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A Study on Cloud Computing Architecture and Research Challenges on Cloud Computing

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Abstract: ***Cloud computing gives a rich set of IT services that are provided to a customer over a network on a leased basis and with the flexibility to rescale or down their service requirements. Usually Cloud Computing services are given by a third party provider who owns the infrastructure. Cloud Computing holds the potential to eliminate the necessities for high quality infrastructure. Those components are virtualized computers. This would allow multi-fold increase within the capacity and capabilities of the present and new software. The resources can be dynamically allowing also for an optimum resource by a pay-per-use model it means customized Service Level. The user can access the data from anywhere just with the help of an internet connection. To access this computing, the user should be authenticated through by providing their identification credentials like Userid and password for security purposes. In a cloud computing environment, the complete data resides over a group of networked resources, enabling the info to be accessed through virtual machines. Despite the potential gains achieved from the cloud computing, the organizations are slow in accepting it thanks to security issues and challenges relevant to it. Security is one in every of the main issues which hamper the expansion of cloud. There are many challenges also there for adopting cloud computing like well managed service level agreement (SLA), privacy, interoperability and reliability. This research paper presents the main concept of cloud computing, the various cloud models and therefore the overview of the cloud computing architecture. It simply states that cloud computing means accessing, retrieving and fetching the data and programs over the internet rather than the computer's hard disk.***

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

I. INTRODUCTION

Internet has been a drive towards the varied technologies that are developed. Arguably, one among the foremost discussed among all of those is Cloud Computing. Over the previous couple of years, cloud computing paradigm has witnessed a huge shift towards its adoption and it's become a trend within the information technology space because it will requires minimum cost and new business potential to its users and providers . The benefits of using cloud computing include:

1) Reduced hardware and maintenance cost,
2) Accessibility round the globe, and
3) Flexibility and highly automated processes wherein the customer needn't worry about mundane concerns like software up-gradation.

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Cloud Computing is an emerging trend to deploy and maintain software and is being adopted by the industry like Google, IBM, Microsoft, and Amazon. There are various platforms provide cloud services IBM ―Blue Cloud infrastructure, the Google App Engine, the Amazon Cloud, and therefore the Elastic Computing Platform. Cloud Computing is perceived because the next progression which will impact organizational businesses and the way they manage their IT infrastructures.

Even though there are numerous variations on the definition of Cloud Computing, some basic principles characterize this emerging computing paradigm. Cloud Computing provides technological capabilities—generally maintained off premises— that are delivered on demand as a service via the web. As long as a 3rd party owns and manages public cloud services, consumers of those services don't possess resources within the cloud model but buy them on a per-use basis. Thus virtualization of the resources is that the key concept. In the important scenario, they're renting the physical infrastructure, platforms and applications within a shared architecture.

Cloud services can differ from virtual infrastructure, computing platforms, centralized data centers to end-user Web-Services and Web applications to enormous other focused computing services.

Cloud Computing could also be applied to unravel problems in many domains of data Technology like GIS (Geographical Information Systems), research project, e-Governance Systems , Decision Support Systems , ERP , Web Application Development , Mobile Technology etc.

II. CLOUD COMPUTING

A. *Overview*

Cloud Computing is a technology for providing efficient, pay -per -use network access to a shared pool of customized computing resources (e.g., networks, servers, storage, applications, and services) which will be rapidly provisioned and released with minimal management effort or cloud provider interaction.

In simple words, Cloud Computing is that the combination of a technology, platform that gives hosting and storage service on the web .In such an environment users needn't own the infrastructure for various computing services. In fact, they will be accessed from any computer in any a part of the planet.

This integrates features supporting high scalability and multi- tenancy, offering enhanced flexibility as compared to the sooner existing computing methodologies. It can deploy, allocate or reallocate resources dynamically with a capability to continuously monitor their performance . Moreover, cloud computing minimizes the cost. This approach is device and user-location independent. Main goal of the cloud computing is to supply scalable and cheap on-demand computing infrastructures with good quality of service levels .

Cloud Computing may be a general term for love or money that involves delivering hosted services over the web. The flexibility to handle traffic fluctuations and demand .

Cloud Computing also supports multi tenancy, providing systems configured in such how that they will be pooled to be shared by many organizations or individuals .To store any information and retrieving information we usually uses databases &servers .those data will be stored in physical servers ,we need to maintain those physical servers.

But after the cloud invented cloud servers are located in data centers all over the world. This maximizes hardware capacity and allows customers to leverage economies of scale .

Benefits of Cloud computing are enormous. the foremost important one is that the purchasers don’t got to buy the resource from a 3rd party vendor, instead they will use the resource and buy it as a service thus helping the customer to save lots of time and money. Cloud isn't just for Multinational companies but it’s also getting used by small and medium enterprises.

III. CLOUD COMPUTING BUILDING BLOCKS

A. *Deployment Models*

1) *Private Cloud:* Private cloud may be a new term that some vendors have recently won’t to describe offerings that emulate cloud computing on private networks. It’s found out within an organization’s internal enterprise datacenter. Within 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 general public cloud therein all the cloud resources and applications are managed by the organization itself, almost like Intranet functionality. Utilization on the private cloud are often far more secure than that of the general public cloud due to its specified internal exposure. Only the organization and designated stakeholders may have access to work on a selected.
2) *Private Cloud:* One among the simplest samples of a personal cloud is Eucalyptus Systems [3].
3) *Public Cloud:* Public cloud resources are dynamically provisioned on a fine-grained, the public cloud deployment model is the most widely understood out of the four. It’s typically supported a pay-per-use model, almost like 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 opposite cloud models because it places a further burden of ensuring all applications and data accessed on the general public cloud aren't subjected to malicious attacks. Samples of a public cloud include Microsoft Azure, Google App Engine.
4) *Hybrid Cloud:* Hybrid cloud may be a private cloud linked to at least one or more external cloud services, centrally managed, provisioned as one unit, and circumscribed by a secure network [12]. It provides virtual IT solutions through a mixture of both public and personal clouds. Hybrid Cloud provides safer control of the info and applications and allows various parties to access information over the web. It also has an open architecture that permits interfaces with other management systems. Hybrid cloud can describe configuration combining an area device, like a Plug computer with cloud services. An example of a Hybrid Cloud includes Amazon Web Services (AWS).

5) *Community Cloud:* Infrastructure shared by several organizations for a shared cause and should be managed by them or a 3rd party service provider and infrequently offered cloud model. These clouds are normally supported an agreement between related business organizations like banking or educational organizations. A cloud environment operating consistent with this model may exist locally or remotely. An example of a Community Cloud includes Facebook. 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 . 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. 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.

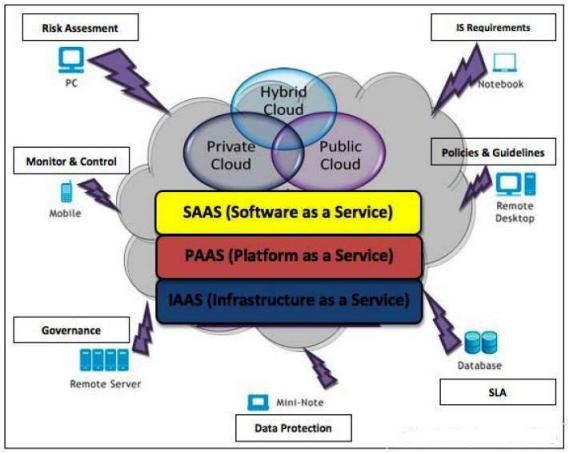

Fig .1. Cloud Deployment model[1]

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 various sorts of services offered, cloud computing are often considered to contain three layers: software as a service (SAAS), platform as a Service (PAAS), and infrastructure as a Service (IAAS). Infrastructure as a Service (IaaS) is that the lowest layer that gives basic infrastructure support service. Platform as a Service (PaaS) layer is that the middle layer, which offers platform oriented services, besides providing the environment for hosting user's applications. Software as a Service (SaaS) is that the topmost layer which features an entire application offered as service on demand [2].

Software-as-a-Service (SaaS): SaaS are often described as a process by which Application Service Provider (ASP) provide different software applications over the web. This makes the customer to urge obviate installing and operating the appliance on own computer and also eliminates the tremendous load of software maintenance; continuing operation, safeguarding and support . SaaS features an entire application offered as a service on demand. In SaaS, there's the Divided Cloud and Convergence coherence mechanism whereby every data item has either the ―Read Lock‖ or ―Write Lock‖ [11]. Two sorts of servers are employed by SaaS: the most Consistence Server (MCS) and Domain Consistence Server (DCS). Cache coherence is achieved by the cooperation between MCS and DCS . In SaaS, if the MCS is broken, 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.

1) *Platform as a Service (PaaS):* PaaS is that 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 so as to implement and test cloud applications. Samples of PaaS includes: Force.com, Google App Engine and Microsoft Azure.

2) *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 form resources like servers, network and storage more readily accessible by applications and operating systems. Generally, the user doesn't manage the underlying hardware within the cloud infrastructure, but he controls the operating systems, storage and deployed applications. The service provider owns the equipment and is liable for housing, running and maintaining it. The client typically pays on a per-use basis. Samples of IaaS include Amazon Elastic Cloud Computing (EC2), Amazon S3, and Go Grid.

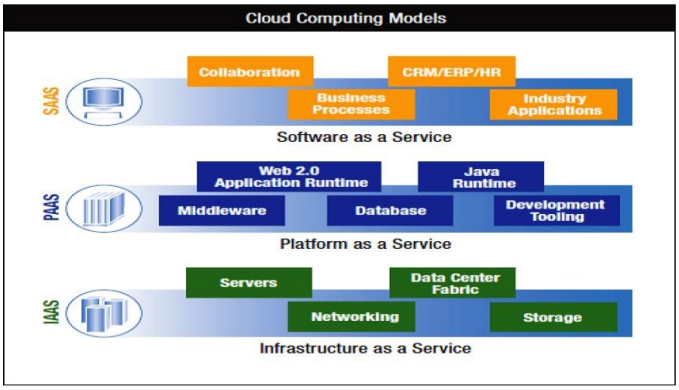

Fig.2. Cloud Computing Service delivery models

Figure 2 shows the integrated illustration of cloud services. A simple client who wants to form use of a software but they need nothing in hand then the client can use SaaS. When the client have a software developed by the client, but they need to deploy and run on a publicly available platform then use PaaS. When the client have the software and therefore the platform ready but they need the hardware to run then use IaaS. Cloud vendors and clients' got to maintain Cloud computing security in the least interfaces.

C. Cloud Computing Architecture : Overview

Cloud computing are often divided into two sections, the user and therefore the cloud. In most scenarios, the user is connected to the cloud via the web. It's also possible for a corporation to possess a personal cloud during which a user is connected via an intranet. However, both scenarios are identical aside from the utilization of a personal and public network or cloud [10]. The user sends requests to the cloud and therefore the cloud provides the service.

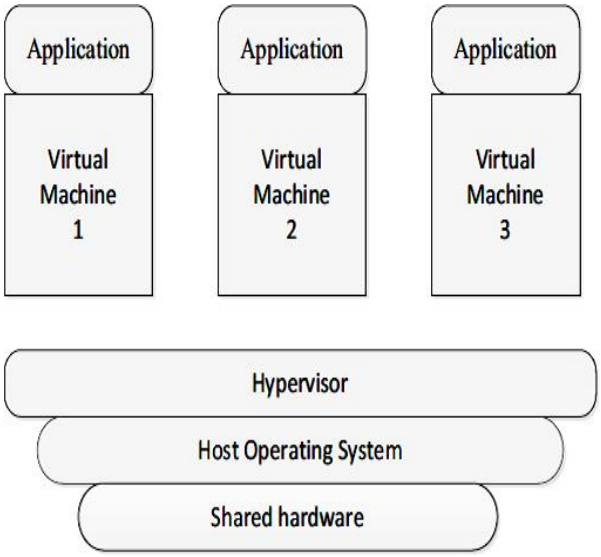

Fig .3. Cloud Architecture [10]

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

1) *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 .
2) *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.
3) *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.

IV. 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 .

1) Service Level Agreements (SLA's)
2) Cloud Data Management & Security
3) Data Encryption
4) Migration of virtual Machines
5) Interoperability
6) Access Controls
7) Energy Management
8) Multi-tenancy
9) Server Consolidation
10) Reliability & Availability of Service
11) Common Cloud Standards
12) Platform Management

a) *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 . 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.

b) *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 . Within the cloud, a central server is liable for administering the system and in some ways functions because the OS of the precise cloud network. Another name for this is often called ―middleware‖ which is that the central server for a specific cloud. Example: Amazon Elastic Cloud Computing [10].

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Cloud Computing research addresses the challenges of meeting the wants of next generation private, public and hybrid cloud computing architectures, also the challenges of allowing applications and development platforms to require advantage of the advantages of cloud computing. The research on cloud computing remains at an early stage. Many existing problems haven't been fully solved, while new challenges keep emerging from industry applications. A number of the challenging research issues in cloud computing are given below.

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The specification of SLAs will better reflect the customers' needs if they address the specified issues at the proper time. a number of the essential questions associated with SLA are uptime i.e. are they getting 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 related to 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 a crucial research area in cloud computing.

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3) *Data Encryption:* Encryption may be a key technology for data security. Remember, security can range from simple (easy to manage, low cost and quite frankly, not very secure) all the thanks to highly secure (very complex, expensive to manage, and quite limiting in terms of access). You and therefore the provider of your Cloud computing solution have many choices and options to think about. for instance , do the online services APIs that you simply use to access the cloud, either programmatically, or with clients written to those APIs, provide SSL encryption for access, this is often generally considered to be a typical . Once the thing arrives at the cloud, it's decrypted, and stored. Is there a choice to encrypt it before storing? Does one want to stress about encryption before you upload the file for cloud computing or does one prefer that the cloud computing service automatically roll in the hay for you? These are options, understand your cloud computing solution and make your decisions supported desired levels of security.

4) *Migration of Virtual Machines:* Applications aren't 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 info center. Additionally, virtual machine migration enables robust and highly responsive provisioning in data centers. 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 main advantage of VM migration is to avoid hotspots; however, this is often not straightforward. Currently, detecting workload hotspots and initiating a migration lacks the agility to reply 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].

5) *Interoperability:* This is that the ability of two or more systems work together so as to exchange information and use that exchanged information. Many public cloud networks are configured as closed systems and aren't designed to interact with one another. The shortage of integration between these networks makes it difficult for organizations to mix their IT systems within the cloud and realize productivity gains and price savings. To beat this challenge, industry standards must be developed to assist cloud service providers design interoperable platforms and enable data portability. Organizations got to automatically provision services, manage VM instances, and work with both cloud-based and enterprise-based applications employing a single tool set which will function across existing programs and multiple cloud providers. During this case, there's a requirement to possess

6) *Cloud Interoperability:* Efforts are under thanks to solve this problem. For instance, the Open Grid Forum, an industry group, is functioning on the Open Cloud Computing Interface, which might provide an API for managing different cloud platforms. So far it's remained a challenging task in cloud computing.

7) *Access Controls:* Authentication and identity management is more important than ever. And, it's not really all that different. What level of enforcement of password strength and alter frequency does the service provider invoke? What's the recovery methodology for password and account name? How are passwords delivered to users upon a change? What about logs and

therefore the ability to audit access? This is often not all that different from how you secure your internal systems and data, and it works an equivalent way, if you employ strong passwords, changed frequently, with typical IT security processes, you'll protect that element of access.

8) *Energy Resource Management:* The energy can be saved while in a cloud data center without sacrificing SLA are a superb economic incentive for data center operators and would also make a big contribution to greater environmental sustainability. It's been estimated that the value of powering and cooling accounts for 53% of the entire operational expenditure of knowledge centers. The goal isn't only to chop down energy cost in data centers, but also to satisfy government regulations and environmental standards. This problem are often approached from several directions. For instance, energy efficient hardware architecture that permits 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 scale back power consumption by turning off unused machines. Recent research has also begun to review energy-efficient network protocols and infrastructures. A key challenge altogether the above methods is to realize an honest trade-off between energy savings and application performance. These patterns are often further analyzed for usage, cost, and carbon footprint during a number of the way that help in optimizing energy. The middle is uniquely positioned to service the clients across the world by deploying a foreign Control Unit that has the capabilities to speak to a cloud-based architecture [13].
9) *Multi-tenancy:* There are multiple sorts of cloud applications that users can access through the web, from small Internet-based widgets to large enterprise software applications that have increased security requirements supported the sort of knowledge being stored on the software vendor's infrastructure. These application requests require multi-tenancy for several reasons, the foremost important is cost. Multiple customers accessing an equivalent hardware, application servers, and databases may affect response times and performance for other customers. For instance , multiple service requests accessing resources at an equivalent time increase wait times but not necessarily CPU time, or the amount of connections to an HTTP server has been exhausted, and therefore the service must wait until it can use an available connection or—in a worst-case scenario— drops the service request .
10) *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 efficient approach to maximize resource utilization while minimizing energy consumption during a cloud computing environment. Live VM migration technology is usually wont to consolidate VMs residing on multiple under- utilized servers onto one server, in order that the remaining servers are often set to an energy-saving state. the matter of optimally consolidating servers during a data center is usually formulated as a variant of the vector bin- packing problem, which is an NP-hard optimization problem. Various heuristics are proposed for this problem. Additionally, dependencies among VMs, like communication requirements, have also been considered recently. However, server consolidation activities shouldn't hurt application performance. It's known that the resource usage (also referred to as the footprint) of individual VMs may vary over time. For server resources that are shared among VMs, like bandwidth, cache and disk I/O, maximally consolidating a server may end in resource congestion when a VM changes its footprint on the server. Hence, it is usually important to watch the fluctuations of VM footprints and use this information for effective server consolidation. Finally, the system must quickly react to resource congestions once they occur.
11) *Reliability & Availability of Service:* The challenge of reliability comes into the image when a cloud provider delivers on-demand software as a service. The software must have a reliability quality factor in order that users can access it under any network conditions (such as during slow network connections). There are a couple of cases identified thanks to the unreliability of on-demand software. One among 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 weren't ready to access mail and synchronize data correctly. To avoid such problems, providers are turning to technologies like Google Gears, Adobe AIR, and Curl, which permit cloud based applications to run locally, some even allow them to run within 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 therefore the user's own computer. Considering the utilization of software like 3D gaming applications and video conferencing systems, reliability remains a challenge to realize for an IT solution that's supported cloud computing .
12) *Common Cloud Standards:* 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 safety professionals. For the operational elements, there are some workable solutions like tweaking the ISO 27001 and using it because the default

measurement standard within the framework of the SAS 704. Currently, one among the most problems is that there are many fragmented activities getting into the direction of Cloud accreditation, but a standard body for the coordination of these activities is missing. The creation of a unified accreditation body to certify the Cloud services would even be an enormous challenge .

13) *Platform Management:* The foremost important parts of cloud platforms provide various quite platform for developers to write down applications that run within the cloud, or use services provided from the cloud, or both. Different names are used for this type of platform today, including on-demand platform and platform as a service (PaaS). When a development team creates an on-premises application (i.e., one which will run within an organization), much of what that application needs already exists. An OS provides basic support for executing the appliance, interacting with storage, and more, while other computers within the environment offer services like remote storage.

VII. CONCLUSION

Cloud Computing, envisioned because the next generation architecture of IT Enterprise may be a talk about the town lately. The way cloud has been dominating the IT market, a serious shift towards the cloud are often expected within the coming years. Cloud computing offers real benefits to companies seeking a competitive edge up today's economy. More providers are getting into this area, and therefore the competition is driving prices even lower. Attractive pricing, the power to release staff for other duties, and therefore the ability to buy ―as needed‖ services will still drive more businesses to think about cloud computing. Mobile cloud computing is predicted to emerge together of the most important marketplace for cloud service providers and cloud developers.

Although Cloud computing are often seen as a replacement phenomenon which is about to revolutionize the way we use the web, there's much to take care about. There are many new technologies emerging at a rapid rate, each with technological advancements and with the potential of creating human's lives easier. However, one must be very careful to know the safety risks and challenges posed in utilizing these technologies. Cloud computing is not any exception. Cloud service providers got to inform their customers on the extent of security that they supply on their cloud. This attempt presents a summary of Cloud Computing, building blocks of Cloud Computing which incorporates different models of cloud computing, overview of Cloud Computing architecture and Cloud Computing entities. Furthermore, research challenges which are currently faced within 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 within the future. Because the development of cloud computing technology remains at an early stage, this attempt will provide a far better understanding of the planning challenges of cloud computing, and pave the way for further research during this area.

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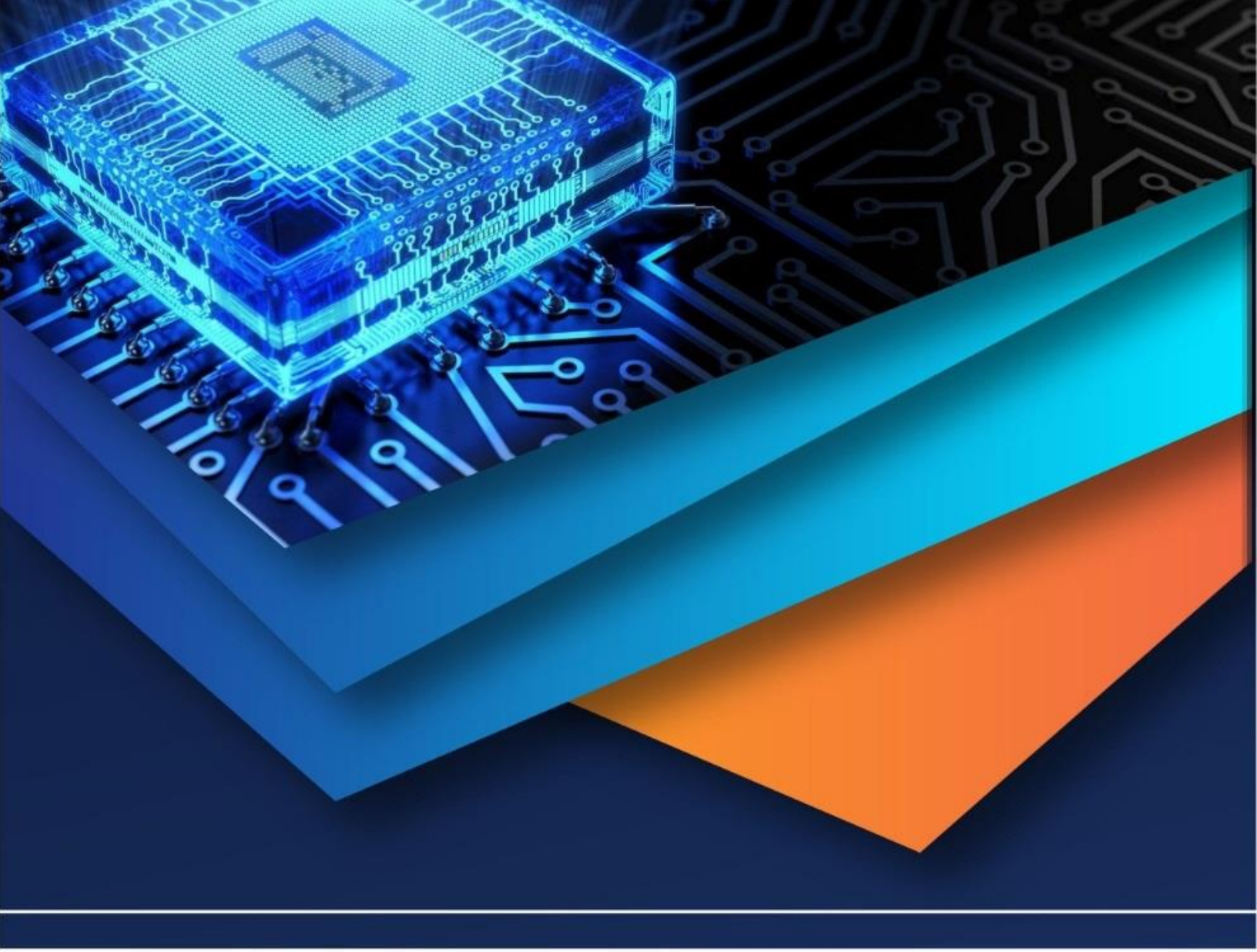

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