Modern Research Provocation in Cloud Computing

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Abstract: *"Cloud" computing – a relatively recent term, builds on decades of research in virtualization, distributed computing, utility computing, and more recently networking, web and software services. It implies a service oriented architecture, reduced information technology overhead for the end-user, great flexibility, reduced total cost of ownership, on-demand services and many other things. This paper discusses the concept of "cloud" computing, some of the issues it tries to address, related research topics, and a "cloud" implementation available today Cloud computing is a set of IT services that are provided to a customer over a network on a leased basis and with the ability to scale up or down their service requirements. Usually Cloud Computing services are delivered by a third party provider who owns the infrastructure. In a cloud computing environment, the entire data resides over a set of networked resources, enabling the data to be accessed through virtual machines. Despite the potential gains achieved from the cloud computing, the organizations are slow in accepting it due to security issues and challenges associated with it. Security is one of the major issues which hamper the growth of cloud. There are various research challenges also there for adopting cloud computing such as well managed service level agreement (SLA), privacy, interoperability and reliability. This research paper presents what cloud computing is, the various cloud models and the overview of the cloud computing architecture. This research paper also analyzes the key research challenges present in cloud computing and offers best practices to service providers as well as enterprises hoping to leverage cloud service to improve their bottom line in this severe economic climate.*

Keywords: Cloud Architecture, Cloud Computing, Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Mobile Cloud Computing (MCC).

1. INTRODUCTION

The use of cloud computing is expanding, and by 2016 this growth will rise to become the bulk of new IT spend. 2016 will be a defining year for cloud as private cloud begins to give way to hybrid cloud and nearly half of large organization will have hybrid cloud deployments by the end of 2017.A model for computing in which something is done in the cloud. "A dummy for on-demand network access to a common pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider Interaction" by National Institute of Standards and Technology[1]. "In general, there are very real trends toward cloud platforms, and also toward massively scalable computing. Service orientation, virtualization and the Internet have converged to sponsor a phenomenon that enables individuals and businesses to choose how they'll acquire or deliver IT services, with less emphasis on the constraints of traditional hardware and software licensing models". "Services provided by the cloud will foster an economy based on delivery and consumption of everything from storage to computation to video to finance deduction management."[2].Cloud Computing is not purely new technology but it is a new name for grid computing. The

vision is same that is to reduce the cost of computing ,storage ,increasing reliability and flexibility by transforming computers from something we buy and operate ourselves to something is operated by a third party[3]. The problems are mostly same in Clouds and Grids. There is a general need to be able to manage large facilities; to define methods by which consumers request, use resources and discover provided by the central facilities; and to implement the often highly parallel computations that execute on those resources. Explanation differs, but the two technologies are struggling with many of the same issues. Cloud Computing is used by many governments, research institutes and industries to solve the problem of large computing and storage required at lesser cost[4].
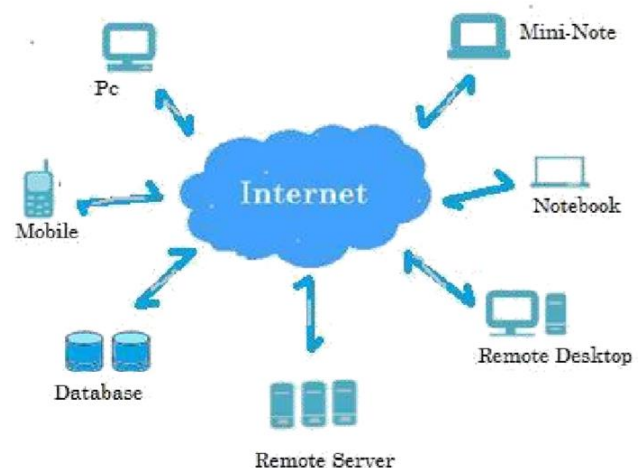

Fig.1. cloud computing visual scheme

2. CLOUD COMPUTING BUILDING BLOCKS

A. DEPLOYMENT MODELS In the cloud deployment model, networking, platform, storage, and software infrastructure are provided as services that scale up or down depending on the demand as depicted in figure 1. The Cloud Computing model has four main deployment models which are:

Private Cloud: Private cloud is a new term that some vendors have recently used to describe offerings that emulate cloud computing on private networks. It is set up within an organization's internal enterprise datacenter. In the private cloud, scalable resources and virtual applications provided by the cloud vendor are pooled together and available for cloud users to share and use. It differs from the public cloud in that all the cloud resources and applications are managed by the organization itself, similar to Intranet functionality. Utilization on the private cloud can be much more secure than that of the public cloud because of its specified internal exposure. Only

the organization and designated stakeholders may have access to operate on a specific Private cloud [38]. One of the best examples of a private cloud is Eucalyptus Systems [3].

Public Cloud: Public cloud describes cloud computing in the traditional mainstream sense, whereby resources are dynamically provisioned on a fine-grained, self-service basis over the Internet, via web applications/web services, from an off-site third-party provider who shares resources and bills on a fine-grained utility computing basis. It is typically based on a pay-per-use model, similar to a prepaid electricity metering system which is flexible enough to cater for spikes in demand for cloud optimization [1]. Public clouds are less secure than the other cloud models because it places an additional burden of ensuring all applications and data accessed on the public cloud are not subjected to malicious attacks. Examples of a public cloud include Microsoft Azure, Google App Engine.

Hybrid Cloud: Hybrid cloud is a private cloud linked to one or more external cloud services, centrally managed, provisioned as a single unit, and circumscribed by a secure network [12]. It provides virtual IT solutions through a mix of both public and private clouds. Hybrid Cloud provides more secure control of the data and applications and allows various parties to access information over the Internet. It also has an open architecture that allows interfaces with other management systems. Hybrid cloud can describe configuration combining a local device, such as a Plug computer with cloud services. It can also describe configurations combining virtual and physical, collocated assets -for example, a mostly virtualized environment that requires physical servers, routers, or other hardware such as a network appliance acting as a firewall or spam filter. An example of a Hybrid Cloud includes Amazon Web Services (AWS).

Community Cloud: Infrastructure shared by several organizations for a shared cause and may be managed by them or a third party service provider and rarely offered cloud model. These clouds are normally based on an agreement between related business organizations such as banking or educational organizations. A cloud environment operating according to this model may exist locally or remotely. An example of a Community Cloud includes Facebook.
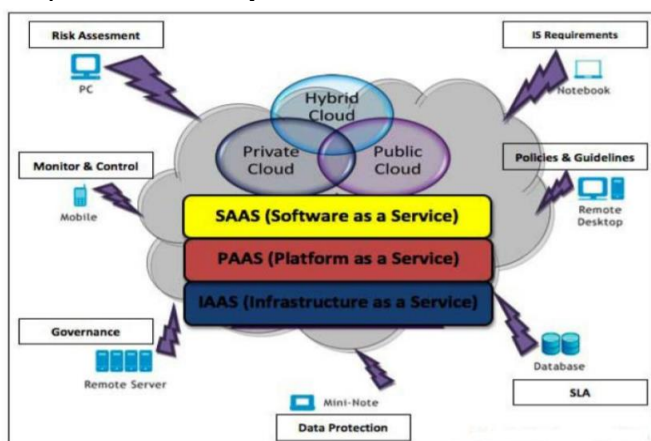

<div align="center">Fig. 2 Cloud Deployment Model [1]</div>

Moreover, with the technological advancements, we can see derivative cloud deployment models emerging out of the various demands and the requirements of users. A similar example being a virtual-private cloud wherein a public cloud is used in a private manner, connected to the internal resources of the customer's data-centre [40]. With the emergence of high-end network access technologies like 2G, 3G, Wi-Fi, Wi-Max etc. and feature phones, a new derivative of cloud computing has emerged. This is popularly referred as ―Mobile Cloud Computing (MCC)‖. It can be defined as a composition of mobile technology and cloud computing infrastructure where data and the related processing will happen in the cloud only with an exception that they can be accessed through a mobile device and hence termed as mobile cloud computing [16]. It's becoming a trend now-a-days and many organizations are keen to provide accessibility to their employees to access office network through a mobile device from anywhere. Recent technical advancements including the emergence of HTML5 and various other browser development tools have only increased the market for mobile cloud-computing. An increasing trend towards the feature-phone adoption [16] has also ramped up the MCC market.

B. SERVICE MODELS According to the different types of services offered, cloud computing can be considered to consist of three layers: software as a service (SAAS), platform as a Service (PAAS), and infrastructure as a Service (IAAS) (Iyer and Henderson, 2010; Han, 2010, Mell and Grance, 2010). Infrastructure as a Service (IaaS) is the lowest layer that provides basic infrastructure support service. Platform as a Service (PaaS) layer is the middle layer, which offers platform oriented services, besides providing the environment for hosting user's applications. Software as a Service (SaaS) is the topmost layer which features a complete application offered as service on demand [2, 24].

Software-as-a-Service (SaaS): SaaS can be described as a process by which Application Service Provider (ASP) provide different software applications over the Internet. This makes the customer to get rid of installing and operating the application on own computer and also eliminates the tremendous load of software maintenance; continuing operation, safeguarding and support [33]. SaaS vendor advertently takes responsibility for deploying and managing the IT infrastructure (servers, operating system software, databases, data center space, network access, power and cooling, etc) and processes (infrastructure patches/upgrades, application patches/upgrades, backups, etc.) required to run and manage the full solution. SaaS features a complete application offered as a service on demand. In SaaS, there is the Divided Cloud and Convergence coherence mechanism whereby every data item has either the ―Read Lock‖ or ―Write Lock‖ [11]. Two types of servers are used by SaaS: the Main Consistence Server (MCS) and Domain Consistence Server (DCS). Cache coherence is achieved by the cooperation between MCS and DCS [35]. In SaaS, if the MCS is damaged, or compromised, the control over the cloud environment is lost. Hence securing the MCS is of great importance. Examples of SaaS includes: Salesforce.com, Google Apps.

Platform as a Service (PaaS): ―PaaS is the delivery of a computing platform and solution stack as a service without software downloads or installation for developers, IT managers or end-users. It provides an infrastructure with a high level of integration in order to implement and test cloud applications. The user does not manage the infrastructure (including network, servers, operating systems and storage), but he controls deployed applications and, possibly, their configurations. Examples of PaaS includes: Force.com, Google App Engine and Microsoft Azure.

Infrastructure as a Service (IaaS): Infrastructure as a service (IaaS) refers to the sharing of hardware resources for executing services using Virtualization technology. Its main objective is to make resources such as servers, network and storage more readily accessible by applications and operating systems. Thus, it offers basic infrastructure on-demand services and using Application Programming Interface (API) for interactions with hosts, switches, and routers, and the capability of adding new equipment in a simple and transparent manner. In general, the user does not manage the underlying hardware in the cloud infrastructure, but he controls the operating systems, storage and deployed applications. The service provider owns the equipment and is responsible for housing, running and maintaining it. The client typically pays on a per-use basis. Examples of IaaS include Amazon Elastic Cloud Computing (EC2), Amazon S3, GoGrid.
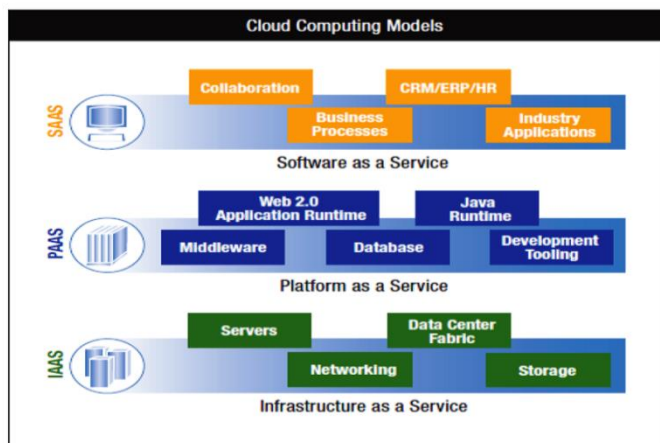

Fig. 2 Cloud Computing Service Delivery Models [26]

Combining the three types of clouds with the delivery models we get a holistic cloud illustration as seen in Figure 2, surrounded by connectivity devices coupled with information security themes. Virtualized physical resources, virtualized infrastructure, as well as virtualized middleware platforms and business applications are being provided and consumed as services in the Cloud [26]. Cloud vendors and clients' need to maintain Cloud computing security at all interfaces.

C. CLOUD COMPUTING ARCHITECTURE: OVERVIEW Cloud computing can be divided into two sections, the user and the cloud. In most scenarios, the user is connected to the cloud via the internet. It is also possible for

an organization to have a private cloud in which a user is connected via an intranet. However, both scenarios are identical other than the use of a private and public network or cloud [10]. The user sends requests to the cloud and the cloud provides the service.
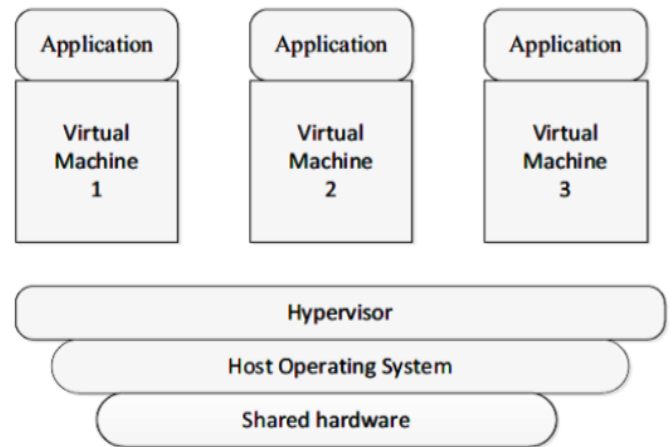

Fig. 3 Cloud Architecture [10]

Within the cloud, a central server is responsible for administering the system and in many ways functions as the operating system of the specific cloud network. Another name for this is called ―middleware‖ which is the central server for a particular cloud. Examples include Google App Engine and Amazon EC2 [10].

D. CLOUD COMPUTING ENTITIES Cloud providers and consumers are the two main entities in the business market. But, service brokers and resellers are the two more emerging service level entities in the Cloud world. These are discussed as follows

Cloud Providers: Includes Internet service providers, telecommunications companies, and large business process outsourcers that provide either the media (Internet connections) or infrastructure (hosted data centers) that enable consumers to access cloud services. Service providers may also include systems integrators that build and support data centers hosting private clouds and they offer different services (e.g., SaaS, PaaS, IaaS, and etc.) to the consumers, the service brokers or resellers [29].

Cloud Service Brokers: Includes technology consultants, business professional service organizations, registered brokers and agents, and influencers that help guide consumers in the selection of cloud computing solutions. Service brokers concentrate on the negotiation of the relationships between consumers and providers without owning or managing the whole Cloud infrastructure. Moreover, they add extra services on top of a Cloud provider's infrastructure to make up the user's Cloud environment.

Cloud Resellers: Resellers can become an important factor of the Cloud market when the Cloud providers will expand their business across continents. Cloud providers may choose local IT consultancy firms or resellers of their existing products to

act as ―resellers‖ for their Cloud-based products in a particular region. Cloud Consumers: End users belong to the category of Cloud consumers. However, also Cloud service brokers and resellers can belong to this category as soon as they are customers of another Cloud provider, broker or reseller.

3. RESEARCH CHALLENGES IN CLOUD COMPUTING

Cloud Computing research addresses the challenges of meeting the requirements of next generation private, public and hybrid cloud computing architectures, also the challenges of allowing applications and development platforms to take advantage of the benefits of cloud computing. The research on cloud computing is still at an early stage. Many existing issues have not been fully addressed, while new challenges keep emerging from industry applications. Some of the challenging research issues in cloud computing are given below [31, 41].

- Service Level Agreements (SLA's)
- Cloud Data Management & Security
- Data Encryption
- Migration of virtual Machines
- Interoperability
- Access Controls
- Energy Management
- Multi-tenancy
- Server Consolidation
- Reliability & Availability of Service
- Common Cloud Standards
- Platform Management

Service Level Agreements (SLA's): Cloud is administrated by service level agreements that allow several instances of one application to be replicated on multiple servers if need arises; dependent on a priority scheme, the cloud may minimize or shut down a lower level application. A big challenge for the Cloud customers is to evaluate SLAs of Cloud vendors. Most vendors create SLAs to make a defensive shield against legal action, while offering minimal assurances to customers. So, there are some important issues, e.g., data protection, outages, and price structures that need to be taken into account by the customers before signing a contract with a provider [15]. The specification of SLAs will better reflect the customers' needs if they address the required issues at the right time. Some of the basic questions related to SLA are uptime i.e. are they going to be up 99.9% of the time or 99.99% of the time? And also how does that difference impact your ability to conduct the business? Is there any SLA associated with backup, archive, or preservation of data? If the service account becomes inactive then do they keep user data? If yes then how long?, So it's an important research area in cloud computing.

Cloud Data Management: Cloud data can be very large (e.g. text-based or scientific applications), unstructured or semi-structured, and typically append-only with rare updates Cloud data management an important research topic in cloud computing. Since service providers typically do not have

access to the physical security system of data centers, they must rely on the infrastructure provider to achieve full data security. Even for a virtual private cloud, the service provider can only specify the security setting remotely, without knowing whether it is fully implemented. The infrastructure provider, in this context, must achieve the objectives like confidentiality, auditability. Confidentiality, for secure data access and transfer, and auditability, for attesting whether security setting of applications has been tampered or not. Confidentiality is usually achieved using cryptographic protocols, whereas auditability can be achieved using remote attestation techniques. However, in a virtualized environment like the clouds, VMs can dynamically migrate from one location to another; hence directly using remote attestation is not sufficient. In this case, it is critical to build trust mechanisms at every architectural layer of the cloud. Software frameworks such as MapReduce and its various implementations such as Hadoop are designed for distributed processing of data-intensive tasks; these frameworks typically operate on Internet-scale file systems such as GFS and HDFS. These file systems are different from traditional distributed file systems in their storage structure, access pattern and application programming interface. In particular, they do not implement the standard POSIX interface, and therefore introduce compatibility issues with legacy file systems and applications. Several research efforts have studied this problem [43].

Data Encryption: Encryption is a key technology for data security. Understand data in motion and data at rest encryption. Remember, security can range from simple (easy to manage, low cost and quite frankly, not very secure) all the way to highly secure (very complex, expensive to manage, and quite limiting in terms of access). You and the provider of your Cloud computing solution have many decisions and options to consider. For example, do the Web services APIs that you use to access the cloud, either programmatically, or with clients written to those APIs, provide SSL encryption for access, this is generally considered to be a standard. Once the object arrives at the cloud, it is decrypted, and stored. Is there an option to encrypt it prior to storing? Do you want to worry about encryption before you upload the file for cloud computing or do you prefer that the cloud computing service automatically do it for you? These are options, understand your cloud computing solution and make your decisions based on desired levels of security.

Migration of Virtual Machines: Applications are not hardware specific; various programs may run on one machine using virtualization or many machines may run one program. Virtualization can provide significant benefits in cloud computing by enabling virtual machine migration to balance load across the data center. In addition, virtual machine migration enables robust and highly responsive provisioning in data centers. Virtual machine migration has evolved from process migration techniques. More recently, Xen and VMWare have implemented ―live‖ migration of VMs that involves extremely short downtimes ranging from tens of milliseconds to a second. The major benefit of VM migration

is to avoid hotspots; however, this is not straightforward. Currently, detecting workload hotspots and initiating a migration lacks the agility to respond to sudden workload changes. Moreover, the in memory state should be transferred consistently and efficiently, with integrated consideration of resources for applications and physical servers [5].

Interoperability: This is the ability of two or more systems work together in order to exchange information and use that exchanged information. Many public cloud networks are configured as closed systems and are not designed to interact with each other. The lack of integration between these networks makes it difficult for organizations to combine their IT systems in the cloud and realize productivity gains and cost savings. To overcome this challenge, industry standards must be developed to help cloud service providers design interoperable platforms and enable data portability. Organizations need to automatically provision services, manage VM instances, and work with both cloud-based and enterprise-based applications using a single tool set that can function across existing programs and multiple cloud providers. In this case, there is a need to have cloud interoperability. Efforts are under way to solve this problem. For example, the Open Grid Forum, an industry group, is working on the Open Cloud Computing Interface, which would provide an API for managing different cloud platforms. Until now it has remained a challenging task in cloud computing.

Access Controls: Authentication and identity management is more important than ever. And, it is not really all that different. What level of enforcement of password strength and change frequency does the service provider invoke? What is the recovery methodology for password and account name? How are passwords delivered to users upon a change? What about logs and the ability to audit access? This is not all that different from how you secure your internal systems and data, and it works the same way, if you use strong passwords, changed frequently, with typical IT security processes, you will protect that element of access.

Energy Resource Management: Significant saving in the energy of a cloud data center without sacrificing SLA are an excellent economic incentive for data center operators and would also make a significant contribution to greater environmental sustainability. It has been estimated that the cost of powering and cooling accounts for 53% of the total operational expenditure of data centers. The goal is not only to cut down energy cost in data centers, but also to meet government regulations and environmental standards. Designing energy-efficient data centers has recently received considerable attention. This problem can be approached from several directions. For example, energy efficient hardware architecture that enables slowing down CPU speeds and turning off partial hardware components has become commonplace. Energy-aware job scheduling and server consolidation are two other ways to reduce power consumption by turning off unused machines. Recent research has also begun to study energy-efficient network protocols and

infrastructures. A key challenge in all the above methods is to achieve a good trade-off between energy savings and application performance. In this respect, few researchers have recently started to investigate coordinated solutions for performance and power management in a dynamic cloud environment. The Global Energy Management Center(GEMC) can help companies monitor energy consumption patterns from multiple sources. These patterns can be further analyzed for usage, cost, and carbon footprint in a number of ways that help in optimizing energy. The center is uniquely positioned to service the clients across the globe by deploying a Remote Control Unit that has the capabilities to communicate to a cloud-based architecture [13].

Multi-tenancy: There are multiple types of cloud applications that users can access through the Internet, from small Internet-based widgets to large enterprise software applications that have increased security requirements based on the type of data being stored on the software vendor's infrastructure. These application requests require multi-tenancy for many reasons, the most important is cost. Multiple customers accessing the same hardware, application servers, and databases may affect response times and performance for other customers. For application-layer multi-tenancy specifically, resources are shared at each infrastructure layer and have valid security and performance concerns. For example, multiple service requests accessing resources at the same time increase wait times but not necessarily CPU time, or the number of connections to an HTTP server has been exhausted, and the service must wait until it can use an available connection or—in a worst-case scenario— drops the service request [39].

Server Consolidation: The increased resource utilization and reduction in power and cooling requirements achieved by server consolidation are now being expanded into the cloud. Server consolidation is an effective approach to maximize resource utilization while minimizing energy consumption in a cloud computing environment. Live VM migration technology is often used to consolidate VMs residing on multiple underutilized servers onto a single server, so that the remaining servers can be set to an energy-saving state. The problem of optimally consolidating servers in a data center is often formulated as a variant of the vector binpacking problem, which is an NP-hard optimization problem. Various heuristics have been proposed for this problem. Additionally, dependencies among VMs, such as communication requirements, have also been considered recently. However, server consolidation activities should not hurt application performance. It is known that the resource usage (also known as the footprint) of individual VMs may vary over time. For server resources that are shared among VMs, such as bandwidth, memory cache and disk I/O, maximally consolidating a server may result in resource congestion when a VM changes its footprint on the server. Hence, it is sometimes important to observe the fluctuations of VM footprints and use this information for effective server consolidation. Finally, the system must quickly react to resource congestions when they occur.

Reliability & Availability of Service: The challenge of reliability comes into the picture when a cloud provider delivers on-demand software as a service. The software needs to have a reliability quality factor so that users can access it under any network conditions (such as during slow network connections). There are a few cases identified due to the unreliability of on-demand software. One of the examples is Apple's MobileMe cloud service, which stores and synchronizes data across multiple devices. It began with an embarrassing start when many users were not able to access mail and synchronize data correctly. To avoid such problems, providers are turning to technologies such as Google Gears, Adobe AIR, and Curl, which allow cloud based applications torun locally, some even allow them to run in the absence of a network connection. These tools give web applications access to the storage and processing capabilities of the desktop, forming a bridge between the cloud and the user's own computer. Considering the use of software such as 3D gaming applications and video conferencing systems, reliability is still a challenge to achieve for an IT solution that is based on cloud computing [41].

Common Cloud Standards: Security based accreditation for Cloud Computing would cover three main areas which are technology, personnel and operations. Technical standards are likely to be driven by organizations, such as, Jericho Forum1 before being ratified by established bodies, e.g., ISO2 (International Standard Organization). On the personnel side, the Institute for Information Security Professionals3 (IISP) is already offering formal accreditation for the security professionals. For the operational elements, there are some workable solutions such as tweaking the ISO 27001 and using it as the default measurement standard within the framework of the SAS 704. Currently, one of the main problems is that there are many fragmented activities going in the direction of Cloud accreditation, but a common body for the coordination of those activities is missing. The creation of a unified accreditation body to certify the Cloud services would also be a big challenge [15].

Platform Management: Challenges in delivering middleware capabilities for building, deploying, integrating and managing applications in a multi-tenant, elastic and scalable environments. One of the most important parts of cloud platforms provide various kind of platform for developers to write applications that run in the cloud, or use services provided from the cloud, or both. Different names are used for this kind of platform today, including on-demand platform and platform as a service (PaaS). This new way of supporting applications has great potential. When a development team creates an on-premises application (i.e., one that will run within an organization), much of what that application needs already exists. An operating system provides basic support for executing the application, interacting with storage, and more, while other computers in the environment offer services such as remote storage.

4. CONCLUSION

Cloud Computing, envisioned as the next generation architecture of IT Enterprise is a talk of the town these days. The way cloud has been dominating the IT market, a major shift towards the cloud can be expected in the coming years. Cloud computing offers real benefits to companies seeking a competitive edge in today's economy. Many more providers are moving into this area, and the competition is driving prices even lower. Attractive pricing, the ability to free up staff for other duties, and the ability to pay for —as needed‖ services will continue to drive more businesses to consider cloud computing. Mobile cloud computing is expected to emerge as one of the biggest market for cloud service providers and cloud developers. Although Cloud computing can be seen as a new phenomenon which is set to revolutionize the way we use the Internet, there is much to be cautious about. There are many new technologies emerging at a rapid rate, each with technological advancements and with the potential of making human's lives easier. However, one must be very careful to understand the security risks and challenges posed in utilizing these technologies. Cloud computing is no exception. Cloud service providers need to inform their customers on the level of security that they provide on their cloud. T his research effort presents an overview of Cloud Computing, building blocks of Cloud Computing which includes different models of cloud computing, overview of Cloud Computing architecture and Cloud Computing entities. Furthermore, research challenges which are currently faced in the Cloud computing were also highlighted. Cloud computing has the potential to become a frontrunner in promoting a secure, virtual and economically viable IT solution in the future. As the development of cloud computing technology is still at an early stage, this research effort will provide a better understanding of the design challenges of cloud computing, and pave the way for further research in this area.

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