM). The SaaS cloud's example includes Salesforce CRM [12] and Google Apps [13].

#### B. Platform as a Service (PaaS):

This service allows user to built applications using several software tools along with programming languages (e.g. Java, .Net, Python) and also deploy user's applications onto the cloud infrastructure. The user needs not to manage the cloud infrastructure, operating system and other requirements for them. The PaaS cloud's example includes Google App Engine [14] and Microsoft Windows Azure [15]

#### C. Infrastructure as a Service (IaaS):

By this user can use storage, network, servers, processing and other resources on rental basis. The user can run and deploy the applications and guest OS. The user does not control or manage the infrastructure but has control over applications, OS, storage etc. The PaaS cloud's example is Amazon EC2 [16].

### IV. How Cloud Computing Works

As an organization recruits new employees they also need to purchase computers, software or software licenses for them. They also need to check whether current software license allows another user [17]. But with cloud they only need to install an application for each new hiring. By this application workers can log into the cloud; as the cloud is hosting all the relevant programs for their jobs. Cloud is owned by another company called the cloud service provider. Cloud provides the shifting of workload from the user's computer to a remote application and also reduces software & hardware demands on user's side. The user only needs to run the system's interface software of cloud.

The cloud system includes several storage servers and a master control server. Using cloud information is stored at a remotely located database owned by a third party (i.e. cloud provider) instead of your computer's hard drive. The internet serves as a medium between the user and the cloud. The users can access their data from any location having internet access. They need not to carry bulky storage devices along. A group of persons belonging to the same project can have access to the same document; thus allowing collaborative efforts.

#### General Cloud Computing Architecture:

As consumers rely on cloud for services, they expect certain quality to be maintained by their provider [1]. Cloud provider needs to maintain quality parameters as negotiated in SLA. Many critical QoS parameters are considered for a service request, such as cost, time, trust/security and reliability. Due to continue changes in business requirements and operating environments the QoS requirements are never static they may change over time. It is valuable for clients as they pay only for services accessed only in the cloud.

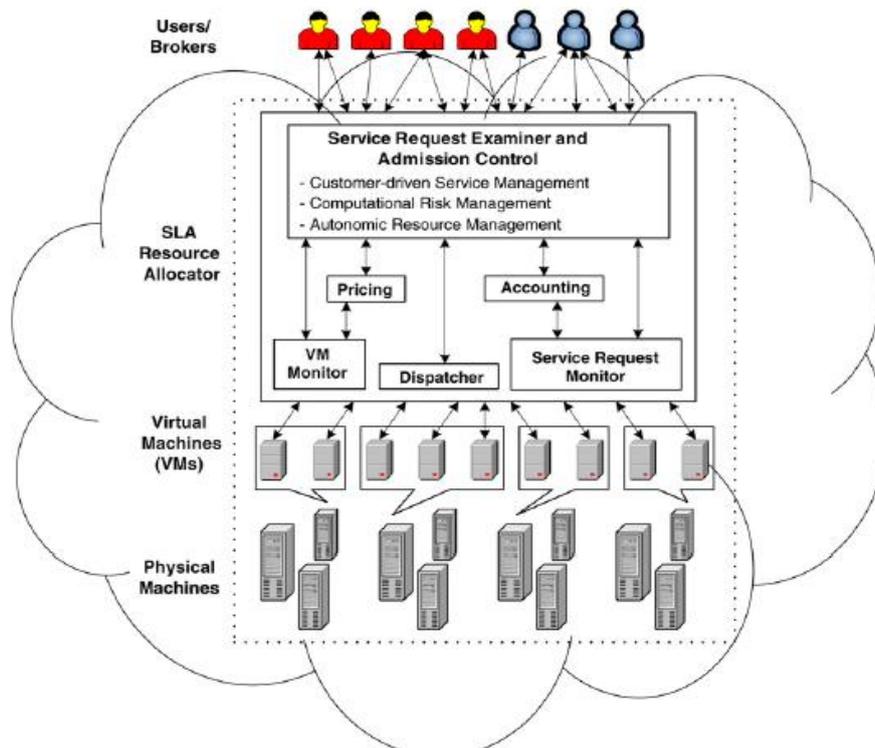


Figure 3: A typical cloud computing system architecture

Figure 3 depicts the high level architecture of cloud computing for resource allocation. Four main entities involved are [1]:

1) *Users/Broker*: They represent entity who submits requests for resources to the Cloud or Data Center from anywhere or any network device having internet access.

2) *SLA Resource Allocator*: This acts as the agreement between the cloud and the User/Broker for resource availability and quality of service. It requires interaction of Service Request Examiner and Admission Control, Pricing, Accounting, VM Monitor, Dispatcher and Service request monitor. *Service Request Examiner and Admission Control* examines each incoming request for QoS basis to accept or reject the request. *Pricing* mechanism considers how to charge each request. *Accounting* mechanism considers the actual usage per request. *VM Monitor* keeps track of the resource entitlements and availability of VMs. *Dispatcher* starts the execution of requests on VMs allocated for them. *Service Request Monitor* keeps track of the progress of every execution.

3) *Virtual Machines*: On a single physical machine number of VMs can be started and stopped on-demand to fulfill the accepted service request. Thus it provides flexibility to multiple VMs to run concurrently for different applications based on different operating systems environments.

4) *Physical Machines*: These are Data Centers containing number of computing servers providing resources for service requests.

#### Requirements for Cloud Computing Implementation:

Cloud delivers services in an on-demand environment. Several applications supported by the cloud must be secure, fast and always available [18]. For this, they need to build a dynamic and intelligent cloud infrastructure with four core properties in mind:

1) *Transparency*: Regardless of the physical implementation of the services within the cloud they must be provided transparently to its users. Their actual implementation is hidden from the end users. The entire cloud appears as a single resource to its customers. This creates a virtual environment for the end users.

2) *Scalability*: As number of potential customers is growing day to day every cloud must be scalable to handle their demands. Some application requires multiple servers for their functionality; cloud must be scalable enough to add more & more users to it and servers as well.

3) *Intelligent Monitoring*: To achieve the transparency and on-demand scalability every cloud requires intelligent monitoring. Moreover this intelligent monitoring is required at the control node to monitor the applications delivered. It is also required for monitoring of any overloaded server and also the network conditions. Control node monitors the behavior of all the nodes for any unexpected behavior.

4) *Security*: All services and associated data within the cloud are at risk if in any case the security of the cloud is compromised. That's why security is the main requirement. As control node is the first entry point; its security requirements are always high. All the potential threads must be handled carefully.

## V. GRID Vs CLOUD COMPUTING

A Grid is a kind of distributed and parallel system that supports the selection, sharing and aggregation of geographically distributed autonomous resources at the runtime dynamically based on their capability, availability, cost, performance and users' quality-of-service requirements [1]. Cloud computing is differentiated from the Grid computing due to virtualization [19]. Virtualization in the cloud computing maximizes its computing power. Cloud computing also increases utilization of resources by assigning several tasks to one server concurrently in contrast to grid computing where multiple servers are allocated single task. Generally, Grid is used merely for the job execution while cloud support long running applications. A comparison between them is depicted in table 1 given below.

**Table 1:** Grid and Cloud Computing Technically Compared

	<b>Grid Computing</b>	<b>Cloud Computing</b>
Utilization Process	Single task or job is allocated to multiple servers.	Virtualization of servers; several tasks are computed by single server concurrently.
Usage pattern	Typically grid is used only for the execution of job, i.e. the program is executed for a limited time.	Cloud is used frequently to support long-running services.
Abstraction Level	All high level details are exposed.	Cloud provides abstraction of higher-level.

## VI. BENEFITS OF CLOUD

Due to several advantages cloud computing has become the best choice for large organizations such as Yahoo, Facebook, Amazon & Google etc. It reduces the initial investments for a business so it is best for the startup users for their daily operations [4]. Now to reduce investments and operation costs most of the organizations are opting cloud and moving their data and applications to cloud. Cloud computing can assist one in their work due to following reasons:-

- **Anytime & Anywhere access:** One can access their data from anywhere if internet access is available, as it is stored at cloud not at any memory chip. This means user has no need to follow as data follows the user.

- **Updated copy access always:** Data owner is now free from the burden of storing multiple copies of data and keep them updating. The cloud maintains one copy that is accessible to user from any location. That's why cloud data is always the updated one.
- **Transferring the Risk:** With cloud user is free from the risk of data lose due to computer failure. Because data is updated and stored at cloud always. Data is maintained in versions at cloud. So user can recover data from its previous version if any version of a document is deleted. To implicitly copy selected files to the cloud, software (e.g. Drop-box) can be installed at the client side.
- **Online Editing:** Google Docs and Sky Drive provides Web based editors. A common group of people can work on same document such as Google doc. This will eliminate the need of mailing documents to each other.
- **Online collaboration:** In the past people used to email documents to each other for collaboration. This was hard to keep track of all the documents. With cloud computing there is need to email the link to the online version only, as only one copy of document is maintained.
- **Minimized Capital expenditure:** Cloud computing eliminates initial investments for a business and also reduces operational and maintenance expenditures. Also organization needs not to buy separate hardware, separate software or software licenses for their employees.
- **Location and Device independence:** End users can access services of cloud by login in from anywhere and through any device having internet access.
- **Utilization and efficiency improvement:** With cloud employees in an organization are free from the burden of data base management, licenses updating, software upgrades, and hardware requirements for any application etc. So employees can focus on their development work more efficiently.
- **Very high Scalability & Sustainability:** Consumers can scale up and scale down their usage of services in case their business demands triggers requirements to be changed.
- **High-level Computing power:** For every application access cloud provides higher level of computing power to the end users.
- **Increased Reliability:** Cloud enhances reliability and scalability of the business.
- **Increased pace of innovation & Environmentally Friendly:** Cloud is an upcoming service that supports innovation and as it reduces the consumption of resources it is environment friendly as well.
- **Recovery & Backups:** As data is not stored on local drives the process of recovering and backing up data is simplified. Flexible & reliable backup solutions are offered by several cloud providers [20].
- **Smaller learning curve:** Consumers feel ease to learn and adopt cloud computing for them [20].

## VII. DOWNSIDES OF CLOUD

As it is clear that cloud computing offers several benefits to its adapters. Still it has some problems and issues associated those can degrade its performance. Some of them are:

- **Service Availability:** If the cloud goes down for hours or more unexpectedly, it can affect the current business strongly [21]. Cloud services sometime may be unavailable due to number of reasons such as some failure at data center, failure of any equipment at client side, security attacks, network failure due to poorer weather conditions etc. [22].
- **Data mobility and ownership:** Who is actually the owner of the data? Will cloud actually delete all the records if the user has deleted some records not needed in future?
- **Privacy:** How the cloud companies are using and maintaining the data collected from different enterprises [21]?
- **No direct control:** When user moves services to the cloud, their direct control to them is over. It is troubling for some IT giants to adopt this [23].
- **Still need on-premises hardware, and an in-house IT staff:** Organization still require IT staff to support services. Sometimes users also need to add more processing servers of their own for proper functioning [23].
- **Possible downtime:** With Cloud computing business becomes totally dependent on the internet availability. One cannot access services offline.
- **Security issues:** How and where the data is actually stored? Is it safe there? So some users are not comfortable while storing their confidential data at cloud [24].
- **Cost:** Firstly cloud appears to be cheaper but cloud doesn't support all the features provided by a software solution installed at a local device [24].
- **Identity Management:** Along with the smooth availability of the service there must be a solid mechanism for identifying every external user [22]. So that authenticated consumer only pay for the services they have processed not for the services accessed by any intruder unknowingly.
- **Inflexibility:** User must be very careful while choosing a particular cloud for their business. Cloud provides limited access to several applications. For ex. Google Docs spreadsheets can't accept documents created in any other format.
- **Lack of support:** There is no other supporting organization for cloud providers in case of any problem [24].
- **SLA Negotiation:** It acts as the compromise between the demands and the needs of both consumer and the provider [22]. Some QoS aspects of the SLA are difficult to impose depending upon the network conditions such as throughput, response time etc.

### VIII. Conclusion

Cloud offers resources sharing in a cost effective and independent way. Through cloud providers are sharing their resources and capabilities with external users on rental basis. Surely, many organizations are benefitting from Cloud computing, as cloud provides facility to run OS for several servers on Virtual machine. Apart from multinational organizations several small enterprises and educational institute are also using cloud services. Now employees can focus on planning and development work instead of wasting time for managing data and other resources. Although cloud's benefits are very appealing, but in distributed environment nothing can be hundred percent secure. There are several risks involved in the cloud. The problems discussed in this paper have made adaptation of hybrid and public cloud difficult. Still numbers of new providers are coming to this business. This increases competition among different cloud providers. So the companies are getting better offers from their cloud providers. So proper care must be taken while putting crucial data into the cloud and also while negotiating for SLA with the provider. The cloud providers must ensure certain QoS and security aspects in SLA so that any of the organization could feel relax while adopting cloud services for their business.

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