



**ALL ABOUT THE CLOUD: CHARACTERISTICS, INFRASTRUCTURE AND APPLICATIONS**

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**Abstract**

*Cloud computing is a computing model in which a large pool of systems are connected in personal or public networks, establishing a dynamically scalable and manageable infrastructure for application, data and file storage. The technology of cloud has reduced the cost of application hosting, content storage, computation and delivery significantly. The paper discusses the important characteristics of the Cloud and its infrastructure. It describes how it is implemented & deployed using different service models. Also discussed are some of the popular applications of Cloud Computing & its applications in areas of Indian context, viz. E-Governance and Rural Development. The paper concludes that although cloud computing is still in its infancy but it is clearly gaining momentum. There are some crucial issues to be solved to successfully deploy cloud computing for the social purposes, but they can be addressed only after detailed study in the subject.*

*Keywords—* agglomeration, service models, IaaS, cloud client, serverless computing, data-centres

**1. INTRODUCTION**

The word "cloud" is commonly used in science to describe a large agglomeration of objects that visually appear from a distance as a cloud and describes any set of things whose details are not further inspected in a given context[1]. Cloud computing is a computing on Internet that provides shared computing resources and data to computers and other devices on demand. It enables on-demand access to a shared pool of configurable computing

resources (e.g., computer networks, servers, storage, applications and services), which can be rapidly provisioned and released with minimal management effort[2].

The technology of Cloud helps companies in reducing infrastructure costs (e.g., purchasing servers). As well, it enables organizations to focus on their core businesses instead of spending time and money on computer infrastructure. Enterprises get their applications running faster, with improved

manageability and less maintenance with the help of cloud technology[3][14].

The term “cloud”, as used in this paper, originated from network diagrams that represented the Internet. “Cloud computing” was coined for what happens when applications and services are moved into the internet “cloud.” It may trace back to a time when computer systems remotely time-shared computing resources and applications[7]. More currently though, cloud computing refers to the many different types of services and applications being delivered in the internet cloud. In many cases, the devices which used to access these services and applications did not require any special applications. (Ref Figure- 1)

## 2. CHARACTERISTICS

Cloud computing is characterized by the following features:

### A. Shared Infrastructure & Resource Pooling —

Uses a virtualized software model, enabling the sharing of physical services, storage, and networking capabilities.

**B. Dynamic Provisioning & Flexibility—** Allows for the provision of services based on current demand requirements using software automation, enabling the expansion and contraction of service capability, as needed.

**C. Wide Network Access—** Needs to be accessed across the internet from a broad range of devices

such as PCs, laptops, and mobile devices, using standards-based APIs (for example, ones based on HTTP).

**D. Managed Metering —** Uses metering for managing and optimizing the service and to provide reporting and billing information.

**E. Cost reductions—** A public-cloud delivery model converts capital expenditures (e.g., buying servers) to operational expenditure.

**F. Device and location independence —** Enables users to access systems using a web browser regardless of their location or what device they use

**G. Easier Maintenance—** Its applications are easier to maintain because they do not need to be installed on each user's computer and can be accessed from different places(e.g., different work locations, while travelling, etc.)[3][5].

## 3. CLOUD INFRASTRUCTURE

### A. The Stakeholders of Cloud

There are three types of stakeholders :

Cloud providers, Cloud users and the End user :  
 Cloud providers provide cloud services to the cloud users. These cloud services are of the form of utility computing i.e. the cloud users uses these services pay-as-you-go model. The cloud users develop their product using these services and deliver the product to the end users.

### B. Cloud clients

Users access cloud computing using networked client devices, such as desktop computers, laptops, tablets and smartphones and any Ethernet enabled device. Some of these devices—*cloud clients*—rely on cloud computing for all or a majority of their applications so as to be essentially useless without it. Many cloud applications do not require specific software on the client and instead use a web browser to interact with the cloud application. (Ref Figure-2)

### C. Service models

The cloud vendors offer their "services" according to different models, of which the three standard models per NIST are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

The NIST's definition of cloud computing defines the service models as follows [2][10]:

**1) Software as a Service (SaaS) :** The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible

exception of limited user-specific application configuration settings.

**2) Platform as a Service (PaaS) :** The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

**3) Infrastructure as a Service (IaaS) :** The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls). (Ref. Figure- 3)

### D. Serverless computing

Serverless Computing is a cloud computing code model in which the cloud provider fully manages starting and stopping virtual machines as necessary

to serve requests, and requests are billed by an abstract measure of the resources required to satisfy the request, rather than per virtual machine, per hour. It is so named because the business or person that owns the system does not have to purchase, rent or provision servers or virtual machines for the back-end code to run on.[6][8]

#### 4. DEPLOYMENT MODELS

##### *A. Private cloud*

Private cloud is cloud infrastructure operated solely for a single organization, whether managed internally or by a third-party.. Self-run data centers are generally capital intensive. They have a significant physical footprint, requiring allocations of space, hardware, and environmental controls. These assets have to be refreshed periodically, resulting in additional capital expenditures.

##### *B. Public cloud*

A cloud is called a "public cloud" when the services are rendered over a network that is open for public use. Public cloud services may be free.. Generally, public cloud service providers like Amazon Web Services (AWS), Microsoft and Google own and operate the infrastructure at their data-centres and access is generally via the Internet[3].

##### *C. Hybrid cloud*

Hybrid cloud is a composition of two or more clouds (private, community or public) that remain distinct entities but are bound together, offering the benefits of multiple deployment models.

##### *D. Others*

###### *1) Community cloud*

Community cloud shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party, and either hosted internally or externally.

###### *2) Distributed Computing*

A cloud computing platform can be assembled from a distributed set of machines in different locations, connected to a single network or hub service.

###### *3) Intercloud*

The Intercloud is an interconnected global "cloud of clouds" and an extension of the Internet "network of networks" on which it is based. The focus is on direct contact between providers and consumers (as is the case for hybrid- and multi-cloud).

###### *4) Multicloud*

Multicloud is the use of multiple cloud computing services in a single heterogeneous architecture to reduce reliance on single vendors, increase

flexibility through choice, mitigate against disasters, etc. [2][9] (**Ref Figure- 4**)

## 5. POPULAR CLOUD APPLICATIONS

### A. Amazon EC2 and S3 Services

*Amazon Elastic Computing (EC2)* is one of the biggest organizations to provide Infrastructure as a Service(IaaS). They provide the computer architecture with XEN virtual machine. The clients can install their suitable operating system on the virtual machine.

EC2 uses Simple Storage Service (S3) for storage of data. Users can hire suitable amount CPU power, storage, and memory without any upfront commitment. Users can control the entire software stack from kernel upwards.

Elastic Compute Cloud , EC2 rents cloud of computers to the users with flexibility of choosing the configuration of the virtual machine like RAM size, local disk size, processor speeds etc[13].

### B. Google App-Engine

Google App-Engine is a platform for developing and deploying web applications in Google's architecture. This provides Platform as a Service(PaaS) to the cloud users. Google App-Engine provides automatic scalability, persistent data storage service. Data store features a query engine and transaction capabilities.

### C. Windows Azure

Windows Azure is an intermediate in the spectrum of flexibility vs programmer convenience. These systems use .NET libraries to facilitate language independent managed environment. This service falls under the category of Platform as a Service(PaaS). By using this service customers can use it to run applications and store data on internet accessible machines owned by Microsoft.Windows Azure platform provides three fundamental components - compute component, storage component and fabric component[11][12].

## 6. CLOUD COMPUTING APPLICATIONS IN INDIAN CONTEXT

Today most of the studies in cloud computing is related to commercial benefits. But this idea can also be successfully applied to non-profit organizations and to the social benefit. In the developing countries like India , cloud computing can bring about a revolution in the field of low cost computing with greater efficiency, availability and reliability.

### A. Cloud Computing & E-Governance

E-Governance is an interface between Government and public or between two governments or between government and business organizations. Objectives are generally to improve efficiency and effectiveness to serve public demand and to save costs for online services.E-Governance refers to the processes and structures needed to deliver electronic services to the

public (citizens and businesses), collaborate with business partners and to conduct electronic transactions within an organizational entity. This E-Governance can be greatly improved by cloud computing[2][7].

Cloud Computing can be advantageous to e-governance in following ways :

- 1) *Scalability*-The data centers of cloud have enough computing and storage capacity to cope up with the spike demand.
- 2) *Modifiable* -Applications hosted in cloud can be modified internally without too much concern of the end users. Change in one place would reflect in all the places inherently and it would be consistent.
- 3) *Data logging* – This central facility can be very useful for locating any fault in the system, for detecting unauthorized usage checking or detecting compromization.
- 4) *Availability* - If any data center is down for any reason there is hot backup ready to work immediately.
- 5) *Reliability* –Replication and migration of instances across data centers make the reliability of the system very high in the cloud scenario.
- 6) *Physical disaster recovery* –Backup policies can be very useful for physical disaster avoidance. Data is stored in different physical location so that hot backup can be provided whenever needed.

7) *Pay model* –Cloud providers’ pay-as-you-use model enables the customer (Government) to reduce cost of deployment and control the usage.

8) *Reduce power consumption* –Adaptation of cloud reduces power consumption in different offices and usage of power is concentrated in the data center only. But also that is not the concern of the government as those data centers are to be handled by the third party who provides cloud services.

### ***B. Rural Development***

In the context of rural development cloud computing can also be used to success for its centralized storage and computing facility and utility based pay model. We’ll now discuss the technological and economic advantages for using cloud in rural models :

- 1) *No upfront commitment* – The villagers need not to invest too much to buy computing system and commit. But instead they can have very low cost terminals with basic functionality of I/O and have a network access.
- 2) *No maintenance issues* – The users need not to be an expert for maintenance. This solves the unavailability of technical experts in the remote villages as the maintenance issues are handled by the cloud provider explicitly.
- 3) *Upgraded version of hardware and software* – The users always use the up-graded version of

software and hardware as maintained by the cloud provider. This reduces the cost of up gradation.

4) *On-demand resource allocation* – The virtual resources can be extended as needed. If the user needs more resource then it is provided on demand basis.

5) *Utility computing model* – The economic model used by the cloud is pay-as- you-use. This enables the users handle the cost they have to pay.

By using cloud computing model some improvement of the current system is possible to bring about social and as well as economic prospect in rural India[3][11][14]..

### C. Miscellaneous

Cloud Computing can be employed in following areas :

1) *Health and medical services* – Consultation among doctors around the world make sharing of knowledge possible and takes telemedicine to the next level, creating a network that goes beyond the one-to-one, patient- to-patient, patient-to-doctor or doctor-to-doctor interactions. In this way a patient suffering from a particular disease can be better treated by consulting with doctors within region and also outside who may have more experience with such a case.

2) *Education in remote areas*– Education in rural areas can be enhanced with the help of distance

education. Education can be provided in different languages and with respect to different curriculum with the aid of e-learning components. Students can be encouraged to build their own multimedia presentations. These can be hosted in the cloud. This type of approach encourage the students to concentrate more on learning .

3) *Government decision making*– Looking at the common knowledge base the Government can have a fair knowledge of the local situation and take adoptive steps.

4) *Access to Information hub* – Government can provide relevant information such as land revenue data, weather data, soil information etc. through these cloud services to the people concerned.

India is now world’s second fastest growing economy. In India there is very large scope of applying IT in domestic level and that encouraged the cloud providers to establish cloud services in India[5][8]. Today companies like Reliance, TATA, Zenith Computers, Wipro Technologies, Netmagic Solutions, and Reliance are providing cloud services in India successfully. These companies can grasp the huge market in the rural India as well as making social development.

## 7. LIMITATIONS & DISADVANTAGES

In cloud computing, the control of the back end infrastructure is limited to the cloud vendor only. Cloud providers often decide on the management policies, which moderates what the cloud users are able to do with their deployment. Cloud users are also limited to the control and management of their applications, data and services. This includes data caps, which are placed on cloud users by the cloud vendor allocating certain amount of bandwidth for each customer and are often shared among other cloud users.[5][12]

Privacy and confidentiality are big concerns in some activities. For instance, sworn translators working under the stipulations of an NDA, might face problems regarding sensitive data that are not encrypted.

## 8. EMERGING TRENDS

Cloud computing is still a subject of research. A driving factor in the evolution of cloud computing has been chief technology officers seeking to minimize risk of internal outages and mitigate the complexity of housing network and computing hardware in-house. Major cloud technology companies invest billions of dollars per year in cloud Research and Development. For example, in 2011 Microsoft committed 90 percent of its \$9.6 billion budget to its cloud. Research by investment bank Centaur Partners in late 2015 forecasted that SaaS revenue would grow from \$13.5 billion in 2011 to \$32.8 billion in 2016 [6].

## 9. CONCLUSION

Cloud computing is a newly developing paradigm of distributed computing. Virtualization in combination with utility computing model can make a difference in the IT industry and as well as in social perspective. Organizations like Google, Yahoo, Amazon are already providing cloud services. The products like Google App-Engine, Amazon EC2, Windows Azure are capturing the market with their ease of use, availability aspects and utility computing model. Users don't have to be worried about the hinges of distributed programming as they are taken care of by the cloud providers. Business organizations are also showing increasing interest to indulge themselves into using cloud services. In developing countries like India cloud computing can be applied in the e-governance and rural development with great success. Although there are serious challenges to deployment of the Cloud, after detailed study of the subject it can be implemented successfully.

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## LIST OF FIGURES

### Figure- 1. The Domain of Cloud Computing

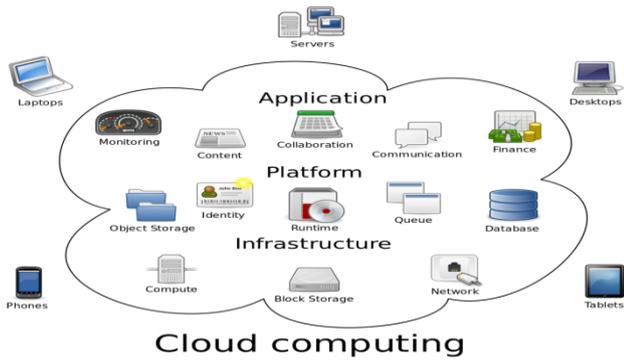


Figure- 2. The Infrastructure of a Cloud

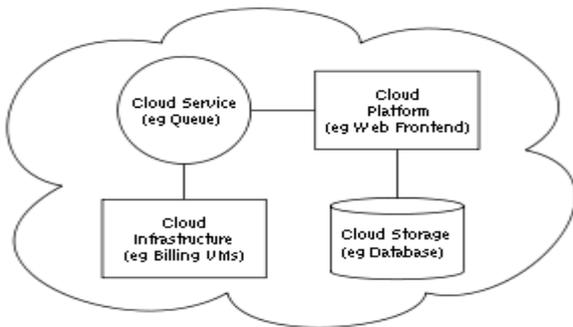


Figure- 3. Service models

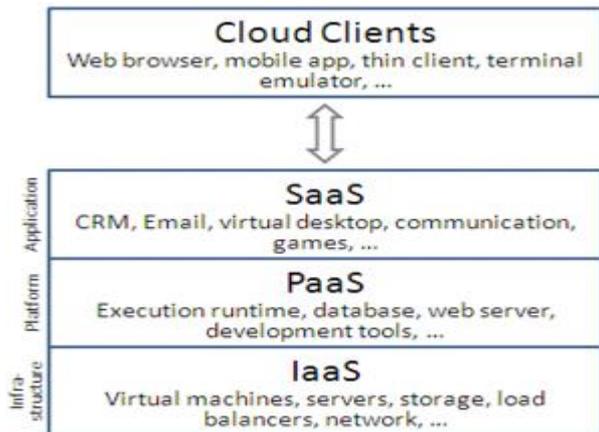


Figure- 4. : Types of Cloud

