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Survey on Different Security Issues & Challenges in Cloud Computing for Multifarious Technology

Prof. Anuradha Bobade
Asst. Prof. D.Y. Patil College of Engineering, Pune,
Maharashtra, India

Abstract—

Cloud computing is a multifarious technological paradigm that is outgrowth of decades of research in parallel computing, virtualization, networking and communication, utility computing and Service-Oriented Architecture (SOA). It offers an on-demand and scalable access to a shared pool of resources hosted in a data centre at providers' site. It reduces the overheads of up-front investments and financial risks for the end-user. The qualitative services and lower cost of services are the key requirements of this technology. Regardless of the fact that cloud computing offers great advantages to the end users, there are several challenging issues that are mandatory to be addressed. Owing to the financial nature of use of the cloud services based on Service Level Agreements (SLA) makes these issues even more serious that needs to be taken care of. This work presents an overview, style and actuality of cloud computing with the objective of presenting challenging issues concerned with various aspects of cloud computing.

Index Terms— Cloud Computing, IT, IaaS, PaaS, SaaS.

I. INTRODUCTION

The advancements in Information Technology (IT) demand a new computing paradigm that supports delivery of computing services on minimal charges without installing them at local sites. Cloud computing offers the same model having above describe properties in which services are delivered over internet in an on-demand elastic way for which the charges are paid at release time of resources. In general, cloud is a multifarious technological paradigm that is an extension of many existing technologies viz. parallel and distributed computing, Service-Oriented-Architecture (SOA), virtualization, networking etc. The distributed computing, virtualization and internet works as indispensable building blocks of the cloud computing. It is a highly sharable computing paradigm where processing, storage, network, applications etc. are shared. The objective of the cloud computing is to provide secure, qualitative, scalable, quick, more responsive, on demand, cost-efficient and automatically provisioned services viz. computation services, storage services, networking etc. being provided in a transparent way (location independent). Cloud computing can help to improve business performance while making a contribution to control the cost of delivering IT resources to any organization.

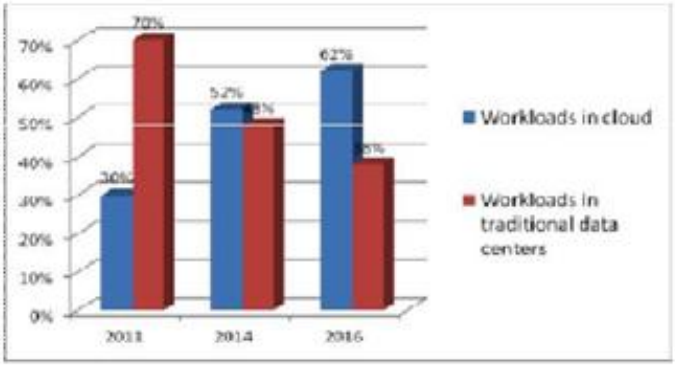

Fig.1.Workload distribution in cloud and traditional data centers [1]

The fundamental idea of cloud computing was pronounced way back in 1960 by Professor John McCarthy, as; "If computers of the kind I have advocated become the computers of the future, then computing may someday be organized as a public utility just as the telephone system is a public utility. The computer utility could become the basis of a new and important industry". Douglas Parkhill first explored the characteristics of cloud computing in 1966 in his book "*The Challenge of the Computer Utility"*. Cloud computing can be thought as an extension of Virtual Private Network (VPN) over network infrastructure which is used in telecommunication world. Initially, telecommunication service providers delivered dedicated point-to-point circuit which was the wastage of the bandwidth; the problem was solved by using VPN services where traffics could be switched to balance the utilization of the overall network. Cloud computing was a buzz word for many years and it turned into reality in 2007 when IT giants Google and IBM announced a collaboration in this domain followed by "Blue Cloud" announcement by IBM [2, 3, 4]. According to blog [5], the prediction of IT

advisory company Gartner says that cloud computing business will surpass $148 billion mark by 2014 while its competitor, Forrester, says it will reach $118 billion. Another Gartner's Survey says that the investment on services in public cloud is expected to increase 18.6% in 2012 to $110.3B that achieves a 17.7% Compound Annual Growth Rate (CAGR) from 2011 through 2016 [1]. In general, the total market is likely to increase to $210B in 2016 from $76.9B in 2010. Figure 1 gives a glimpse of the distribution of workloads in cloud and a traditional data centre that shows that popularity of cloud will be grow with a very fast rate. Therefore, cloud computing area looks very promising for researchers and businesses. On the other hand, its realization brings many challenging issues that need to be carefully addressed. The organization of remaining paper is as follows. Section 2 presents an overview of cloud computing, its essential characteristics, different deployment models and service models. Section 3 describes the advantages and disadvantages of cloud. Section 4 describes various issues and challenges of cloud computing that are necessary to address in order to adopt this technology. Finally, section 5 concludes the papers.

II. CLOUD COMPUTING

To properly understand cloud, it is important to know what it is, some essential characteristics that a system must possess to qualify as a cloud along with various services that can be offered using it through various deployment models.

A. The Definition

Cloud computing is in its infant form and numerous definitions have been proposed by many scientists. Some of the definitions are, Buyya et al. defines, "A Cloud is a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation between the service provider and consumers" [6].According to P. Gaw, "The way I understand it, 'cloud computing' refers to the bigger picture…basically the broad concept of using the internet to allow people to access technology-enabled services. According to Gartner, those services must be 'massively scalable' to qualify as true 'cloud computing' [1]J. Kaplan says, "I view cloud computing as a broad array of web-based services aimed at allowing users to obtain a wide range of functional capabilities on a 'pay-as-you-go' basis that previously required tremendous hardware/software investments and professional skills to acquire. Cloud computing is the realization of the earlier ideals of utility computing without the technical complexities or complicated deployment worries"[7]The National Institute of Standards and Technology (NIST) defines, "A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models" [8].

B. Five Essential Characteristics

The cloud computing must have some characteristics in order to meet expected user requirements and to provide qualitative services. According to NIST [8], these five essential characteristics can be classified as:On-demand self-service: A consumer can access different services viz. computing capabilities, storage services, software services etc. as needed automatically without service provider's intervention.Broad network access: To avail cloud computing services, internet works as a backbone of cloud computing. All services are available over the network and are also accessible through standard protocols using web enabled devices viz. computers, laptops, mobile phones etc.Resource pooling: The resources that can be assigned to users can be processing, software, storage, virtual machines and network bandwidth. The resources are pooled to serve the users at a single physical location and/or at different physical location according to the optimality conditions (e.g. security, performance, consumer demand). The cloud gives an impression of resource location independence at lower level (e.g. server, core) but not at the higher level (e.g. datacenter, city, country).Rapid elasticity: The beauty of cloud computing is its elasticity. The resources appear to users as indefinite and are also accessible in any quantity at any time. The resources can be provisioned without service provider intervention and can be quickly scale in and scale out according to the user needs in a secure way to deliver high quality services.Measured service: A metering capability is deployed in cloud system in order to charge users. The users can achieve the different quality of services at different charges in order to optimized resources at different level of abstraction suitable to the services (e.g. SaaS, PaaS and IaaS).

C. Service Models

The cloud services are delivered in three forms viz. Infrastructure-as-a-Service (IaaS), Software-as-a-Service (SaaS) and Platform-as-a-Service (PaaS). The services are delivered over the network by using Web browser, Web Based mail etc. The service models are as follows:Software-as-a-Service (SaaS): In this multitenant service model, the consumers use application running on a cloud infrastructure. The cloud infrastructure including (servers, OS, Network or application etc.) is managed and controlled by the service provider with the user not having any control over the infrastructure [8, 9]. Some of the popular examples are SalesForce.com, NetSuite, IBM, Microsoft and Oracle etc. Platform-as-a-Service (PaaS): With this model, the provider delivers to user a platform including all the systems and environments comprising software development life cycle viz. testing, deploying, required tools and applications. The user does not have any control over network, servers, operating system and storage but it can manage and control the deployed application and hosting environments configurations [8, 9]. Some popular PaaS providers are GAE, Microsoft's Azure etc.Infrastructure-as-a-Service (IaaS): In this service model, the provider delivers to user the infrastructure over the internet. With this

model, the user is able to deploy and run various software's including system or application softwares. The user has the ability to provision computing power, storage, networks. The consumers have control over operating systems, deployed applications, storage and partial control over network. The consumer has no control over underlying infrastructure [8, 10]. Some important IaaS providers are GoGrid, Flexiscale, Joyent, Rackspace etc.

D. Deployment models:

Cloud systems can be deployed in four forms viz. private, public, community and hybrid cloud as per the access allowed to the users and are classified as follows:Private cloud: This deployment model is implemented solely for an organization and is exclusively used by their employees at organizational level and is managed and controlled by the organization or third party. The cloud infrastructure in this model is installed on premise or off premise. In this deployment model, management and maintenance are easier, security is very high and organization has more control over the infrastructure and accessibility [8, 10]. Public cloud: This deployment model is implemented for general users. It is managed and controlled by an organization selling cloud services. The users can be charged for the time duration they use the services. Public clouds are more vulnerable to security threats than other cloud models because all the application and data remains publicly available to all users making it more prone to malicious attacks. The services on public cloud are provided by proper authentication [8, 10]. Community cloud: This cloud model is implemented jointly by many organizations with shared concerns viz. security requirements, mission, and policy considerations. This cloud is managed by one or more involved organizations and can be managed by third party. The infrastructure may exist on premise to one of the involved organization or it may exist off premise to all organizations [8, 10]. Hybrid cloud: This deployment model is an amalgamation of two or more clouds (private, community, public or hybrid). The participating clouds are bound together by some standard protocols. It enables the involved organization to serve its needs in their own private cloud and if some critical needs (cloud bursting for load-balancing) occur they can avail public cloud services [8, 10].

III. ADVANTAGES AND DISADVANTAGES OF CLOUD COMPUTING

The degree of acceptance for any computing paradigm is measured by its strengths and weaknesses. If advantages owing to computing paradigm are fair enough and the overheads are bearable to some extent, the degree of acceptance is very high and that computing paradigm will be accepted by users. Following are some important advantages and disadvantages offered by the cloud can be written as:

A. Advantages

Cloud computing offers many benefits and flexibility to its users. User can operate from anywhere at any time in a secure way. With the increasing number of web-enabled devices used now-a-days (e.g. tablets, smart phones etc.), access to one's information and data must be quick and easier. Some of these relevant benefits in respect to the usage of a cloud can be as follows [9, 10]: Reduces up-front investment, Total Cost of Ownership (TCO), Total Operational Cost (TOC) and minimizes business risks. Provides a dynamic infrastructure that provides reduced cost and improved services with less development and maintenance cost. Provides on-demand, flexible, scalable, improved and adaptable services on pay-as-you go model. Provides consistent availability and performance with automatically provisioned peak loads. Can recover rapidly and has improved restore capabilities for improved business resiliency. Provides unlimited processing, storage, networking etc. in an elastic way. Offers automatic software updates, Improved Document Format Compatibility and improved compatibility between different operating systems. Offers easy group collaboration i.e. flexibility to its users on global scale to work on the same project. Offers increased return on investment of existing assets, freeing capital to deploy strategically. Provides environment friendly computing as it only uses the server space required by the application which in turn reduces the carbon footprints.

B. Disadvantages of Cloud Computing

Every coin has two faces. That's not to say, of course, cloud computing is without disadvantages. Some of the disadvantages while using a cloud an be summarized as [9]: Requires high speed network and connectivity constantly .Privacy and security is not good. The data and application on a public cloud might not be very secure. Disastrous situation are unavoidable and recovery is not possible always. If the cloud loses one's data, the user and the service provider both gets into serious problems. Users have external dependency for mission critical applications. Requires constantly monitoring and enforcement of service level agreements (SLAs).

IV. ISSUES AND CHALLENGES OF CLOUD COMPUTING

A. Security and Privacy

The existing computing paradigms viz. distributed computing, SOA, networking etc. are building blocks of cloud computing. There are numerous issues associated with theses computing paradigms and some new challenges emerged from cloud computing are required to be addressed properly in order to realize the cloud to its full extent. Current cloud adoption is associated with numerous challenges as shown in Figure 2 and 3 depicting the specific business risk of adopting cloud services and biggest barriers. Therefore, these issues must be addressed in order to provide high quality services to the users while complying with the service provider's needs. The issues can be organized into several different categories varying from security, protection, identity management, resource management, power and energy management, data isolation, availability of resources, heterogeneity of resources. Although, there are several issues that demand attention but the following could be treated as of prime concern [11-14]:

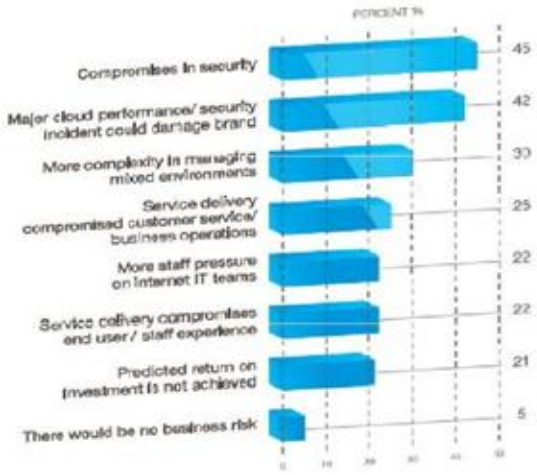

Fig. 2. Specific Business Risk of adopting cloud services [14]

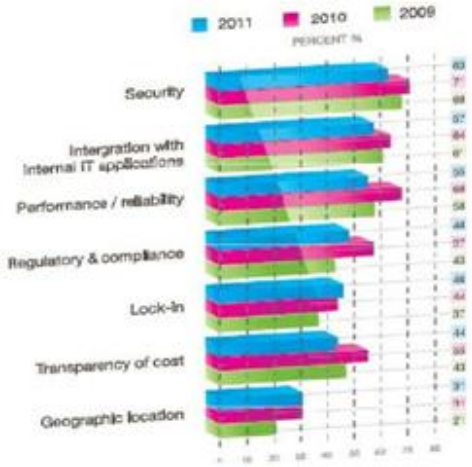

Fig. 3. Biggest Barriers to adoption of cloud services [14]

According to the survey of International Data Corporation (IDC), Security, Performance and Availability are the three biggest issues in cloud adoption. The critical challenge is how it addresses security and privacy issues which occur due to movement of data and application on networks, loss of control on data, heterogeneous nature of resources and various security policies. Data stored, processing and movement of data outside the controls of an organization poses an inherent risk and making it vulnerable to various attacks. The security threats can be of two types viz. internal and external. The external risk is posed by various persons and organizations e.g. enemies or hackers that do not have direct access to the cloud. The internal security risk is a well-known issue which can be posed by organizational affiliates, contractors, current or former employees and other parties that have received access to an organization's servers, networks and data to facilitate operations. Cloud computing poses privacy concerns because the service providers may access the data that is on the cloud that could accidentally or deliberately be changed or even removed posing serious business trust and legal consequences [8, 11-14].

B. Performance

According to IDC's survey, performance is the second biggest issue in cloud adoption. The cloud must provide improved performance when a user moves to cloud computing infrastructure. Performance is generally measured by capabilities of applications running on the cloud system. Poor performance can be caused by lack of proper resources viz. disk space, limited bandwidth, lower CPU speed, memory, network connections etc. Many times users prefer to use services from more than one cloud where some applications are located on private clouds while some other data or applications being on public and/or community cloud. The data intensive applications are more challenging to provide proper resources. Poor performance can results in end of service delivery, loss of customers, reduce bottom line revenues etc. [2, 11, 13].

C. Reliability and Availability

Any technology's strength is measured by its degree of reliability and availability. Reliability denotes how often resources are available without disruption (loss of data, code reset during execution) and how often they fail. One of the important aspect that creates serious problems for the reliability of cloud computing is down time. One way to achieve reliability is redundant resource utilization. Availability can be understood as the possibility of obtaining the resources whenever they are needed with the consideration to the time it takes for these resources to be provisioned. Regardless of employing architectures having attributes for high reliability and availability, the services in cloud computing can

experience denial of service attacks, performance slowdowns, equipment outages and natural disasters. Data shows that some of the current cloud computing providers have some frequent outages last year. e.g Amazon EC2 outage. In order to remove FUDD (fear, uncertainty, doubt, and disinformation), probably the reliability, availability and security are the important and prime concern to an organization. Therefore, the level of reliability and availability of cloud resources must be considered as a serious issue into the organization's planning to set up the cloud infrastructure in order to provide effective services to consumers [19].

D. Scalability and Elasticity

Scalability and elasticity are the most amazing and unique features of the cloud computing. These features provide users to use cloud resources being provisioned as per their need in unlimited amount as required. Scalability can be defined as the ability of the system to perform well even when the resources have been scaled up. Elasticity, on the other hand, is the ability to scale resources both up and down as and when required. Elasticity goes one step further, though, and does also allow the dynamic integration and extraction of physical resources to the infrastructure. The elastic cloud computing means that allocation of resources can get bigger or smaller depending on the requirement. Elasticity enables scalability—which means the system can easily scale up or down the level of services to which the user has subscribed. Scalability can be provided in two ways- horizontally and vertically whereby horizontal scalability (Scale Out) refers to addition of more nodes to the system such as adding a new computer to an existing service provider system while vertical scalability (scale up) refers to addition of resources to a single node in the system, typically involving the addition of memory or processors to a single computer [19].

E. Interoperability and Portability

Interoperability is the ability to use the same tools or application across various cloud service providers platforms. The interoperability can be defined at various levels viz. application, service, management and Data interoperability. Cloud users must have the flexibility of migrating in and out and switching to clouds whenever they want without no vendor lock-in period. One of the adoption barriers in cloud computing interoperability is the vendor lock-in risk. The main problems to realize it are the lack of open standards, open APIs and lack of standard interfaces for VM formats and service deployment interfaces. Cloud portability ensures that one cloud solution will be able to work with other platforms and applications as well as with other clouds [14].

F. Resource Management and Scheduling

Resources management can be consider at various levels viz. hardware, software, virtualization level with performance, security and other parameters being dependent on the management and provisioning of resources. It includes the management of memory, disk space, CPU's, cores, threads, VM images, I/O devices etc. Resource provisioning can be defined as allocation and management of resources to provide desired level of services. Job scheduling is a type of resource provisioning where jobs execution order is established in order to finish job execution to optimize some parameters viz. turnaround time, response time, waiting time, throughput and resource utilization. Since cloud computing is a combination of many existing technologies, existing job scheduling strategies are eligible to be applied on cloud system. The major issues of job scheduling on cloud systems are partitioning of jobs into parallel tasks, interconnection network between clouds or processors, assigning priority to jobs and selection of processors or cloud to allocate the job(s), job flexibility, level of pre-emption supported, workload characteristics, memory allocation, task execution monitoring, recourse allocation requirements, topology, nature of the job, effect of existing load, load balancing, parallelism, job migration policy, redundant Resource selection, synchronization, communication overheads, job pre processing requirements etc. The job scheduling is one of critical process that must be decided very carefully and wrong selection of scheduling strategy can lead to devastating effect on performance leading to wastage of resources while falling to meet Quality of Service (QoS) standards.

G. Energy Consumption

According to a survey done by Amazon as shown in Figure 4, the cost consumption of Amazon data centers is shocking as 53% of the total cost is consumed by the servers for a 3-year amortization period while energy and cooling requirements consume 42% of the total budget including both direct power consumption (~19%) and the cooling requirements (23%) for amortization period of 15-years [16]. In 2006, data centers of United States consumed more than 1.5% of the total energy produced in that year, and this percentage is expected to increase 18% annually [15].

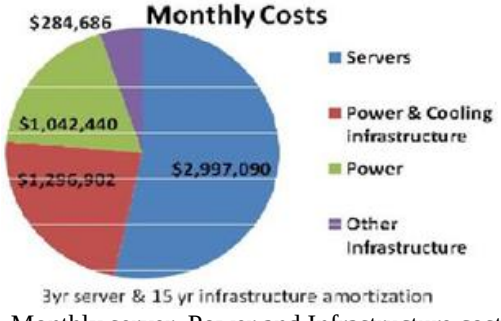

Fig. 4. Monthly server, Power and Infrastructure costs [16]

Cloud data centers house thousands of servers and set up the cooling infrastructure to remove heats generated by these servers. These servers and cooling infrastructure consume a large amount of energy and produces green house gases (GHGs). In addition, the cloud data centres which are inherent part of the cloud infrastructure are also very expensive to operate and consume energy at a very large scale. For example, the power consumption of Google data centre is equivalent to a city such as San Francisco. Since ICT aids towards developing applications and facilities for human prosperity, we require designing such hardware, software, scheduling policies, networks and other protocols that consume energy in eco-friendly and optimized manner. The goal is not only to reduce the consumption of energy and hence the cost consumed by data centers, but also to maintain environmental standards necessary not only to survive but to thrive [16, 20].

H. Virtualization

Virtualization is the creation of a virtual version of a storage device, an operating system, a server or network resources. The virtualization divides the resource into multiple execution environments and hides the physical characteristics of computing resources to simplify the way in which other systems, applications or end users interact with those resources. Virtualization is used in two forms viz. Type 1 hypervisors / Bare-Metal Virtualization and Type 2 hypervisors / OS virtualization. Virtualization is one of the key technology in order to make it possible to realize the cloud computing. Virtualization realization typically enables consumers to migrate their computation and data to a remote location with some varying impact on performance. There are numerous benefits of virtualization which could not otherwise be achieved. Some of the benefits include elasticity and scalability, cost effectiveness, location independence, infrastructure independency, customization, simplified access interface etc. However, virtualization provides many benefits to users, while on the other hand it poses many challenges to cloud computing. It has many critical issues to be address viz. VM sprawl challenges, workload characterization of VMs, security issues in hypervisor based cloud communication, Live migration security, unnecessary migration to a private cloud etc. Virtualization makes infrastructure management more complex, and massive automation is required in order to support the key aspects such as automation, on-demand and elasticity requirements.

I. Bandwidth Cost

High speed communication channels work as a backbone of cloud computing. With cloud computing, business gets the ability to save money on hardware and/or software but still requires spending more on the bandwidth. It is almost impossible to fully exploit the services of cloud computing without high speed communication channels. Migration to cloud almost removes the up-front cost, while it increases the cost of data communication on network i.e. the cost involved in transfer of data to and from the private and other clouds [17]. This problem is prominent if consumer application is data intensive and the consumer's data is distributed amongst a number of clouds (private/public/community). Cloud computing provides lesser cost for CPU intensive jobs than data intensive jobs with gray's argument "Put the computation near the data" still applicable for data intensive jobs still finding relevance [18]. In other words, data intensive applications can perform better being employed on private cloud rather than public/hybrid cloud.

J. What to Migrate

According to a Survey conducted by IDC in 2008, seven IT systems/applications being migrated to the cloud are: IT Management Applications (26.2%), Collaborative Applications (25.4%), Personal Applications (25%), Business Applications (23.4%), Applications Development and Deployment (16.8%), Server Capacity (15.6%), and Storage Capacity (15.5%). This survey, with a sample size of 244, reveals that organizations still are not ready to move their data on to cloud due to security/privacy concerns. The survey also shows that peripheral functions such as IT management and personal applications are the easiest IT systems. The organizations are conservative in employing IaaS compared to SaaS being ready to outsource their marginal functions to cloud while critical activities being kept domestic. The survey also reveals that the organization will move their 31.5% Storage Capacity to the cloud in next 3 years while the collaborative applications will reach to 46.3% by that time [21]. However, various issues and challenges of cloud computing have been taken up in this section still there are many other compelling issues that needs to be considered. Some of these like capacity planning, management of additional and remaining resources, management of automation of resources, costing model, Service Level Agreement (SLA) etc. are also there demanding an early attention. These issues should not be considered as road blocks in the pursuit of cloud computing, it is rather important to give serious consideration to these issues and explore the possible ways out before adopting this technology.

V. CONCLUSION

Cloud computing can be considered as an integral component of almost all businesses in near future and it is expected to change the landscape of IT industry. It is based on the model of delivering services on internet with pay-as-you-go model with advantages like no up-front cost, lower IT staff, lower cost of operation to name a few. Although cloud computing has bright prospects both for business and researchers certain challenging issues including security, performance, reliability, scalability, interoperability, virtualization etc. needs to be addressed carefully. The improvement in bandwidth technology, corresponding service models and security models can really revolutionize this area along with the IT industry. The paper has discussed the concept of cloud computing and shades some lights on various issues and challenges that needs to be addressed in order to realize the implementation of the cloud and making it a dominant part of our life in order to thrive.

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