Cloud Computing: Types, Characteristics, Services and Applications

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Abstract : Cloud computing is an evolving paradigm which offers great computational power to the organizations which require processing of large amount of data. The growth of high speed networks have led to the rise in the concurrent transactions a day. Cloud computing is architecture for providing computing service via the internet using the central remote servers to maintain data and applications. We are in unprecedented times in view of the recent outbreak and far-reaching spread of the Corona virus, which leads us to respond to new work settings, including a remote work environment and virtualization. With increase in computer and Mobile user's, data storage has become a priority in all fields. Cloud computing is the on-demand availability of system resources, especially data storage and computing power without direct active management by the user. It allows access to a pool of shared resources namely networks, storage, servers, services and applications, without physically acquiring them. Users can store, access, and share any amount of information in cloud. The data is secured and can access anytime and from anywhere. This paper presents the basics of cloud computing, it's types, characteristics, services and applications in various sectors.

Keywords - **Cloud computing, architecture, deployment models, service models, pay-per-use, Resource Pooling.**

I. INTRODUCTION

Cloud computing is a set of resources that are offered to the users through the network. Here the term cloud represents internet or network. Cloud Computing refers to manipulating, configuring, and accessing the hardware and software resources on the remote servers that are hosted on internet instead of computer's hard drive. It offers online data storage, infrastructure, and application.

Fig.1:Client-server architecture of cloud computing

Cloud computing is considered as a client-server architecture (Figure 1) where the servers which collectively called as the cloud reside remotely and are accessed via the internet. It act as a virtual platform that allows us to store, access, and share data anytime and from anywhere without any limitations. It offers platform independency, as the software is not required to be installed locally on the PC. The only thing that user must be able to run is the cloud computing systems interface software, which can be as simple as Web browser, and the Cloud network takes care of the rest. Some of the popular cloud services we have used or we are still using are mail services like Gmail, hotmail or yahoo etc. Hence, the Cloud Computing is making applications mobile and collaborative. Cloud computing is one of the most popular technology in recent trends. This paper presents an overview of cloud computing, the characteristics, types and services offered by cloud computing and its application in different sectors.

II. HISTORY OF CLOUD COMPUTING

Transformation in the digital space has completely reshaped shopping, online experiences, and even customer expectations in physical stores. The concept of Cloud Computing came into existence in the year 1950 with implementation of mainframe computers, accessible via thin/static clients. Since then, cloud computing has been evolved from static clients to dynamic ones and from software to services. Figure 2 explains the evolution of cloud computing:
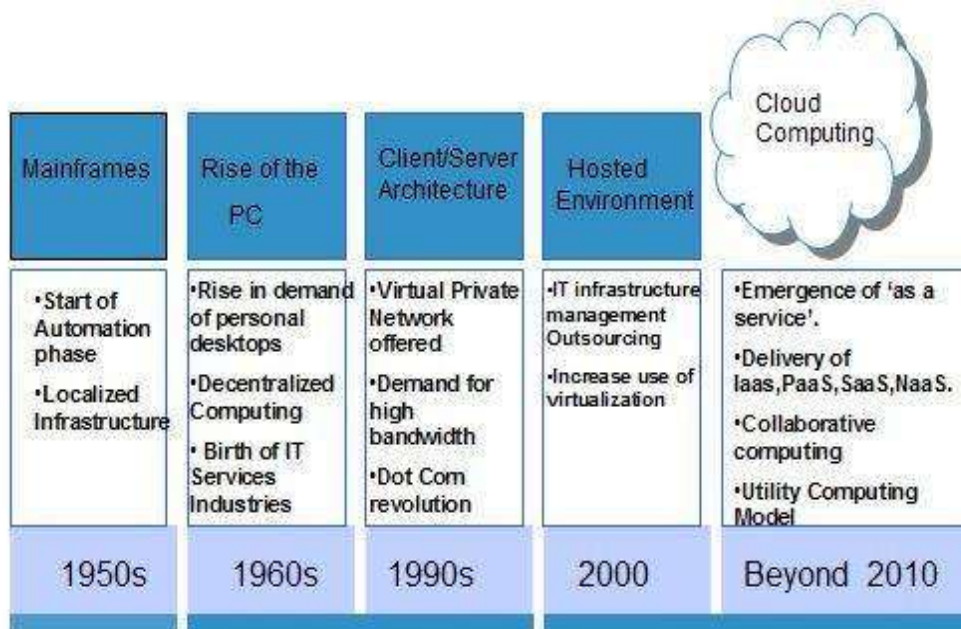
Fig.2: History of cloud computing

III. CLOUD COMPUTING ARCHITECTURE

Cloud Computing is an emerging technology which is skyrocketing nowadays. This technology is often used by big companies as well as the startups as it is flexible for both. The data is secured and can access anytime and from anywhere..Cloud Computing architecture is a combination of service-oriented architecture and event-driven architecture. Cloud Computing architecture basically comprises of two parts as shown in Figure 3. They are the front-end and the back-end. The front end is the end which uses by the user and the back-end manages by the host. Both the end connects to each other with the means of internet.
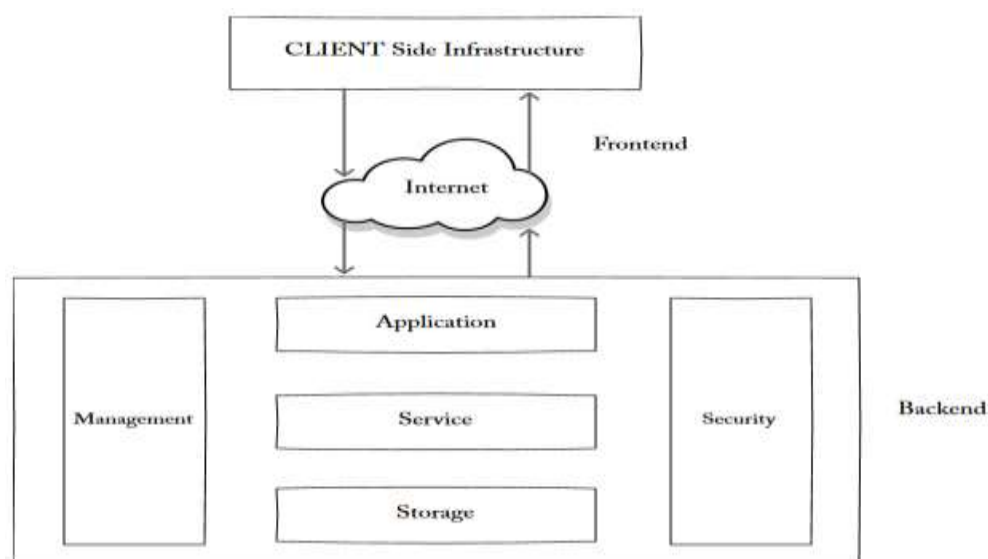

Fig.3: Cloud computing architecture

3.1. Front End - The front end is the client part of Cloud Computing which uses as per the requirement of the user. Front-end comprises of the applications and the interfaces which help to access the cloud computing. Example- Browser or an application created by the company itself.

3.2. Back End - The back end is a part which manages by the allotted authorities of the company and their back end has large data storage facilities, Virtual machines, security system, and servers. They are also engaged in traffic management along with security management.

IV. CLOUD COMPUTING DEPLOYMENT MODELS

There are mainly two types of cloud computing models which are service based and deployment based. Cloud computing deployment models are based on location. There are four types of cloud that can deploy (Figure 4) according to the organization's needs.
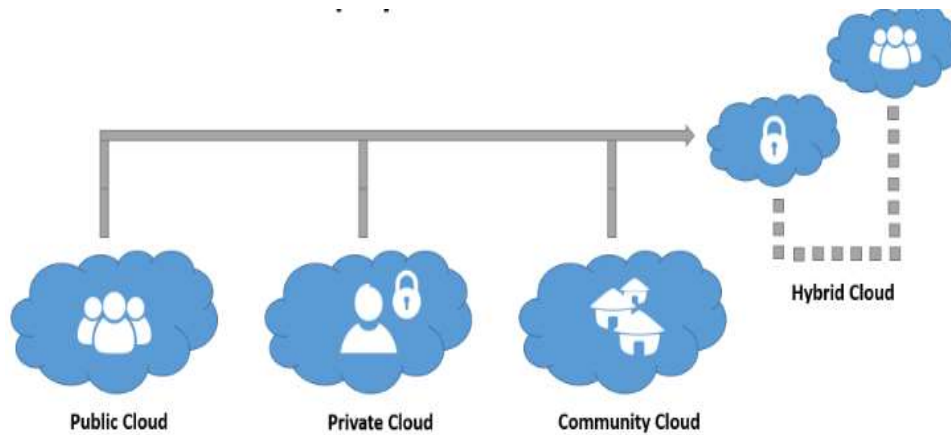

Fig.4: Cloud computing deployment models

4.1. Public Cloud,

Public Cloud is a type of hosting where cloud services are delivered over a network for public use. In public cloud, computing resources are managed and operated by the Cloud Service Provider (CSP). Customers do not have any control over the location of the infrastructure. The cost is shared by all users, and are either free or in the form of a license policy like pay per user. Example: Amazon elastic compute cloud (EC2), IBM Smart Cloud Enterprise, Microsoft, Google App Engine, Windows Azure Services Platform.

4.2. Private Cloud

Private Cloud is a cloud infrastructure that is solely used by one organization. Private cloud is also known as an internal cloud or corporate cloud. It is used by organizations to build and manage their own data centers internally or by the third party. It gives organizations greater control over security and data which is safeguarded by a firewall and managed internally. It can be hosted internally or externally. It can be deployed using Open source tools such as Openstack and Eucalyptus.

4.3. Hybrid Cloud

Hybrid Cloud uses both private and public clouds, but can remain separate entities. Hybrid cloud is partially secure because the services which are running on the public cloud can be accessed by anyone, while the services which are running on a private cloud can be accessed only by the organization's users. Example: Google Application Suite (Gmail, Google Apps, and Google Drive), Office 365 (MS Office on the Web and One Drive), Amazon Web Services.

4.4. Community Cloud

Community cloud is an infrastructure that is mutually shared between organizations that belong to a particular community. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them. Example: Community cloud at banks, government in a country, or Health Care community.

V. CLOUD COMPUTING SERVICES

Cloud computing is offered in three different service models which each satisfy a unique set of business requirements. These three models are known as, Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) as shown in Figure 5.
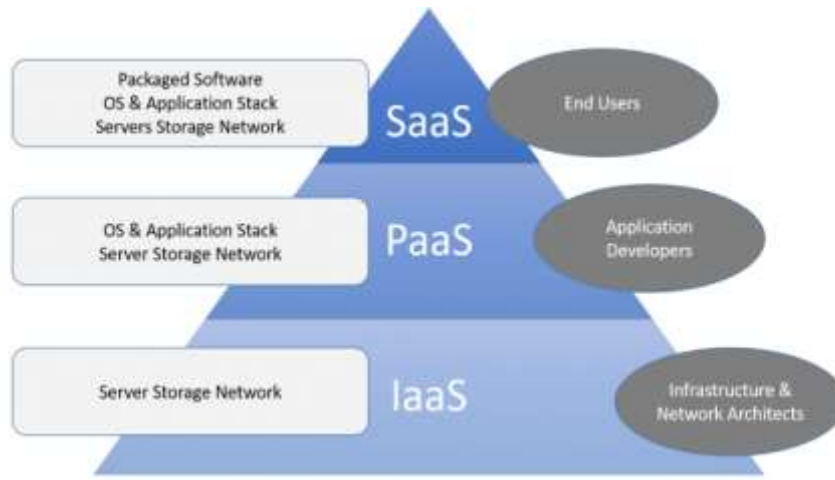
Fig.5: Cloud computing services

5.1. Infrastructure as a Service (IaaS)

IaaS is also known as **Hardware as a Service (HaaS)**. It is a computing infrastructure managed over the internet. The main advantage of using IaaS is that it helps users to avoid the cost and complexity of purchasing and managing the physical servers. There are the following characteristics of IaaS -

- Resources are available as a service
- Services are highly scalable
- Dynamic and flexible
- GUI and API-based access
- Automated administrative tasks
- **Example:** DigitalOcean, Linode, Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), Rackspace, and Cisco Metacloud.

5.2. Platform as a Service (PaaS)

PaaS cloud computing platform is created for the programmer to develop, test, run, and manage the applications.There are the following characteristics of PaaS -

- Accessible to various users via the same development application.
- Integrates with web services and databases.
- Builds on virtualization technology, so resources can easily be scaled up or down as per the organization's need.
- Support multiple languages and frameworks.
- Provides an ability to "**Auto-scale**".
- **Example:** AWS Elastic Beanstalk, Windows Azure, Heroku, Force.com, Google App Engine, Apache Stratos, Magento Commerce Cloud, and OpenShift.

5.3. Software as a Service (SaaS)

SaaS is also known as "**on-demand software**". It is a software in which the applications are hosted by a cloud service provider. Users can access these applications with the help of internet connection and web browser. There are the following characteristics of SaaS -

- Managed from a central location
- Hosted on a remote server
- Accessible over the internet
- Users are not responsible for hardware and software updates. Updates are applied automatically.
- The services are purchased on the pay-as-per-use basis
- **Example:** Big Commerce, Google Apps, Salesforce, Dropbox, ZenDesk, Cisco WebEx, ZenDesk, Slack, and GoToMeeting.

VI. CHARACTERISTICS OF CLOUD COMPUTING

As we all know that Cloud computing is trending technology. Almost every company switched their services on the cloud to rise the company growth. Cloud computing technique allows worldwide access, easy set-up, more storage, elasticity, workload resilience, automatic updates and many other beneficial applications

Following are the characteristics of Cloud Computing:

6.1. Worldwide Access

With cloud computing, it is possible to access the documents from any device in any corner of the world. For instance, it allows business men to work from home or any other business trips, thereby increasing productivity.

6.2. Resources Pooling

The cloud works in a distributed computing environment. It shares resources among users and works very fast. It means that the Cloud provider pulled the computing resources to provide services to multiple customers with the help of a multi-tenant model. There are different physical and virtual resources assigned and reassigned which depends on the demand of the customer. The customer generally has no control or information over the location of the provided resources but is able to specify location at a higher level of abstraction.

6.3. High availability and reliability

The availability of servers is high and more reliable because the chances of infrastructure failure are minimum. The cloud service is available every time as all the queries and the issues are resolved with the help of technical support, which is provided through the phone call. The workers can get assistance from anywhere. The capabilities of the Cloud can be modified as per the use and can be extended a lot. It analyzes the storage usage and allows the user to buy extra Cloud storage if needed for a very small amount.

6.4. Unlimited storage capacity

Cloud computing models offer more storage capacity and avoid the concerns of low storage and back-up abilities. The companies can upload documents, videos, audio and data to the cloud and retrieving them as per convenience, storage space on the desktop or laptops is saved. Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

6.5. On-Demand Self-Service

Cloud provides us the capability of consuming computing resources such as server time, network and storage automatically without the interaction of any human being. It is one of the important and valuable features of Cloud Computing as the user can continuously monitor the server uptime, capabilities, and allotted network storage. With this feature, the user can also monitor the computing capabilities.

6.6. Multi-tenant

Each customer that uses the cloud is termed as a tenant. So, cloud computing allows a multi-tenant system in which multiple customers are served by a single instance of software applications. Furthermore, some parts of the applications can be customized and given to the customers if needed. This architecture, therefore, is found to be economical for companies as the maintenance and developments costs are shared.

6.7. High Scalability

The infrastructure of the cloud is very elastic to expand with respect to nodes and the services. Cloud providers have the capability to add new nodes in the cloud and adding services for the customers in the cloud. Cloud offers "on-demand" provisioning of resources on a large scale, without having engineers for peak loads.

6.8. Easy Set-up

It is simple to adjust individual settings such as choosing a device to connect to network and set up a password. With easy steps, it allows one to start using the software, information or resources within no time.

6..9. Easy Maintenance

Maintenance of cloud computing applications is easier, since they do not need to be installed on each user's computer and can be accessed from different places. So, it reduces the cost also. The servers are easily maintained and the downtime is very low and even in some cases, there is no downtime. Cloud Computing comes up with an update every time by gradually making it better. The updates are more compatible with the devices and perform faster than older ones along with the bugs which are fixed.

6.10. Device and Location Independence

Cloud computing enables the users to access systems using a web browser regardless of their location or what device they use e.g. PC, mobile phone, etc. As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet, users can access the data of the cloud or upload the data to the cloud from anywhere just with the help of a device and an internet connection. These capabilities are available all over the network and accessed with the help of internet.

6.11. Economical

It is the one-time investment as the company (host) has to buy the storage and a small part of it can be provided to the many companies which save the host from monthly or yearly costs. Only the amount which is spent is on the basic maintenance and a few more expenses which are very less.

6.12. Improved Data Security

Cloud Security, is one of the best features of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled. It creates a snapshot of the data stored so that the data may not get lost even if one of the servers gets damaged. The data is stored within the storage devices, which cannot be hacked and utilized by any other person. The storage service is quick and reliable. Cloud Computing offers a high level of security as the data has been saved at multiple places, there is no loss of data. Even if the device is lost the data can modify or delete from anywhere with remote access with the help of an internet connection.

6.13. Pay-Per-Use scenario

Application Programming Interfaces (APIs) are provided to the users so that they can access services on the cloud by using these APIs and pay the charges as per the usage of services. Services provided by the cloud service providers are not free of cost; customers have to pay for accessing and using the services but only for what they use. In cloud computing, the user has to pay only for the service or the space they have utilized. There is no hidden or extra charge which is to be paid. The service is economical and most of the time some space is allotted for free. Some applications such as Dropbox are even free. While others for which you need to pay are affordable too. It's possible to continue the service on monthly and yearly payments. Also, you can choose a plan without contract and terminate the services any time - it enables you to pay for only the services you used (Pay-per-use). Microsoft Azure, Google Cloud platform and AWS are some of the cloud providers which offer pay-per-use model as per pricing considerations.

6.14. Measured Service

Cloud Computing resources used to monitor and the company uses it for recording. This resource utilization is analyzed by supporting charge-per-use capabilities. This means that the resource usages which can be either virtual server instances that are running in the cloud are getting monitored measured and reported by the service provider. The model pay as you go is variable based on actual consumption of the manufacturing organization.

6.15. Improved collaboration

Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage. Cloud allows many individual organizations to collaborate and work together for finding the solution to a problem or for any research work.

6.16. Automatic Updates

Automatic updates in case of the services are provided by the cloud providers. It's just simple to follow those updates, download and continue the service you need. The instructions will be given by the provider automatically and it's not necessary for one to take any expert's advice. They can monitor, control, and report the usage. It will provide transparency for the host as well as the customer.

VII. CHALLENGES OF CLOUD COMPUTING

Cloud Computing has provided many exciting services and features but cloud security is still a big issue. This section discusses the problems related to cloud computing

7.1. Privacy

Cloud computing utilizes virtual computing technology. In this, user's personal data is kept on various virtual data centers which may cross international boundaries. This is where data privacy protection may face controversy of various legal systems. Customer is never sure whether the Service is trustworthy or not, and whether his data is secure from the intruders or not. The customer and Service provider are bound by Service Level Agreement (SLA) document. This is a type of an agreement between the customer and the service provider; it contains the duties of service provider and his future plans. But unfortunately there are no standards for SLA. This the main issue faced by cloud computing now days.

7.2. Confidentiality

Confidentiality means to prevent the disclosure of private and important information. Since all the information is stored on geographically dispersed locations, confidentiality becomes a big issue. Many methods are used to preserve confidentiality from which, encryption is the widely used method. But it is relatively an expensive method.

7.3. Authenticity

It refers to the improper modification of information. As the data resides in different places in a cloud so the access control mechanism should be very secure and each user must be verified as an authentic user. Authentication problem can be solved by using the digital signatures but even after having access to digital signatures a user can't get access and verify the subsets of data.

7.4. Vulnerable to attack

If you are connected to the internet there are chances that you suffer severe attacks as you are exposed to potential vulnerabilities. The chances are less but sometimes even the best team suffers.

VIII. APPLICATIONS

Due to technology advancements, maximum fields are using cloud computing applications these days for the better and smooth functioning of their business. These are applications which can be accessed anytime, anywhere and in any part of the world .The most widely used cloud computing applications are given below :

8.1. Social Applications

Social cloud applications allow a large number of users to connect with each other using social networking applications such as Gmail, Face book, Twitter, LinkedIn, etc.

- Google's email service provider Gmail, provides unlimited storage on the cloud. Gmail has revolutionized the way we send emails and largely responsible for the increased usage of email worldwide.
- Facebook is a social networking website which can store an infinite amount of information, images, and videos on your profile. They can then be easily accessed on multiple devices. Facebook goes a step further with their Messenger app, which allows for profiles to exchange data.
- Twitter is a social networking site. It is a microblogging system. It allows users to follow high profile celebrities, friends, relatives, and receive news. It sends and receives short posts called tweets.
- LinkedIn is a social network for students, freshers, and professionals.

8.2. Education Applications

Cloud computing in the education sector becomes very popular. It offers various online distance learning platforms and student information portals to the students. The advantage of using cloud in the field of education is that it offers strong virtual classroom environments, Ease of accessibility, secure data storage, scalability, greater reach for the students, and minimal hardware requirements for the applications.There are the following education applications offered by the cloud -

- Google Apps for Education is the most widely used platform for free web-based email, calendar, documents, and collaborative study.
- Chromebooks for Education is one of the most important Google's projects. It is designed for the purpose that it enhances education innovation.
- Tablets with Google Play for Education allows educators to quickly implement the latest technology solutions into the classroom and make it available to their students.
- Amazon's AWS cloud provides an education-friendly environment to universities, community colleges, and schools. AWS Cloud features a virtual desktop infrastructure (VDI) solution. Through the cloud, allows instructors and students to access teaching and learning software on multiple devices.

8.3. Health care system

Today's lots of healthcare sectors working on paperwork, to reduce and reform this sector cloud computing technology is adopted. In Healthcare industry, it plays a vital role in moving the healthcare to a digital platform becoming more patient centered and data driven. Human health, profile, as well as activities are monitored and processed intelligently for better care with low cost.

- Cloud computing helps healthcare industry in storing large data, sharing information among hospitals and physicians. This is a major boost for efficiency. Ultimately, cloud technology ensures patients receive the best possible care without unnecessary delay. The patient's condition can also be updated in seconds through remote conferencing.
- Telemedicine: Cloud-based telemedicine is being provided to individuals living in the remote areas of developing countries, so those communities can have some type of access to healthcare. Telemedicine enables an extension of services, such as psychiatric care to a patient who is unable to travel. Regardless of how telemedicine platforms and apps are designed, their back ends tend to process information using extensive cloud computing resources.
- To provide robust healthcare services, recognition of patient daily life activities is required. Context information with real-time daily life activities can help in better services, service suggestions, and change in system behavior for better healthcare. Human health, profile, as well as activities are monitored and processed intelligently for better care with low cost. Health monitoring system using cloud computing monitor human health and shares this information among doctors, from the Cloud.

8.4. Business Applications

Business applications are based on cloud service providers. Today, every organization requires the cloud business application to grow their business. It also ensures that business applications are 24*7 available to users.

- MailChimp is an email publishing platform which provides various options to design, send, and save templates for emails.
- Salesforce platform provides tools for sales, service, marketing, e-commerce, and more. It also provides a cloud development platform.
- Paypal offers the simplest and easiest online payment mode using a secure internet account. Paypal accepts the payment through debit cards, credit cards, and also from Paypal account holders.
- Quickbooks works on the terminology "Run Enterprise anytime, anywhere, on any device." It provides online accounting solutions for the business. It allows more than 20 users to work simultaneously on the same system.

8.5. Data Storage and Backup Applications

Cloud computing allows us to store information (data, files, images, audios, and videos) on the cloud and access this information using an internet connection. As the cloud provider is responsible for providing security, so they offer various backup recovery application for retrieving the lost data.

- Box.com provides an online environment for secure content management, workflow, and collaboration. It allows us to store different files such as Excel, Word, PDF, and images on the cloud. The main advantage of using box is that it provides drag & drop service for files and easily integrates with Office 365, G Suite, Salesforce, and more than 1400 tools.

- Mozy provides powerful online backup solutions for our personal and business data. It schedules automatically back up for each day at a specific time.
- Joukuu provides the simplest way to share and track cloud-based backup files. Many users use joukuu to search files, folders, and collaborate on documents.
- Google G Suite is one of the best cloud storage and backup application. It includes Google Calendar, Docs, Forms, Google+, Hangouts, as well as cloud storage and tools for managing cloud apps. The most popular app in the Google G Suite is Gmail. Gmail offers free email services to users.

8.6. Entertainment Applications

Today, most people come on an internet for entertainment. Cloud based entertainment can reach using any device like TV, mobile, Virtual box or any other entertainment devices. Entertainment industries use a multi-cloud strategy to interact with the target audience. Cloud computing offers various entertainment applications such as online games and video conferencing.

- Online games -Today, cloud gaming becomes one of the most important entertainment media. It offers various online games that run remotely from the cloud. The best cloud gaming services are Shaow, GeForce Now, Vortex, Project xCloud etc.
- Video Conferencing Apps provides a simple and instant connected experience. It allows us to communicate with our business partners, friends, and relatives using a cloud-based video conferencing. The benefits of using video conferencing are that it reduces cost, increases efficiency, and removes interoperability.

IX. CONCLUSION

Cloud computing is a widely used technology providing many types of services to the customers online on the basis of Pay-Per-Use mechanism. Users can store, access, and share any amount of information in cloud. The data is secured and can access anytime and from anywhere. Cloud computing enhances the computational power of the organizations which require processing of very large amount of data every day. Applicability of Cloud computing in diverse fields makes it an evolving paradigm in the high performance computing. It has become an essential part of almost all technology. Cloud systems are virtualized, there are a number of natural advantages such as backups are much easier to create and the risk associated with hardware failure is minimized. This paper describes the basic of Cloud Computing, and its effects of use in the various fields. Cloud computing is the latest technology which is becoming so popular due to its uses.

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