Cloud Computing - A Potential Area for Research

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Abstract - With the emerging and enormous development of I.T. sector in different walks of business and human life since many years, there is a greater need for computing the operations virtually. Out of the many networks available on the computer, cloud computing takes lead and occupies top place in the present computing scenario. Cloud becomes more widely and intensely accepted by many users and migrating to the cloud by the users remains an attracting opportunity from a financial perspective to many both individuals and organisations. It needs to connote clarity in documenting cloud structure, types of clouds, security and governance. This helps better to articulate properly the cloud-related aspects to both technical and managerial counterparts. In this paper, we propagate some major challenges and some problem areas in cloud computing. Suitable and relevant potential research topics in the area of cloud computing are also projected.

Keywords - Cloud Computing, Benchmarking, Governance

I. INTRODUCTION

The dictionary meaning of the word 'cloud' is a white or grey mass of condensed watery vapour floating in the sky. Scientifically, it may be expressed as a large aggregation of objects that visually appear at a remote place and these objects are not physically supervised, touched or inspected. But in I.T. jargon, the cloud emblem is devoted to connote the computing cloud networks which extend both to multiple servers and also the network infrastructure of several users. Though cloud is real but abstracted and the users can't have a glance over it.

Business organisations live in a more dynamic and versatile environment. Every day, they need to face several risks and challenges. They have to match capacity to demand for a better and optimum utilisation of limited available resources. Further, the organisations generate data that is much larger to be processed and analysed by different methods. Moreover, the intricacies of data are increasing at a rapid pace and as such, management of data is becoming increasingly complex. But, the budgets of these organisations are tied-up specifically in routine and regular projects. As such, many showed inclination towards outsourcing for reducing their capital costs. Hence, all organisations need to constantly align and integrate innovative I.T. services to their business needs and fulfilling their business requirements.

There has been a gradual transformation of the systems and technology from a traditional one to a new and a more innovative one and many organisations have been experiencing it for the last so many years. Cloud computing is considered as an emerging and a more consequent example of such transformation. It is a new paradigm of technology in computing applications and the solutions arrived at have been emerged as a beacon light to many small, medium-sized and large organisations in the present day computing world. This creates a landmark in the history of the process of computing revolution wherein the businesses are getting themselves accessible to a greater levels of highly sophisticated and systematically devised techniques of computing with broader and newer range of applications and solutions.

II. CLOUD COMPUTING

Cloud Computing is a systematically devised mechanism wherein the users can use the computing applications as and when they need and they are made accessible under 'cloud' through a simple browser or any other web-based tool. With cloud computing, the users can cut costs by using other people's hardware, software and other facilities to run and get computing applications easily and in time. Cloud Computing allows Internet-related resources, software, data and services to be provided on demand to the users by the provider by using a pay-as-you-go pricing model, often referred to as utility pricing model. It relieves organisations mostly from owning the I.T. resources which carry huge capital costs.

Many companies like Amazon, Apple, Google, IBM, Microsoft and others are taking lot of interest in disseminating cloud computing techniques to a number of users in the world. A wide range of innovative services are also offered by them to both individuals and business users. Further, the computing applications and solutions under the cloud are also used mostly in different sectors like business, science and technology, public services and utilities. These techniques are proved more successful to the users to enable them access to even most difficult and discrete types of information and also communication services of organisations of different sizes. Retailing industry is also slowly adopting the cloud computing technol-
ogy which can provide the major benefits including the reduced costs, scalability, lesser time and flexibility [13]. Many individuals also use cloud-related services for e-mail, web searching and also social networking. Scientists and engineers use cloud to make themselves accessible to different latest computing and data handling methods.

The innovative techniques of cloud computing allow many employees of the user organisations to access themselves to the cloud distantly and can work at home through internet. As such, it is a way to check both administrative and maintenance costs of the organisations. Hence, cloud computing is made more versatile and pervasive and entered deeply into all human and business life of to-day. India witnessed many activities in this segment. An initiative has already been taken by the government to start a national cloud. It estimated to create 2 million jobs in the near future in many segments. Different I.T. giants also took steps in investing huge amounts in cloud computing business in different countries and also more specifically in India. A typical system of cloud computing is presented in Fig.1.

![Fig.1: A typical Cloud Computing System.](image)

**III. CLOUD CHARACTERISTICS**

The U.S. National Institute of Standards and Technology contended that the characteristics of cloud computing are on-demand self-service, broad network access, pooling of computing resources, automatic, rapid and elastic provisioning of resources and measured service [1]. These characteristics correspond to technologies like virtualization, elasticity and utility computing [4]. In virtualization, properties of individual resources are abstracted and the abstracted properties are offered as a single large resource of that type. Elasticity means that a resource is always available to the user and it grows or shrinks according to utilization. Utility computing means to provide computing resources to the users on 'pay-as-you-go-basis'. Further, the characteristics also imply that an user can get the service from the provider such as real time and data storage automatically and on demand. Computing capabilities are also available in the cloud software and can be made accessible to the users with mobile phones, laptops and tablets through a much broader and wider network. Further, all computing resources are also pooled into the cloud to meet the requirements of many users by using multi-tenancy model. The resource usage by the user must be measured and gets payment to the provider accordingly. Cloud resources are mostly distributed and adaptable amongst users so as to enable themselves accessible to the delivery of efficient and high performance computing applications. Fig.2 shows cloud characteristics.

![Fig.2: Cloud Characteristics](image)

**IV. CLOUD ELEMENTS**

The applications and also solutions are being delivered by the providers to the users with the help of computing architecture and through internet. This process consists of four basic elements which are known service models. These are -

i) **Software as a Service (SaaS)** makes the cloud provider to install, establish and maintain the software as required by the users in the cloud so as to enable them to get the service properly and also more efficiently. The four general methods of providing software under the cloud to the users are single instance, multi-instance, multi-tenancy and also flex-tenancy. The providers are also proved to be much speedier in their approach in responding to the changes in the requirements of the present users. They are also introducing novel and innovative changes in their applications and find ways to attract new customers in good number.
At present, the open source software has been in use on an increasing scale and many users used to get benefits out of it. Many computing services are rendered by the providers through mostly in an open source code, known as open cloud and entered their open source into their final computing applications. As such, the users can’t face any risk due to loss, disadvantage, disaster or failure even when the providers lost their proprietary rights and gone out of business.

Virtualisation is also an important pillar of cloud computing and the virtualisation software reallocates the load amongst different servers available in the cloud which promotes much efficient utilisation of computing resources. This coexists and supplements with the other available technological and software design approaches. The cloud providers are using highly specialized software by upgrading the previously used software by taking into consideration its drawbacks and also shortcomings. A collaborative technology is used to get instant and easy communication amongst users under the cloud despite their location. At present, the most successful and the best technology that penetrates into both the individuals and also the business market is the cloud computing technology and also its associated software.

ii) Platform as a Service (PaaS) isan architecture upon which computing solutions are arrived at. The cloud platforms come in different shapes and sizes that are mostly depending on the nature, type and magnitude of the applications required by the user and the scale of their utilization.

The cloud platform is just an environment used for construction, deployment and management of a computing application and also a solution arrived at under the cloud. It is just similar to the way of desktop computing. But these platforms are bringing relevant software into the cloud and are made accessible to many users in time. The role of these platforms is becoming great and also proved very important as the cloud increases its complexity and intricacy overtime. These will do something more than just providing basic functionality of software. It reduces the software footprint and these have successfully driven down the time, risk and cost of computing applications and solutions. Further, there is no need to install, upgrade or host platforms since these are ubiquitous.

The cloud platforms provide combination of both infrastructure and application and these are easily amenable for change. Any change can be incorporated into the platform easily and also immediately. As change is an ongoing and everlasting activity of the platforms, constant monitoring of these changes is essential and consequently necessary upgrades are maintained. These changes move the entire gamut of computing architecture in the platform for better directions and also for improved results.

iii) Infrastructure as a Service (IaaS) provides cloud resources that are very much needed to deliver the cloud services timely and also efficiently. IaaS comprises of the physical resources available under the cloud. The infrastructure consists of data centres that are monitored and also maintained by the cloud providers. It should be very robust and enables the users to assure availability of service at any time and as per their need and requirement. The cloud infrastructures can be organised mostly in distinct security domains like forming specifically federated clouds. These are mainly formed as a collection of single clouds that can operate, maintain and exchange data amongst centres by adopting different computing interfaces. The biggest advantage of IaaS for government is that it offers a cloud-based data centre without requiring to install new equipment or to wait for the hardware procurement process [3].

iv) Identity as a Service (IDaaS) offers good amount of information for identification purpose. This identity can be used mainly during electronic transactions. It refers to a set of attributes and characteristics that are associated with something which makes it identifiable. All objects and variables are not having the same identity and hence a unique identity of the object is worth-mentioning and requires adequate consideration. Directory services, registration information, association services, authentication information and profile management are some of the weapons in the hands of the provider to identify the users and their activities and also operations. Though this element is an auxiliary one but needs extensive discussion and thorough examination in the present day computing boom.

The four elements of cloud computing are depicted in Fig 3.

V. TYPES OF CLOUDS

There are certain models in which the cloud computing technology is made accessible to the users. There are four types of clouds wherein the users can make use of these clouds for efficient deployment. These are-

i) Public cloud is a cloud which is made available to general public regardless of their origin or affiliation. This cloud works only for some computing applications and in many cases; the users are
not verified and monitored by the provider. Many enterprises are getting services under this cloud mainly to save capital costs. But, it raises serious and grave concerns about the privacy and security of the data, data transfer and also performance.

Under this cloud, the third party vendor delivers services and applications to various users. For a successful and an efficient working of the cloud, the vendor should be a right person or a trusted and an impartial organisation infusing confidence into the minds of the users by adopting new, innovative, comprehensive, commercially and technically viable security measures.

**ii) Private cloud** is generally operated to serve mainly an organisation. This cloud is primarily designed and specifically dedicated to an organisation that wishes to use it. The usage of this cloud is strictly restricted to its members, employees and the partners of that organisation. In a private cloud, internal computing resources are used to serve its internal users. Private clouds leverage virtualization and exist within a private data centre. Enterprises showed interest towards private clouds since they can’t host their data outside their boundary levels due to mere privacy and also many legal issues.

**iii) Hybrid Cloud** enables the use of both private and public clouds in a seamless manner. Many users accepted and endorsed this computing environment in the recent past under hybrid cloud which consists of the virtualised computer networks, more innovative and practical computing applications and also necessary solutions. This computing environment cannot only reduce management cost, but is pivotal to enabling next generation of applications on unprecedented scales [14]. By creating more flexible computing environment under the cloud, the users get benefits of both efficiency and high performance. As such, there is a tremendous acceptance of this cloud by even small and medium-size organisations. The Government, reputed educational institutions, well-noted scientists and also engineers advocated the use of this cloud in a great measure. They assumed that an unprecedented next generation computing applications and solutions are expected to be arrived under this cloud.

**iv) Community Cloud** is generally shared by a multiple or a group of organisations and allows systems, architecture and services to be accessible by these organisations or a group. This means that the infrastructure under the cloud is belonging to a specific community and having common and identical concerns. A community cloud lies between public and private clouds.

**v) Social Cloud** is a recently emerged cloud. This is a new type of cloud wherein the friends, relatives, peers and subordinates of the users are providing applications and solutions under the cloud through an online social network [6]. At present, this cloud is occupying a prominent place in computing operations since the social media permeates in all day-to-day computing activities. A pictorial presentation of the different types of clouds is given in Fig.4.

![Fig.4: Types of Clouds](image)

**VI. ARCHITECTURE**

The cloud computing architecture includes many cloud components and comprises of a good set of cloud services. The basic and general archi-
tectural model for cloud computing can be applied to any I.T. system with suitable work distribution carried out by virtual servers and adequate cloud storage techniques coupled with several cloud services. The Service Oriented Architecture (SOA) technique is used mainly to make the cloud components extensively available over the network as a service. The SOA using cloud computing is the best and a more prominent architectural approach which supports and promotes the ability of the cloud to address different problems and challenges involved in raising computing resources using the best possible configuration. The SOA is given in Fig.5.

Fig.5: Service Oriented Architecture

The cloud resources are generally virtualised and they are commonly distributed and adaptable dynamically to enable the delivery of highly qualitative computing applications, amongst users. These resources are much expandable in nature and they can be scaled up or scaled down depending on utilisation. The architecture of the software and hardware used under the cloud can vary significantly amongst providers for any specified service model. There are several cloud architectural models. Each model signifies a common usage and a characteristic. Generally, the provider determines the location of each model of the cloud architecture and its design so as to enable reliability and scalability. They also use other computing devices, in place of virtual machines, especially to provide services for other service models.

VII. SELECT A PROVIDER

As there is a mounting increase in the number of cloud providers and also a varied range of services available, selecting a provider in the right perspective by the user is as important and also a more determining factor. It includes the factors like identifying the ability and the economic viability of the cloud provider in providing and maintaining cloud platform and also a suitably associated network, extensive analysis and clear understanding of the policies and practices of the provider with regard to storage, security, transparency and governance, pricing and benchmarking performance and also the terms and conditions of the provider and its ability to restore normalcy when interruptions in services are caused.

Each provider serves a specific function. When they choose a provider, compare their needs to the cloud services available. Their cloud needs will vary depending on how they intend to use the space and resources associated with the cloud. If it will be for their personal home use, they will need a different cloud type and provider than if they will be using the cloud for business [9]. The user expects that the solutions offered to them and given by the provider through the cloud need to be more versatile, secured, reliable and authentic. As data security and consistency are highly dependent on each other, they promote a reliable cloud environment. Besides, more expanding and highly adjustable cloud computing in general, implies a highly available and also an extensively scalable environment of the cloud.

VIII. SERVICE-LEVEL AGREEMENT

The Service-Level Agreement or SLA represents the terms and conditions for access and use of the services given by the provider under cloud to the users. It includes terms like period of cloud services, conditions of storage and security, acceptable behaviour and attitude of the user, termination of the agreement, compensation payable, and modification to SLA and finally disposition of data. Insufficient SLAs generally lead to many security gaps [5] and these gaps can't be compensated or recouped many a time. These are having a negative dent on the profitability of both the provider and also the users.

The need of the day is to shift from the ownership-based cloud to subscription-based cloud. It gives an opportunity that all subscribers are made an integral part of the cloud ownership and each subscriber has a role to play in the cloud. As such, it enhances positively the scale and orbit of the cloud infrastructure.

IX. MAJOR CHALLENGES

Cloud computing is believed to be the new wave which will determine and dominate the entire computing world. While cloud computing offers many advantages to the users, there are still a number of challenges before it gets wider acceptance and use [8]. The important major challenges identified in the cloud computing paradigm are inconsistency in applications provided by several cloud providers, non-standardisation of query language, limited documentation, bench-marking criteria and immaturity in cloud solutions. Basically, the users need to understand first the basics of the provider's
cloud structure wherein how their data is transferred, where it is stored and its related security problems and also how data is moved into and out of a cloud during a specified period of time. As many users request the provisioning of service at one time and simultaneously, the service provider has a big challenge and poses a threat to scale up or scale down the software resource and computing network amongst users in a more decisive and also a much diligent manner.

There is another challenge to cloud computing. It is the applications and solutions that can easily be migrated from one cloud to another. However, this is not made available to users perfectly since each of the providers use different query languages for their networks, data centres and platforms. The provider lock-in is still continuing because of technical and language barriers and restrictions and the portability of cloud computing is yet to materialise. Besides, cloud computing framework faces lot of many other difficulties in the present day computing society especially in the process of efficient provisioning and delivery of applications and also solutions.

X. OTHER PROBLEM AREAS

The following are the other problem areas encountered by the users and the user organisations in the process of using and getting applications and solutions under cloud computing. The degree and the graveness of the problem differ from user to user and organisation to organisation depending upon the nature and also the scale of use.

(a) Benchmarking: Cloud performance is basically a key concern for many users. It is the process of determining who is the very best, who sets the standards and what that standard is. It is also to measure internal processes of the cloud provider against an external standard. This has generally been identified as the ability to move users' data files to and from the cloud computing service at a speed that supports the cloud business. The actual test for evaluating the cloud performance is using different services and applications by adjusting the platform and also the network framework suitably. These services are designed in such a manner to optimize the performance of the cloud system.

Different and discrete software and infrastructure applications and solutions are generally referred to as the final products of the cloud system. In the benchmarking criteria, each and every cloud provider has to look upon the industry's best standards to perform cloud functions and render cloud services to the users efficiently and also purposefully. The costs to the users should be in conformity with those of the other competitors in the industry and the cloud activities, operations and processes are run on the basis of the acceptable and ideal cloud standards.

Although some efforts are in the offing to establish benchmarking standards, the adoption of these standards by the providers in practice has been limited. It will become a major setback to the cloud system. This setback lies not in the infrastructure but in the policies relating to data storage, security and transparency in the service and operations of the cloud. Further, it being an emerging technology, it poses many questions relating to its environmental sustainability and also its maintenance.

Cloud computing auditing is also an emerging area wherein the cloud operations are periodically audited so as to ensure better comparison amongst data centres of the multiple providers for complying with the established and acceptable standards of the industry and also the best policies of industry's performance.

Cloud computing testing is also an important ingredient and supporting feature of the cloud infrastructure and its performance. Although it is a complicated and a more difficult task, it needs to have a relevant and careful planning and exhaustion of the system network. The reliability, inter-dependability and also operability of the computing architecture are also to be examined properly. As new cloud domains are born over time, cloud testing becomes more complex and at the same time proved more useful and much relevant for to-day's user requirements and also for benchmarking performance.

(b) Energy Saving: Cloud Computing requires huge amount of computing power for processing enormous amount of data generated day by day. This is being done through a large number of data centres having several servers with extensive and high scaled infrastructure and also network systems. It contributes much to escalated operational costs and carbon footprints to the environment. Carbon emission and thus consequent economy in energy consumption has become a need concern of many providers. Significant saving in the energy budget of a data centre, without sacrificing service level agreements, are an excellent economic incentive for data centre operators, and would also make a significant contribution to greater environmental sustainability [15].

Energy saving can be achieved in data centres through optimisation mechanisms [7]. The green cloud solutions which minimised energy consumption and reduces operational cost are proved successful in many quarters. A green grid which is nothing but a worldwide consortium of providers helps bring economy in power consumption and
considered energy savvy for many data centres. Without sacrificing the quality and tenderness of the service compatibility of the cloud providers, the green cloud structure is worth noted for reducing its carbon footprint so as to enable energy saving efficiency.

As data centres are being built in good numbers, they consume extensive amounts of energy. It has been surveyed that the energy consumption of cloud computing will increase by three times the present consumption by 2020. It is proved that an insignificant amount of savings in energy consumption under cloud by each provider leads to a much significant financial and carbon savings in the aggregate. In place of the hard disc drives, it is more relevant to use solid discs in cloud computing for a vast economy in energy use.

Depend on the technique of virtualization, a single hardware unit is to be run by many virtual machines depending on the scale and extent of user utilisation. This is meant server consolidation and is mainly responsible for energy saving and also efficiency in data centres. As less hardware is used for computing operations, the energy used for cooling can also be reduced significantly when utilisation increases. Further, relevant energy efficient scheduling mechanism also reduces per unit consumption of energy. Many a time’s renewable energy sources may also be used by the providers to reduce energy usage under cloud.

(c) Security, Privacy and Trust: The security, privacy and trust under cloud are a great concern at present. As cloud resources may be available to a large number of users, protecting the confidentiality of user data is among the top priority requirements for cloud systems [12]. Though it is a main stumbling block for wide coverage of clouds, the data relating to individual health information and more sensitive data is to be protected and safeguarded with a highly defined and more secured gamut of the provider. This highly secured computing environment under the cloud rests greatly on many security measures and the computing solutions should work together in unison to achieve the desired results.

The main components of a highly desired security level are the availability, reliability, confidentiality and also integrity. The cost of efficient security management include cloud migrating, implementing, integrating, upgrading and training personnel costs. Further, constant monitoring and evaluating security updates, taking remedial measures whenever necessary and adopting suitable new deviations, if any, to the actual and more acceptable legal standards.

Techniques efficiently are worth-mentioning for enunciating a secured cloud environment when an event of security interruption occurs.

The cloud computing is a global phenomenon and it crosses extensively beyond the borders of the different countries. It needs to have concern over privacy amongst different cultures, territories, languages and also the privacy regulations. Privacy is the ability of an individual or groups to seclude themselves or information about themselves and thereby reveal themselves selectively [11]. Many complex privacy issues are associated with cloud computing. Hence, the cloud providers need to examine study and undertake relevant Privacy Impact Assessments [2] before materialising their applications in different countries.

Provider accountability to the user is best recognised as a basis for promoting trust on the cloud. It is a complex and discrete social phenomenon and the users need to review constantly the trust mechanism and measures of the providers. Trusted solution has become a big matter into cloud environment and trust has become a hot environment of research because of a lot of security issues [10]. A trustworthy co-operation between user and provider should be done in a manner wherein both the user and the provider agreed upon the contract with full satisfaction. They adhered strictly and completely to with their behaviour to the contract and take proper measures forthrightly resolving of differences, if any, amongst them amicably. An evidence-based trust judgement for different users generally supports and promotes a common trustworthy framework for all the cloud users in the present day computing environment.

(d) Governance: The term 'governance' is generally a management tool. Cloud computing also requires governance in all its operations and applications in order to be more successful. The best approach to governance for computing under cloud is to focus on the education of those who uses computing systems and also to properly maintain, govern and control them. It strictly connotes the best and more ideal standard behaviour of the service.

The cloud governance specifies that the cloud operations, applications and solutions are executed in accordance with the terms and conditions specified in the agreements. For maintaining transparency and governance in cloud computing, the providers need to execute the specified services and also the policies are getting themselves audited properly and authenticated in time. This will give information to the provider regarding the

The providers also need to be proactive in maintaining governance in cloud computing as the designed mechanism clearly gives ways and means
XI. CONCLUSION

Similar to other things, Cloud Computing has also both pros and cons. Though the technology is considered to be an asset not only to an individual but also to an organisation, it could also cause bad and even worse, if not examined and understood properly. To conclude, many issues need to be analysed carefully and requires timely examination without any ambiguity. Cloud computing is recently emerged as a multi-disciplinary research field. It consists of a number of issues for research. Some of the prominent and worth-researching issues are the provision of dynamically architectural cloud solutions, ensuring efficient virtualisation methods for cloud computing, encapsulation of innovative techniques for subscription-based cloud computing and developing and augmenting the degree of reliability, adaptability, privacy, and trust and security measures under cloud.

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BIOGRAPHY

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