

Cloud Computing Applications: A Review

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Abstract

In recent years, cloud computing is an emergent field in the Internet era. There is rapid development in high-performance computing and technology extended from grid computing to cloud computing to provide computing resources on pay per basis. Cloud service providers developed applications for users to easily access cloud services with quality of service (QoS) because cloud application plays an important role in service delivery of cloud organization. This paper provides a review of cloud computing technology, cloud models, deployment and cloud applications such as types of applications, reliability, and security. Finally, open research issues are provided for future research development.

Keywords: Cloud computing, Applications, Security, storage

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1. Introduction

Cloud computing has come with the concept of computing resources as a utility, which can be consumed based on pay on demand the same as you go fashion like electricity, water and gas [1, 2]. Cloud services mainly controlled and supported by data centers [3]. Cloud computing as a utility is a long-held dream in the information technology sector and it will become true with the advent of low-cost data centers [4]. Security is another major obstacle for opening up the vision of computing as a utility [5]. Datacenters are the most important entity in cloud service architecture. Datacenters act as cloud providers, which provide different types of cloud services to users [6]. A range of information technology companies provides services to their users as pay as you go fashion [7]. These companies are Facebook, Amazon, Salesforce, Yahoo, Cisco, Microsoft, and Google [8]. They have their own data centers deployed at different geographical locations.

SaaS is an application service licensing model that provides software facilities on demand [9]. A single application is run on the server-side, which is accessed by one or more runs on the cloud services and multiple end-users or client organizations. All leading organization get benefits of SaaS resources as its scope is limited and cost remain within the forecasted budget. The most widely

known example of SaaS is salesforce.com, Google Apps, Dropbox, MailChimp, ZenDesk, DocuSign, Slack, Hubspot, although salesforce.com is providing the services of cloud computing from the last few years [10].

The main concern in the application is the authenticity of users and privacy of data, which remain at risk as the main control management remains with cloud providers [10]. Besides other terms and conditions, one of the fundamental factors in the cloud environment is to maintain security issues of cloud users. The most common security issues are spoofing, phishing, scams or frauds in the cloud environment [11]. Cloud network is considered to be a place of heaven for hackers who may perform offensive tasks over the internet by using unauthorized and illegal web browsers. However, the main challenge remains with the cloud provider to protect the users from any loss or damage.

SaaS is also assumed to be the basic services model that is used for accessing software through the cloud. Cloud users may tradeoff on the internet by establishing a connection with the end-user. Cloud buyers must consider the tradeoffs among computation, communication, and integration [12]. Whereas moving to the Cloud can essentially diminish the infrastructure cost, it causes a rise within the taken a toll of information communication, i.e. the cost of exchanging an organization's information to and from the open and community cloud and the cost per unit of computing asset utilized is likely to be higher.

Cost analysis is done by the experts to forecast the expected financial impact of the SaaS resources [13]. Currently, the telecom sector is investing a huge amount in utilizing such software applications for the end-user that produce a handsome amount of income for the company. Multiple models are tested to get the most beneficial deal for the organization. The market trend is also examined for the expected cost. SaaS helps out in measuring trade-off to cost yielded by amortization.

Cloud consumers do not influence the quality, integrity, and availability of data and they have to rely on the security measures adopted by the cloud providers [14]. It is necessary to gain a formal commitment through SLA (Service Level Agreement) and ensure that all terms and conditions are fully governed as per the predefined settlement. The reputation of cloud service providers is mainly dependent on the SLA fulfillment, which they perform during operational activities [15]. The giant organizations tend to take multiple cloud application services to provide the best services to their consumers. This is also referred to as the Hazy Cloud process. This forces cloud vendors to sometimes lock their services and users have to shift from one service to another simultaneously.

This paper will address the topic of cloud computing applications and types of applications according to usage fields and details of cloud computing service models and deployment. Limitations of previous cloud applications and open research issues for future application development are discussed.

The paper is organized into 7 sections; section 2 is based on the cloud computing service models. Section 3 provides details of cloud deployment models and section 4 based on applications of cloud computing. Section 5 is based on the security and privacy of applications and section 6 provides open research issues and finally, in section 7 we conclude our work.

2. Cloud computing service models

Cloud computing is also said to be a model for acquiring flexible on-demand access to network with an interconnected pool of configurable IT resources like networks, server machines, storage devices, applications, and online services. These cloud models promote the availability and composed of five essential characteristics, three service delivery models, and four deployment models [16].

The delivery model provides the facilities as per user demands or requirements and has the capabilities as per the type of service. In any of the models of the cloud environment cloud server and cloud, the user has some kind of understanding and assumed to be a logical bonding. Cloud services are sometimes are said to be cloud user-dependent [17]. The said understanding is documented through signing SLA. The classification of platforms is dependent on different factors like user requirement, internet accessibility, storage specification, network infrastructure, server application/software and so on [18]. This is the

reason the services offered in the cloud environment mainly lied on the mentioned factors. The cloud delivery model is further divided into three models.

➤ SaaS (Software as a service)

This is one of the types of cloud delivery model in which the software or services are used on the cloud provider base and consist of software applications [19]. The connectivity is made through interfaces such as web or email. SaaS offers services promptly requested by the user's such webmail, interface application or software and business applications such as ERP, CRM, and SCM [20]. SaaS platform provides a limited approach at the client end that makes the server end much resourceful. Therefore it provides minimal integrated control for service-based functionality to end-users of the client. To evaluate the possible vulnerabilities of security issues in the cloud, the overall background of relationships and dependencies should be estimated. SaaS and PaaS are mainly functioned on top of IaaS; thus, any breach in IaaS will affect the mechanism of security of both PaaS and SaaS [21]. This will show the high level of dependencies between the layered base function. Such a structure of models strengthens the model reliability as well as security however; it may also invoke the technical risk [22].

The services offered by cloud providers are assumed to be the rental based mechanism. The services can be acquired from a single enterprise cloud provider or a group of multiple entities. In either way, there always are triggered attitudes of users while accessing the services and each entity must have to take incentives at their end to improve security.

➤ PaaS (platform as a service)

This is the way to provide a base (platform) to the consumer for the deployment of cloud infrastructure with the help of its applications without enabling own local machine. PaaS refers to sharing platform layer and software layered resources such as operating systems and application-based frameworks. All the categories of cloud computing provide support as per the standards or limitations of resources. Client users adopt PaaS service mainly because of less than optimal solutions or results of IaaS. This statement looks rationale at some point, but in reality, it depends on the specifications of the IT applications involved in the network [23].

➤ IaaS (infrastructure as a service)

In IaaS cloud service provider shares a pay-as-you-go facility to access the several features of network servers, computational applications, and storage over the web or internet [24]. IaaS can be a single virtual or physical service or a combination of both [25]. It behaves as the basic unit of IT resources, which minimizes the workload and reduces the

number of computing resources. In this system, the cloud users can perform the tasks as per on-demand basis and can

also shrink or extend the resources. It will certainly adjust the expenditure cost and unnecessary availed infrastructure.

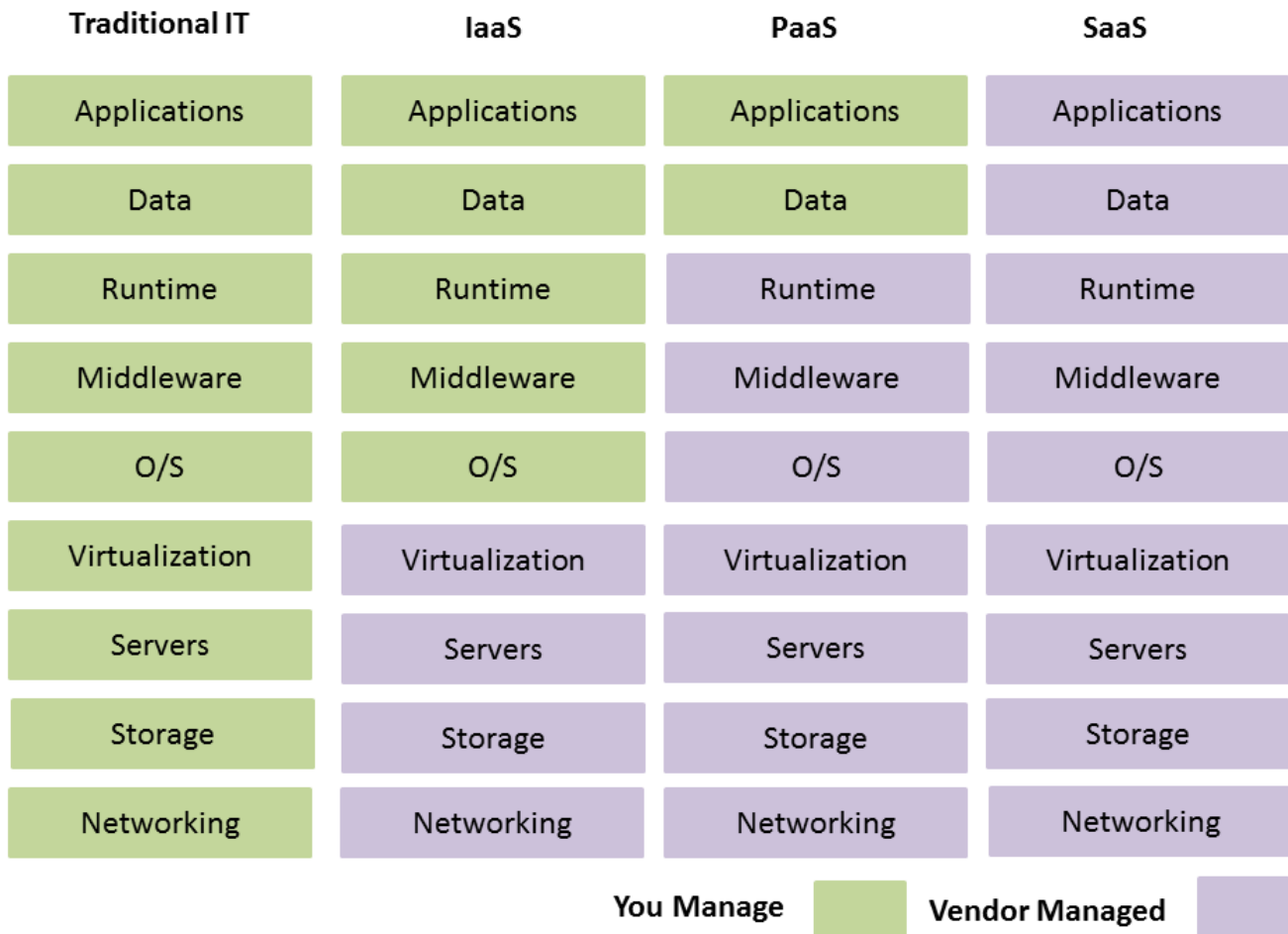


Figure 1. IBM Cloud [29]

IaaS, PaaS, and SaaS are proposed to be layer-based services one after the other [26]. IaaS provides a platform of physical control to users of cloud services such as computer devices, networks, and storage used in the virtualization process. PaaS is the second step in accessing the cloud resources by taking control of the system at management level such as operating system and run time application [27]. SaaS is the last service based on the end-user application, where the main control remains with the vendor or owner of the cloud [28]. This is the simplest description of three services at the primary level understanding each offer a dynamic layer of reflection after that. IaaS abstracts absent the physical compute, organize, capacity, and the innovation required to virtualizes those assets. IBM has provided chart based information for understanding the nature of services controlled at different layers is given Figure 1.

3. Cloud Deployment Models

The deployment models are dependent on the infrastructure of the network [30]. There are four common cloud deployment models: public, private, community, and hybrid. The deployment models are classified as per the location of the environment of the cloud structure [31, 32]. As cloud domain provides the outsourced IT services, which certainly keep down the operational cost. The organization opts for cloud applications as per their exclusive interest in the business. However, the other factors such as scalability, affordability, and reliability of resources analyzed on time to time basis. Besides such factors, the main focus remains the authenticity and security concerns.

The most common practice of choosing a deployment model starts once the service model for the respective cloud network is finalized. However, it depends on the usage of cloud services and the requirement of the users.

There are four common examples of cloud deployment models are given in Figure 2.

A. Public cloud

As per the name, the public cloud is the most common and simple types of cloud where users opt to apply

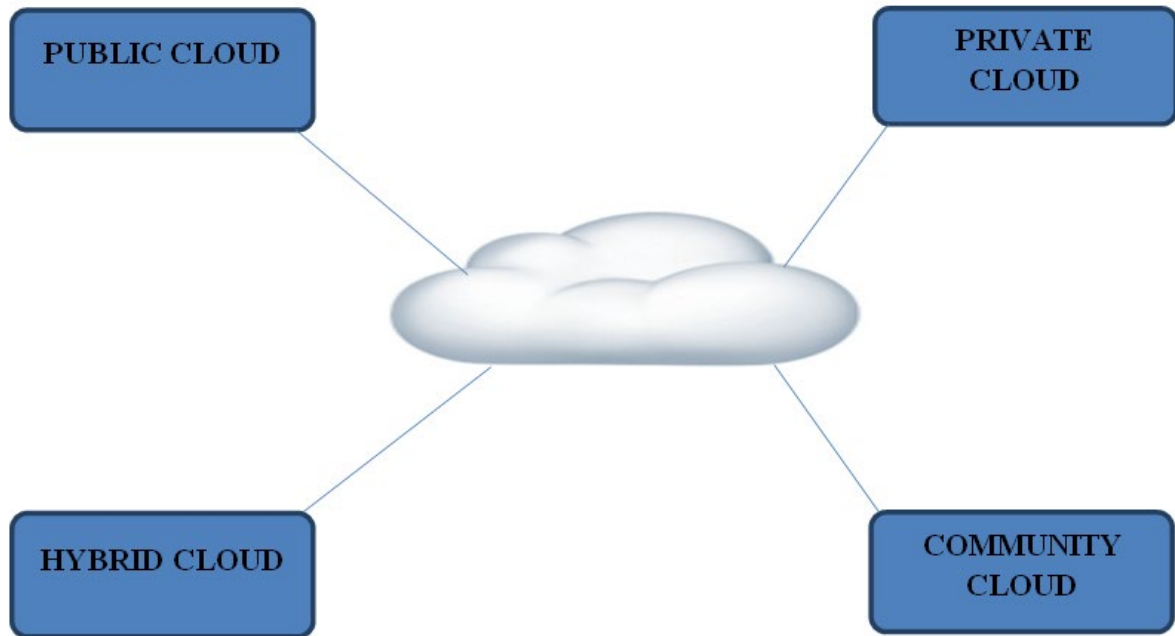


Figure 2: Common types of cloud deployment models

Companies and individuals both maintain their accounts for the subscription of services with the cloud.

B. Private cloud

Private cloud refers to a model of cloud computing where IT services are maintained through a private channel or network hardware for an individual entity [34]. In a private cloud, the communication of the network is controlled through private channels or servers. This can be done by the organization itself or sometimes share or rented to a third party for just only controlling the purpose of resources. All such networks of resources are handled through the internet [35]. This can be understood by the head office and branch or zone network. A branch operating in one part of the world is controlled by the internet through the private network in remote areas. The other term for the private network can also be intranet work.

C. Community cloud

This has become very popular amongst organizations or domains of the same point of thought [36]. The main purpose of building such a cloud between similar entities is to share the general policies, adaptation or

computing resources like hardware and software for accessing applications on a subscription basis [33]. It could be a simple browsing application or algorithm code-based software used by developers. Social networking involves public clouds as they are intended to welcome users for accessing services through the internet.

implementation, benefiting the ideal framework and comparison of mechanism [37]. Educational institutions, health-related domains, scientific research organizations, and several other giant associations use this community cloud to access and share information.

D. Hybrid cloud

This is the combination of one or several networks of the cloud [38]. It can be a collection of private networks or a mixture of one private and another public network. This is the most extensive type of cloud which provides facilities to every end-user in any area. It involved several services and networks; there possibility of a huge concern about security issues [39].

4. Cloud computing applications

Nowadays organizations, especially small and medium-sized organizations are utilizing the benefits of cloud computing by putting their data and applications over the cloud [40]. The adaptation of cloud computing may lead to reduce the cost of purchasing and maintaining the IT infrastructure [41]. Cloud computing is composed of several features and provides plenty of facilities

specifically for remote online access to resources. There are five common features illustrated at different domain as below [42].

- On-demand services
- Wide network accessibility
- Resource pooling
- Quality of service
- Prompt scalability

The current era has strongly affected the storm of cloud applications. There are several possible reasons for such a shift of resources from physical to virtualization. The social network has altered the fundamentalist approach of IT resources. Quality of service (QoS), Internet of Things (IoT) and E-commerce are the few renowned technological terms that emerge as the state of the art fields of advancement. Google trends can be analyzed for forecasting and comparison of the virtualized technology with that of conventional grid computing [43].

As per the latest research, the cloud has stored approximately more than 60% of the data such as official transactions and personal information through various cloud application software. Social networks or media are the latest applications that create big data [44]. There could be several reasons for the expansion of data in recent years, but in reality, it is the innovation of the cloud. However, despite the increase in cloud software the concerns for security and authenticity have also risen in users of the internet [45]. It can be said that the consequence of such a boom in social networking through the cloud has increased the risk of security.

The traditional applications require many resources to perform their tasks smoothly, but many of us usually do not have that many resources to get proper benefits. Cloud computing applications play a very important role in today's digital world as it facilitates from bits to Big Data as they are operational tools for completing many routine tasks and usage of available resources efficiently and effectively [46]. The role is countless and functionalities are also limitless.

The cloud computing plays a great role in following areas now days.

4.1 Ecommerce and Business Applications

Ecommerce is the internet-based sales and services setup that got attention in the 20th century [47]. The recent trends of mobile computing encourage vendors and service providers to take additional benefits from the internet revolution in terms of business. The dawn of mobile apps and ecommerce websites helps entrepreneurs to take risks into new ventures [48]. The e-commerce increased revenues of companies at very minimum investment. The architecture of today's ecommerce relies on the availability of the website's live time the cloud manages it very well as it does not rely on a single machine. The cloud is the interlink connectivity of several machines with updated hardware & software resources to support one to another for providing the best availability

of resources in terms of product storage, browsing of product catalogs, and processing electronic payments [49].

According to Danping Wang [50], the development of cloud computing is making modern benefit environments that will coordinate all the E-commerce assets and encourage the unused benefit mode. For E-commerce suppliers, cloud computing is making great opportunities whereas challenging the existence of traditional service providers. The world's leading ecommerce services providers rely on cloud computing and some of them e.g. Amazon and Alibaba also provide cloud computing services to other businesses around the globe [51].

4.2 File Storage and Access applications

Cloud storage could be a cloud computing show in which information are stored on inaccessible servers gotten to from the net, or "cloud." it's maintained, operated and managed by a service provider on storage servers that are engineered on virtualization techniques [52, 53].

Traditional storage platforms such as hard drives, flash drives and other types of physical storage devices have long lost their sheen. The days when these physical storage devices are ruling the world of technology are long gone, and people are turning to more advanced and more attractive technical options to store their files and data. With the development of cloud storage services, the risk of lost storage and demand for cloud storage has increased. Cloud provides remote file storage services to subscribers based on the data storage server [54]. The subscriber can then process all their stored files on these storage servers and can save or retrieve the files they need when they want. Allows access to files from remote locations using only stable internet connection allows the cloud to cloud over other storage options.

Some of the famous online cloud File storage and access applications are Google Drive, One Drive, Dropbox, Mediafire, etc. The main advantage of cloud-based storage services is accessibility as a user can access from anywhere in the world or by using any interconnected device like PC, Laptop, Tablet, Smart Phone or Smart Watches [55].

4.3 Multimedia Processing applications

According to Ramasubramanian et al., cloud-based processing is a new set of techniques, which is used to store multimedia content and provide different functionalities to its users through Internet access [56]. The cloud provides a standard service for software, hardware and a centralized server, which gives full support of its connected peripheral device [57].

Multimedia Processing applications usually subscribed to their content to users and mainly based on two modes i.e. free or paid, where the revenue generated from paid

subscribers helps service owners to maintain its service and pay cloud processing bills [58].

The Multimedia processing tasks required high processing speed and large storage space the few minutes clips may be reserved several GBs of data and their processing time also calculated according to the processing speed of the computer system [59]. The cloud helps a lot in multimedia processing tasks the architecture of cloud in terms of 24 hours availability makes it easier to processing multimedia requests such as encoding, conversion, marking, streaming [60, 61]. There are many cloud-based multimedia processing applications available online such as YouTube and Netflix.

4.4 Security and Antivirus applications

The cloud plays a very important role in securing the digital world. The need for data protection increased in recent years due to numerous attacks on different computers [62]. The new types of attacks are also opening new demands of security. Knowledge holds on within the cloud area unit accessible to users within the sort of completely different services with the assistance of ancient networks and it's conjointly better-known to be the cloud storage, which it holds a short description regarding cloud user profiles, business details and copy info to form obtainable ubiquitously via the web as backbone. Online knowledge backup, knowledge archiving, knowledge compliances, disaster recovery, and compliance rule area unit are the number of the problems in cloud knowledge storage [63]. The Most common cloud-based end-point protected antivirus is Malwarebytes, Sophos, Webroot, Symantec, and Eset are given in Figure 3.

4.5 Map and Location based applications

Nowadays Location identification applications are widely used. The Common usage of these utilities is to identify places, best routes, and locations on the selected map. Different types of applications used different types of maps i.e. 2D or 3D [64]. Some applications such as Google Maps show real-time information of available roots or best route the advancements in technology allow end-users to find out conjunction in traffic and trace out the best possible route to way out from a particular location [65, 66]. These applications usually connected with satellite and the vast amount of data usually transmitted between satellites and computing devices

that's why there is always a very big need of high processing machines with good quality of enhanced storage devices, therefore, the concept of cloud computing helps very much to support geo-specific map and location-based applications. High-performance cloud computing enables these applications to perform their live functions in efficient and effective manners.

The common application, which is getting benefits from the map and location-based applications are ride-sharing, assets tracking, Gaming, Traffic, GPS, etc [67]. The Real-estate based business also gets benefits from these apps by marking real-estate on maps and can easily measure the estate in few clicks these all activities fully supported by cloud computing models. The Famous cloud-based map and locations applications are Google Maps, Sygic, Here, MapFactor, Waze, Maps.me and TomTom etc [68].

4.6 Miscellaneous applications

The cloud offers a range of services from data processing to architectural designating to organizations while not requiring major amounts of revenue. By reviewing these resources, as needed, businesses and people will keep versatile and economical, giving the time required to be inventive and to assume. By approaching cloud applications, users can enjoy a variety of activities over the internet, which was impossible to perform in previous decades [69]. Cloud has shrunk the global database to single click execution of the command, which helps in assessing and experimenting with the latest knowledge from a range of sources.

The latest innovation of cloud is the IoT [70]. Current technological evolution has merged several platforms to perform a multi-task using the internet and strengthen the communication system effectively. Automation of resources has gear up the launch of innovative new services. This trend has helped management control and responsibility sharing to every workforce in an organization. A huge investment has been done to automate things and revolutionized the industrial or manufacturing boom. The auto industry and health-related diagnosis institute are a few of the key examples of the latest cloud technology.

Cloud base business programs have evolved a series of programs for HR-related staff training [71]. A person residing in one part of the world like a head office can train and monitor the workforce in another part of the world.



Figure 3. Antivirus applications

5. Security and privacy of cloud applications

In the cloud computing environment, the data reside on the cloud while the user has minimal or no control and may face severe threats to maintain the security measures [72]. This is one of the powerful reasons for the susceptibility of the cloud data, which often affected due to vulnerability or penetration. The most common security issues are data authenticity, data accessibility, data controllability. There are few common security and privacy issues specifically running cloud applications such as data security and authenticity issues, application security issues, virtualization security issues [73].

There are several issues related to cloud computing, but the most common is network security problems. In the cloud, data reside at a different location and it must flow through a tunnel-like internet or intranet, there should be a sound network or hardware devices that protect the data from leakages or theft. An updated scanning application should be installed to monitor to check and verify the flow of packets [74].

Cloud computing is an evolving stage we ensure that the cloud is providing a swift and low-cost solution to enterprises, the security and privacy would not be compromised as well. Confidentiality is a vital need and essential to run an enterprise application to restrict from unauthorized sources. Few enterprise sectors likely banking financials and Government entities are abided to follow justified rules to comply with high-security measures. Such institutes faced objection from regular and compliance authorities for compromising security by enabling cloud applications. Few security threats in cloud computing are discussing below.

- *Insecure Interface*: Application interface lying on the same cloud from different customers used and multiple interfaces are provided in the same environment [75].
- *Unauthorized Access*: Authorization access standards are not followed and may attract authorized persons to misuse the data. Once access allowed on the cloud, data application may not be assumed reliable [76].
- *Data Leakage*: Leakage may occur due to insufficient measures; data is placed at cloud service providers premises and may not reject the certainty of leakage of data.
- *Malicious Attack*: Malicious attacker may be insider or outsider, trustee user have access particularly.
- *Sensitive Information*: Through various loop holes sensitive data may not be used as software/application as earlier.
- *Reliability*: Customers' confidential data is hosted at a remote site at the cloud service provider this again depends on cloud service

provider reputation and history. Reliability depends on security standards applied by the service provider.

The advancement in data sciences has produced a way for big data and companies undoubtedly involved in maintaining data issues such as its security, accessibility, and integration as well. The data accessed through cloud may involve mainly wireless telecommunication. There are numerous instances of such feature base data such as social networking which has become the top leading technology in data sciences. Facebook, WhatsApp, Google drive or several other apps has produced high volume data through wireless networks [77]. The bulk of people involved the creation, up-gradation, manipulation or deletion of information on the web at every single second. Time and distances have squeezed in the opposite direction. A single click can be enough to approach distant edges. In either of the social networks specifically involve the web, the security, and privacy of information have emerged to be an unseen challenge. The basic cloud computing security issues are analyzed and evaluated by surveying social networking (SNG) and the emergence of big data privacy [78].

The other most security breach is the denial of service attack when the servers are fully packed with huge traffic meanwhile, users face accessibility problems with the server. Such problems become more severe if encryption applied in the cloud network is simple or open-sourced. To boost network authenticity, an intrusion detection system (IDS) is implemented to limit the unauthorized request of users [79].

6. Open research issues

There are plenty of issues related to the cloud network resources raised by the users as well as the service providers. So far a huge number of publications can be retrieved globally about the vulnerabilities, threats, weakness, and risks, but the responded research for the said issues are still to be answerable. The most common barriers that arise with cloud services and require an extensive effort are security and privacy, open accessibility, cultural issues, connectivity, interoperability, general technological solutions and socio/economic conditions [80]. In spite of the fact that there are numerous benefits to receiving cloud computing, there are moreover a few critical obstructions to selection.

There is an indispensable need to develop generalized or uniform standards for the representation of values or services offered by the cloud providers. Currently, different patterns of data types and semantic models are followed by different vendors, which in return may produce a conflict of interest [81]. To simplify the implementation of cloud services and smooth implementation, systematic research should be adopted. It will eventually cover every section and provide clarity in

the usage of cloud-based tools [93, 94]. Further, it will also differentiate the understanding of wired and wireless network accessories and their requirements in a particular domain [82, 83].

Runtime assurance process for confirmation of absolute delivery of services to end-users as per predefined standards is one of the fields that require an immense study of understanding [84]. Besides resource accessibility, the other concerning aspect is data and application migration when the end-user has to switch its application data information from a normal MIS to a cloud environment such as online shopping or e-commerce. The particular synchronization of sensitive data also demands a thorough analysis of data migration security [85].

The latest issues raised by cloud application but still, the most frequent blocks of challenges for handling operations are handling uncertainties, controlling dynamic variations in workload maximization of virtual network topologies [86]. Scrutiny and verification of services as per SLA document and other procedural framework is also a hot issue for IS auditors and forensic professionals. To meet the latest day to day challenges of IT resources, the audit firms must comply and equip their technical staff for threats and challenges. One way to meet such issues is by providing extensive knowledgebase management training to concerned professionals [87]. Most of the cloud applications did not the functionality of Quality of experience (QoE) features to assess user experience [88, 89]. The future development of application based on QoE features in cloud applications to improve performance of service delivery and build good relationships between the client and service providers [90]. The cloud application developer also required applications for those users who are researching the image processing field for easy data upload for rendering purposes and get results [91, 92].

7. Conclusion

The technology has become full of innovations and explorations these days. The competitive attitude amongst organizational domains has made it much worthier to adopt cloud services. Progressive engagement of a virtualized environment attracts investors to pour money on the acquisition of cloud features. Despite the mentioned security threats or vulnerabilities, the benefits of accessing cloud resources are fruitful as compared to its worst affecting results. To mitigate risks involved in cloud computing applications, a lot has been done for avoiding it, but still a long way to get through for high performing achievements. The SLA documents should be audited and evaluated by renowned third party companies who can verify the services claimed within the documents. The penetration testing agencies report can also provide an effective approach to validate the security and authenticity efforts of the cloud providers. Comprehensive guidance and manuals can also be ascertained by reputable academic institutions, which help

in training the professionals that dealt with the system software and hardware. However, cloud computing resources have still become one of the common tools to extend the business along with lowering the operational cost. The most important factor of cloud computing applications will remain the data/information security, availability, accessibility, integrity, and redundancy. With the advent of social network and app-based features, huge data of users has become the top priority. The organizations tend to not compromise with the security issues and sometimes become susceptible to threats as well as malware attacks by hackers. This can be one of the reasons for the existence of a professional who is hired by the companies to cope with hacking vulnerabilities. And eventually, cloud applications are more prone to such disastrous intrusion because of their web-based applications or virtualized resources.

In either way, the research or understanding of the most updated scripts, applications, programming languages and security tools can help in solving the most complex security threats of the cloud environment.

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