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Cloud Computing Characteristics and Services: A Brief Review

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Abstract – This study helps organizations and individuals understand how cloud computing can provide them with reliable, customized and cost-effective services in a wide variety of applications. In this paper, we have tried to explore various cloud computing services, applications and characteristics; we give various examples for cloud services delivered by the most common Cloud Service Providers (CSPs) such as Google, Microsoft, and Amazon. We have also discussed cloud computing service models and their benefits.

Keywords – Cloud Computing, Virtualization, Data recovery, E-Governance, Service provider.

I. INTRODUCTION

Cloud computing in simple terms means storing and accessing data and programs over the Internet instead of our computer's hard drive. The cloud is just a metaphor for the Internet. In a computer network we typically represent the internet as a cloud as shown in figure.

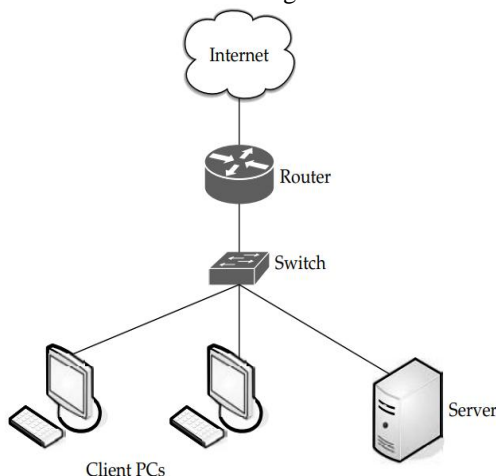


Fig1: Internet is depicted by a cloud in a network

Cloud Computing is the use of hardware and software to deliver a service over a network (typically the Internet). With cloud computing, users can access files and use applications from any device that can access the Internet. An example of a Cloud Computing provider is Google's Gmail.

(The NIST Definition of Cloud Computing) Cloud computing is a model for enabling ubiquitous, 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. This cloud model is composed of five essential characteristics, three service models, and four deployment models. [1]

Cloud Service Providers (CSPs) (e.g., Google, Microsoft, Amazon) are vendors who provide to their customers the facilities of cloud computing resources and services that are dynamically utilized based on customer's demand according to a certain business model [2]. Services in different areas such as business, education and governance are provided to the customers online and are accessed via internet using a web browser, while data and software programs are stored on the cloud servers located in the data centres [3].

Cloud computing has made a major breakthrough in the IT sector. With its emergence it has truly revolutionized the IT sector. It has played an important role in catering to the increasing demands for storage and infrastructure. The exceptional capability of cloud is its ability to provide resources like hardware and software over a network. There exists number of resources in cloud computing which can be hired on pay per use basis. Broadly we can divide the cloud as [4]:

1. **Private cloud:** This type of cloud works for a defined organization or business, e.g. cloud for a specific organization.
2. **Public cloud:** Public clouds are easily available from Google, Amazon, Microsoft, etc. Public cloud provides

infrastructure and services to the public or any organization. Resources are shared by hundreds or thousands of people.

3. **Community cloud:** In a community cloud the services and infrastructure is provided to organizations with similar interests.

4. **Hybrid cloud:** This type of cloud is a mixture of private and public cloud. Though the clouds are mixed up, still each has its individual identity and therefore aiding multiple deployments.

Table 1: Comparison of Cloud Computing Service Models

<i>Model</i>	<i>Scope</i>	<i>Managed by</i>	<i>Security Level</i>
Public Model	General public and industries	Cloud service providers	Low
Private Model	Single organization	Single organization	High
Community Model	Organizations having similar policies and same security concerns	Many organizations or cloud service providers	High
Hybrid Model	Public and organization	Public and organization	Medium

Some common Cloud Service Providers

1. Google: This is a pure cloud computing service, with all the storage found online so it can work with the cloud apps: Google Docs, Google Sheets, and Google Slides. In fact, most of Google's services could be considered cloud computing: Gmail, Google Calendar, Google Maps, Picasa, Google Analytics and so on.

2. Apple iCloud: Apple's cloud service is primarily used for online storage, backup, and synchronization of your mail, contacts, calendar, and more. All the data we need remains available on iOS, Mac OS, or Windows device.

3. Amazon Cloud Drive: Storage at the big retailer is mainly for music, preferably MP3 that you purchase from Amazon, and images - if you have Amazon Prime, you get unlimited image storage. It's essentially storage for anything digital you'd buy from Amazon, baked into all its products and services.

II. CLOUD COMPUTING TECHNOLOGY

Cloud computing is not a single piece of technology, like a microchip or a cell phone. Rather, it's a system, primarily comprised of three services: infrastructure as a service (IaaS), software as a service (SaaS) and platform as a service (PaaS).

Cloud computing is becoming the usual and standard way for technology companies to access informational technology infrastructure such as software and hardware

resources. The cloud technology enables companies to be able to utilize the services managed by third party companies. Cloud computing systems are particularly established for business or research purposes. Cloud computing helps business establishments to work more efficiently and save on software and hardware that are important for different operations to run effectively [5].

Companies can use cloud computing to increase their IT functionality or capacity without having to add software, personnel, invest in additional training or set up new infrastructure.

III. CLOUD COMPUTING SERVICE MODELS

The basic cloud computing models include the following:

A) Infrastructure as a Service (IaaS)

In (IaaS) the cloud service provider provides a set of virtualized computing resources like CPU, Memory, OS, and Application Software etc in the cloud. IaaS uses virtualization technology [6] to convert physical resources into logical resources that can be dynamically provisioned and released by customers as needed. Some of the major companies offering infrastructure as a service include Rackspace Cloud Servers, Google, Amazon EC2, IBM, and Verizon.

Benefits of IaaS Solutions

- Reduces cost of capital expenditures.
- Users pay for the service they want.
- Access to enterprise-grade IT resources and infrastructure.
- Users can scale up and scale down the resources based on their requirements at any time.

B) Platform as a Service (PaaS)

This is more advanced type of cloud computing service. In PaaS, a cloud service provider offers, runs and maintains both system software (i.e., the operating system) and other computing resources. PaaS services include design, development and hosting of applications. Other services include collaboration, DB integration, security, web service integration, scaling etc. Users don't need to worry about having their own hardware and software resources or hire experts for management of these resources. This scheme provides flexibility in installing software on system; scalability is another advantage of the PaaS. A downfall of the PaaS is the lack of interoperability and portability among providers.

Consumers purchase access to the platforms, enabling them to deploy their own software and applications in the cloud. Examples of PaaS solutions include Rackspace Cloud Sites, Salesforce.com's [Force.com](https://www.salesforce.com) and Google App Engine, Microsoft Azure.

Benefits of PaaS Solutions

Community – Most of the time, many people are involved in building cloud applications in PaaS environments. This creates a strong supportive community that can help your development team along the way.

No more upgrades – Companies are not required to update or upgrade the infrastructure software. Instead, the PaaS provider handles all upgrades, patches and routine software maintenance.

Lower cost – Companies face lower risk since they do not have to make upfront investment in hardware and software.
Simplified deployment – The development team can concentrate on developing the cloud application without having to worry about the testing and deployment infrastructure.

C) Software as a Service (SaaS)

In this model, cloud service providers are responsible for running and maintaining application software, operating system and other resources. SaaS model appears to the customer as a web-based application interface where internet is used to deliver services that are accessed using a web-browser. The hosted applications like Gmail and Google Docs can be accessed through different devices like smart phones and laptops etc. Unlike traditional software, SaaS has the advantage that the customer does not need to buy licences, install, upgrade, maintain or run software on his own computer [7]. It has also other advantages such as multitenant efficiency, configurability and scalability [8].

Benefits of SaaS Solutions

- Rapid Scalability
- Accessibility from any location with Internet
- Eliminates infrastructure concerns
- Custom levels of service offerings
- Bundled maintenance and Support

D) Recovery as a Service (RaaS)

Recovery as a Service (RaaS) solutions helps companies to replace their backup, archiving, disaster recovery and business continuity solutions in a single, integrated platform. RaaS providers help companies recover entire data centers, servers (OS, applications, configuration and data), and database files.

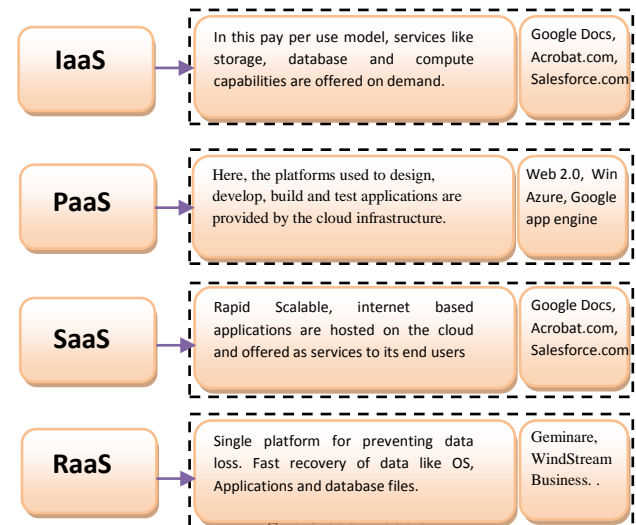
RaaS helps business establishments in reducing the impact of downtime in case of disasters or like situations. RaaS is also called as DRaaS (Disaster Recovery as a Service) Example of companies doing RaaS is WindStream Business, Geminare etc.

Benefits of RaaS Solutions

- Prevent temporary or permanent loss of critical company data.

- Prevents permanent loss of physical infrastructure, including IT infrastructure.
- Cost-effective way of recovering data.
- Enables faster recovery while maintaining accuracy.
- Offer greater flexibility on the type of backup required (either primary or secondary backup)

Businesses can benefit from cloud services by improving efficiency and reducing costs. Based on their priorities different companies can adopt various cloud services, business processes and areas of expertise. Careful planning and preparation should be adopted in case with an IT project before switching to cloud services.



IV. CHARACTERISTICS OF CLOUD COMPUTING

Cloud computing systems satisfy many interesting characteristics that make them promising for future IT applications and services. The National Institute of Standard and Technology (NIST) [9] have defined five essential characteristics for cloud computing systems [10, 11, 12, 13, 14] and we describe them below:

- **On-demand self-service:** cloud services such as CUP time, Storage, network access, server time, web applications etc can be allocated automatically as required by the consumers without any human interaction.
- **Cost effectiveness:** Services provided by the cloud service providers are very cost effective if not free. The billing model is pay as per usage; there is no need to purchase the infrastructure and therefore lowers maintenance cost.
- **Broad Network Access (mobility):** consumers can access cloud resources over the Internet all the time and from anywhere (i.e., ubiquitous) through different types of devices (e.g., mobile phones, laptops, and PDAs).

- **Resource Pooling:** physical and virtual computing resources are pooled into the cloud. These resources are not dependent on location in the sense that the customer has no control nor has knowledge over their location.

- **Rapid Elasticity:** computing resources can be rapidly and elastically provisioned and released based on the demand of the consumer. Consumers view these resources as if they are infinite and can be purchased in any quantity at any time.

- **Measured Services:** cloud resources and services are monitored, controlled and optimized by the CSPs through a pay-per-use business model. Consumers utilize these services in a way similar to utilizing electricity, water and gas. Other cloud computing characteristics are [15, 16]:

- **Multitenancy:** a cloud provides services to multiple users at the same time. Those users share cloud resources at the network level, host level and application level, however, each user is isolated within his customized virtual application instance.

- **Scalability:** the infrastructure of cloud computing is very scalable. Cloud providers can add new nodes and servers to cloud with minor modifications to cloud infrastructure and software.

- **Reliability:** is achieved in cloud computing by using multiple redundant sites. High reliability makes the cloud a perfect solution for disaster recovery and business critical tasks.

- **Economies of scale:** in order to take advantage of economies of scale, clouds are implemented to be as large as possible. Other considerations are also taken to reduce cost such as locating the cloud close to cheap power stations and in low cost real estate.

- **Customization:** a cloud is a reconfigurable environment that can be customized and adjusted in terms of infrastructure and applications based on user demand.

- **Efficient resource utilization:** delivering resources only for as long as they are needed allows for efficient utilization of these resources.

- **Virtualization:** Cloud computing makes user gets service anywhere, through any kind of terminal. The resources it required come from cloud instead of visible entity. You can complete all you want through net service using a laptop or a mobile phone. Users can attain or share it safely through an easy way, anytime, anywhere. Users can complete a task that can't be completed in a single computer.

V. APPLICATIONS OF CLOUD COMPUTING

Cloud Computing is one of the most dominant field of online computing because resource sharing and its management is easy using cloud. Therefore cloud computing has its importance in the following fields:-

A) E-Learning

As for as Education is concerned this field provides an attractive environment to students, researchers and faculty members. Students, faculty members and researchers can connect to the cloud of their organization and access data and information from there.

B) E-Governance

The government can improve its functioning by introducing cloud computing. This way the services provided by the various government organizations can be delivered in an improved and more sophisticated way. Cloud computing will also cut off the burden of managing, installing and upgrading applications.

C) Enterprise resource planning (ERP)

When the business of an organization grows up the use of Cloud in ERP comes into existence. The work of managing applications, human resources, payroll etc becomes expensive and complex. To overcome such problems the service providers can install ERP in the cloud itself.

Table 2: Different applications of cloud computing.

Application	Service Delivered
E-Learning	E-mail, simulation tools, files broadcasting, class recording, virtual classrooms, virtual labs, surveys, education forums etc.
E-governance	Complaint resolution system, employee management system, E-police, E-Tendering, E-court, payment and tax system, agriculture and food, industry and energy etc.
ERP Cloud	Supply chain and vendor, project and HR Management, customer Relationship management, finance and accounting etc.

VI. CLOUD COMPUTING CHALLENGES

Despite its growing influence, concerns regarding cloud computing still remain an issue. Some common challenges are:

A) Data Protection

Data Security is a crucial element that must always be taken into consideration. Organizations are reluctant to buy an assurance of business data security from vendors. They fear

losing data to competition and the data confidentiality of customers. In many instances, the actual storage location is not disclosed, adding onto the security concerns of organization. In the existing models, firewalls across data centers (owned by enterprises) protect this sensitive information. In the cloud model, Service providers are very much responsible for providing data security and enterprises would have to rely on them.

B) Data Recovery and Availability

All business applications have Service level agreements (SLA) that are strictly followed. Operational teams play an important role in management of service level agreements and runtime governance of applications. In production environments, operational teams support:

- Data Replication
- Appropriate clustering and Fail over
- System monitoring (Transactions monitoring, logs monitoring and others)
- Disaster recovery
- Capacity and performance management
- Maintenance (Runtime Governance)

If, any of the above mentioned services is under-served by a cloud provider, the damage & impact could lead to a data disaster.

C) Management Capabilities

Despite there being multiple cloud providers, the management of infrastructure and platform is still in its infancy. Features like dynamic-scaling, dynamic-resource allocation for example, are a crucial requirement for many enterprises. There is huge potential to improve on the scalability and load balancing features provided till date.

D) Regulatory and Compliance Restrictions

In some of the European countries, Government regulations do not allow customer's personal information and other sensitive information to be physically located outside the state or country. In order to meet such requirements, cloud providers need to setup a data center or a storage site exclusively within the country to comply with regulations. Having such an infrastructure may not always be feasible and is a big challenge for cloud providers.

With cloud computing, the action moves to the interface – that is, to the interface between service suppliers and multiple groups of service consumers. Cloud services will demand expertise in distributed services, procurement, risk assessment and service negotiation – areas that many enterprises are only modestly equipped to handle.

VII. CONCLUSION AND FUTURE WORK

Cloud computing is an emerging technology which is expected to rapidly change the IT field in the next couple of

years. Various applications and services can be provided in the Cloud due to its various promising and interesting characteristics, services and applications. In this paper, we explored some of these characteristics, services and applications and we are quite sure that many others will be explored in the near future. Cloud services and applications are expected to attract many organizations and individuals from different disciplines and our study helps them understand the impact of these services on their business, however, cloud computing technology is not free of risks and concerns. Security and privacy issues continue to be the biggest concern on cloud computing that limits its adoption in practice. The future work in cloud computing will certainly focus on developing various approach that are able to address its security issues. In our future work, we would like to address the security problem in cloud computing and would try to propose a framework and a security model that address the security threats and mitigate risks associated with cloud computing.

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Dr. Amit Chaturvedi obtained the Ph.D. degree in Mar, 2012. He is presently teaching in the Govt. Engineering College, Ajmer. He has 17 years long PG teaching experience. Five doctorate degrees are awarded under his supervision. He has published around 71 research papers in national/international Journals and conference. He has written three text books in the computer science subjects. Presently he is working on the subjects of cloud computing and multicast communication in adhoc networks.

