Next Generation of Computing through Cloud Computing Technology

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Abstract—**Cloud computing, one of the emerging topic in the field of information technology, is the development of parallel computing, distributed computing and grid computing. By using the internet and central remote services it maintains the data, applications etc which offers much more efficient computing by centralizing storage, memory, processing, bandwidth and so on. It can also concentrate all computation resources and manage automatically through the software without intervene. There are several layers in present cloud computing architecture, service models, platforms, issues i.e. security, privacy, reliability, open standard etc. and types. This paper presents all about the promising cloud computing technology i.e. its architecture, advantages, platforms, issues and challenges, applications, future and research options of cloud computing. There four generations of computing such as mainframe based computing, personal computing, client server based computing and web server based computing respectively. As there are several advantages over present generation of web server based computing such as fast micro processor, huge memory, high-speed network, reliable system architecture etc. we can say that cloud computing will provide the next generation of computing services.**

I. Introduction

Cloud computing has been envisioned as the next-generation computing model for its major advantages in on-demand self-service, ubiquitous network access, location independent resource pooling and transference of risk [1]. Cloud Computing is the latest developments of computing models after distributed computing, parallel processing and grid computing. Cloud computing achieve multi-level virtualization and abstraction through effective integration of variety of computing, storage, data, applications and other resources, users can be easy to use powerful computing and storage capacity of cloud computing only need to connect to the network. There is no doubt that cloud computing is the most popular topic in IT industry in 2009, Google, Amazon, Yahoo and other Internet service providers, IBM, Microsoft and other IT vendors have put forward their own cloud computing strategy, various telecom operators are also have put a great deal of attention on cloud computing, the very low cost of cloud computing platform becomes the focus of the industry. There are many cloud computing initiatives from IT giants such as Google, Amazon, Microsoft, IBM as well as startups such as Parascale, Elastra and Appirio. In October 2007, IBM and Google announced collaboration in cloud computing. The term "cloud computing" become popular from then on. Beside the web email, the Amazon Elastic Compute Cloud (EC2), Google App Engine and Salesforce's CRM largely represent a promising conceptual foundation of cloud services. The services of cloud computing is broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). Cloud computing also is divided into five layers including clients, applications, platform, infrastructure and servers. The five layers look like more reasonable and clearer than the three categories.

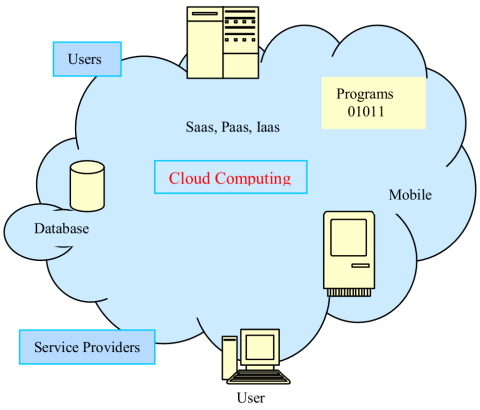

Figure 1: Cloud Computing

There are more than 20 definitions of cloud computing that seem to only focus on certain aspects of this technology. Mean while, Oracle CEO L. Ellison thinks that cloud computing is nothing more than "everything that we currently do". The cloud computing will provide the dynamic resource pool, the virtualization, the high usability etc. for next generation. There are several layers in cloud computing architecture, service models, platforms, issues and types. This paper describes as follows, in section 2, 3, 4, 5, 6, 7, 8, 9 and 10 overview of cloud computing, why we have to go cloud computing, its architecture, its present platforms, different issues of cloud computing, different types of it, some examples, its applications and challenges, the future of cloud computing are described and last section 11 concludes.

II. What is Cloud Computing?

Cloud computing is TCP/IP based high development and integrations of computer technologies such as fast micro processor, huge memory, high-speed network and reliable system architecture [2] and [3]. Without the standard inter-connect protocols and mature of assembling data center technologies, cloud computing would not become reality too [4]. Cloud computing, builds a virtual group of resources e.g. networks, storage, central processing unit and memory to carry out the user's resource requirement, without obstacle offers on

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demand hardware and software [5]. It is also called dynamic computing because of providing the resources according to necessity. Cloud computing handles the group of resources automatically and dynamically through software and hardware. Cloud computing is the provision of data storage or processing, using multiple servers as if one computer accessed over the internet. A person can access a word processing application, opened within an internet browser, write the document and send it back to the cloud for storage and it is ready to be accessed for later. Cloud computing provides secure access all our applications and data from any network device.

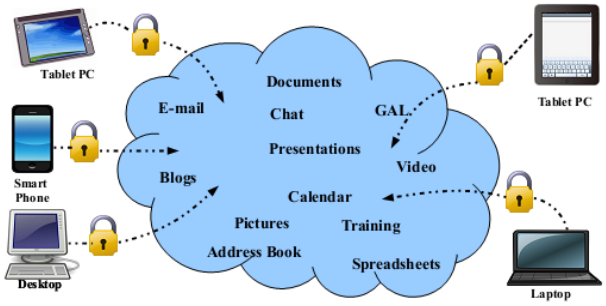


Figure 2: Cloud Computing

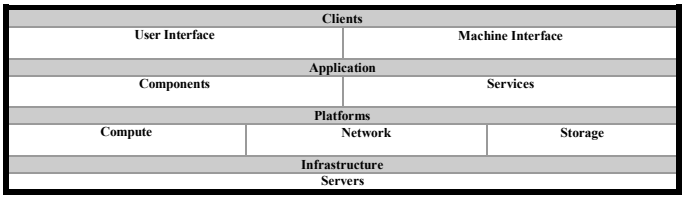
III. WHY CLOUD COMPUTING?

In this section why we have to be used the cloud computing technology is described. There are a lot of benefits of cloud computing over traditional computing. The major cloud providers such as Google, Microsoft and Amazon have built and are working on building the world's largest data centers across the United States and elsewhere. Each data center includes hundreds of thousands of computer servers, cooling equipment and substation power transformers. For example, consider Microsoft's data center in Quincy, Washington. It has 43,600 square meters of space and uses 4.8 kilometers of chiller piping, 965 kilometers of electric wire, 92,900 square meters of drywall and 1.5 metric tons of backup batteries. The company does not release the number of servers at this site; however it says that the data center consumes 48 megawatts which is enough to power 40,000 homes [6]. As another example, the National Security Agency is planning to build a massive data center at Fort Williams in Utah which is expected to consume over 70 megawatts electricity. By the way, the cloud computing technology is environment friendly as by replacing the hardware with cloud computing systems reduces energy costs as well as reduces CO_2 emissions, it has business benefits because businesses can directly acquire the benefits of the huge infrastructure without having to implement and administer it directly, it can reduce implementation and maintenance costs having low initial cost, it has ease of backup system with compared to backing up all thick client PCs, it has mobility of information which easily used globally, it provides IT resources immediately and enables scalability according to needs of user or customer which is especially useful during peak times of the year when there is a need for additional resources that are not needed in other parts of the year. Users of cloud services have just operative expenses and capital expenses are minimized as much as possible. Usage of cloud computing services can foster innovation because there are no huge upfront costs for test and development environments. Cloud computing will boost new markets which are already present in other business fields. This includes cloud brokers which will be able to sell and buy resources like brokers do today on stock markets. Cloud computing also makes possible parallel batch processing which allows users to analyze terabytes of data for small periods of time and small costs, business analytics that can use the vast amount of computer resources for huge data warehousing. Cloud computing provides the most reliable and secure data storage center. Users do not have to worry about data loss, virus attack and other problems. The "cloud" manages information by a professional team. Besides, strict rights management strategy can help us to share data. It requires minimum for users' terminal device. And it is easy and convenient to use. It is not necessary to download software and data or to upgrade dynamically in the "cloud" side. We can access cloud services anytime and anywhere only with a computer connecting to the Internet. Cloud computing has super computing power. Thousands of computers form a super server in cloud services which provided users with powerful computing and data processing capacity that is hard to realize for a personal computer. It can reduce infrastructure management responsibility. The benefits of deploying applications using cloud computing include reducing run time and response time, minimizing the risk of deploying physical infrastructure, lowering the cost of entry and increasing the pace of innovation. Cloud computing users avoid Capital Expenditure (CapEx) on hardware, software and services when they pay a provider only for what they use. It can also allow for unexpected resource loads.

IV. OVERVIEW OF THE ARCHITECTURE

A. Cloud Computing Layers

Cloud computing is broken down into three segments: applications, platforms and infrastructure [7]. Each segment serves a different purpose and offers different products for businesses and individuals around the world.



A cloud client consists of computer hardware and/or computer software that relies on cloud computing for application delivery, or that is specifically designed for delivery of cloud services and that, in either case, is essentially useless without it. And the server layer consists of computer hardware and/or computer software products that are specifically designed for the delivery of cloud services.

B. Service Models

1) Software-as-a-Service (SaaS): Cloud application services or Software as a Service is software that is deployed over the internet and/or is deployed to run behind a firewall in our local area network or personal computer. This is a "pay-as-you-go" model and was initially widely deployed for sales force automation and Customer Relationship Management

(CRM) [4], [6]. The advantage of SaaS are no need of specific hardware to run software, pay per use instant scalability security reliability, examples are CRM financial planning, human resources, word processing, commercial services are sales force.com, email cloud etc. SalesForce CRM is an example of SaaS provider.

2) Platform-as-a-Service (PaaS): Cloud platform services or Platform as a Service, another SaaS and this kind of cloud computing provide development environment as a service. We can use the middleman's equipment to develop our own program and deliver it to the users through Internet and servers [2], [3]. The advantages of PaaS are no need to buy special hardware and software to develop and deploy enterprise applicationns, pay per use, instant scalability, security, reliability; the popular services are storage, database, scalability etc. and the examples are Google Apps, Microsoft Windows Azure etc.

3) Infrastructure-as-a-Service (IaaS): Cloud infrustructure services or Infrastructure as a service delivers a platform virtualization environment as a service. Rather than purchasing servers, software, data center space or network equipment, clients instead [2], [3]. The advantages of IaaS are pay per use, instant scalability, security, reliability, Application Programming Interfaces (APIs) and the examples are flexi scale, AWS: EC2 etc.

4) Hardware-as-a-Service (HaaS): According to Nicholas Carr, "the idea of buying IT hardware or even an entire data center as a pay-as-you-go subscription service that scales up or down to meet your needs. But as a result of rapid advances in hardware virtualization, IT automation and usage metering and pricing, we think the concept of HaaS and may at last be ready for prime time [2]. This model is advantageous to the enterprise users, since they do not need to invest in building and managing data centers.

V. CURRENT CLOUD COMPUTING PLATFORMS

A. AbiCloud Platform

Abicloud is a cloud computing platform developed by Abiquo, a company locates in Barcelona Spain that is mainly focused on the development of cloud platform. It can be used to build, integrate and manage public as well as private cloud in the homogeneous environments [8]. We think using Abicloud, user can easily and automatically deploy and manage the server, storage system, network, virtual devices and applications etc.

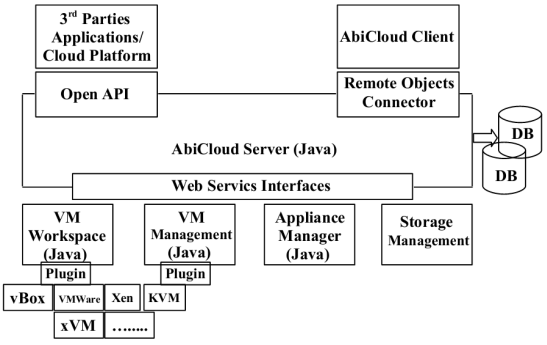


Figure 3: The structure of AbiCloud platform

Using the Abicloud, user can finish deploying a new service by just dragging a virtual machine with mouse. According to Abicloud, there is no perfect cloud platform. For each user needs his own cloud infrastructures and every cloud provider has his own management tools, say monitor, billing and so on, so generally it is very hard to deploy a cloud platform according to user's requirement. Besides, the cloud platform should also have all kinds of interfaces that support the third parties products. With all these characteristics, providers can build the cloud computing platform of their own thoughts.

B. Eucalyptus Platform

Eucalyptus (Elastic Utility Computing Architecture for Linking Your Programs to Useful Systems) project began from California University Santa Barbara and mainly was used to build open source private cloud platform. Now it has been run by Eucalyptus System Company [9]. Eucalyptus is an open source implementation of Amazon EC2 and compatible with business interfaces. It also implements virtualization depending on Linux and Xen as EC2. Eucalyptus is an elastic computing structure that can be used to connect the users' programs to the useful systems, it is an open source infrastructure using clusters or workstations implementation of elastic, utility, cloud computing and a popular computing standard based on service level protocol that permit users lease network for computing capability. Currently, Eucalyptus is compatible with EC2 from Amazon.

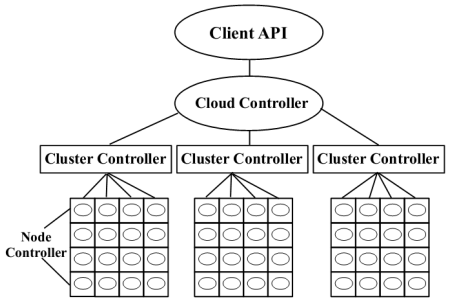


Figure 4: The resource topology structure of Eucalyptus

C. Nimbus Platform

Nimbus is an open tool set and also a cloud computing solution providing IaaS. Put forward based on scientific research in the early stage, Nimbus have supported many non-scientific research domain applications [8]. It permits users lease remote resources and build the required computing environment through the deployment of virtual machines.

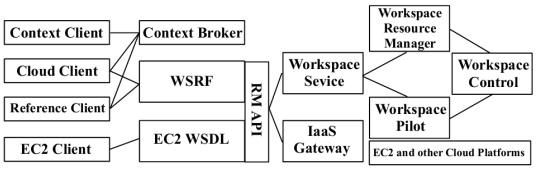


Figure 5: The structure of Nimbus cloud platform

Generally, all these functional components can be classified as three kinds. One kind is client supported modules which are used to support all kinds of cloud clients. Context client module, cloud client module, reference client module and EC2

client module are all belong to this kind of component. The second kind of component is mainly service supported modules of cloud platform, providing all kinds of cloud services.

D. OpenNebula Platform

OpenNebula is one of the key technologies of reservoir plan and the flagship research project in virtualization infrastructure and cloud computing of European Union [11]. Like nimbus, it is also an open source cloud service framework. It allows user deploy and manage virtual machines on physical resources and it can set user's data centers or clusters to flexible virtual infrastructure that can automatically adapt to the change of the service load. The main difference of OpenNebula and Nimbus is that nimbus implements remote interface based on EC2 or Web Service Resource Framework (WSRF) through which user can process all security related issues, while OpenNebula does not.

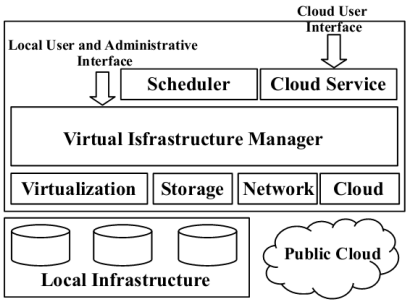


Figure 6: The structure of OpenNebula cloud platform

E. Comparative Study

Junjie Peng et al show a comparison among some platforms of cloud computing in their paper [12]. In this section we also show a comparative study of four present platforms.

TABLE I. THE COMPARISON OF SEVERAL CLOUD COMPUTING PLATFORMS

	Abicloud	Eucalyptus	Nimbus	OpenNebula
Cloud Character	Public/ Private	Public	Public	Private
Scalability	Scalable	Scalable	Scalable	Dynamical, Scalable
Cloud Form	IaaS	IaaS	IaaS	IaaS
Compatibility	Not Support EC2	Support EC2, S3[2]	Support EC2	Open, Multi-platform
Deployment	Pack and Redeploy	Dynamical Deployment	Dynamical Deployment	Dynamical Deployment
Deployment Manner	Web Interface Drag	Command Line	Command Line	Command Line
Transplant Ability	Easy	Common	Common	Common
VM Support	VirtualBox,Xen[3], VMware,VM	VMWare, Xen, KVM[4]	Xen	Xen, VMWare
Web Interface	Libvirt	Web Service	EC2 WSDL, WSRF	Libvirt, EC2, OCCI API[1]
Structure	Open Platform Encapsulate Core	Module	Lightweight Components	Module
Reliability	---	---	---	Rollback Host and VM
OS Support	Linux	Linux	Linux	Linux
Development Language	Ruby, C++, Python	Java	Java, Python	Java

Kernel-based Virtual Machine (4); http://www.xen.org, http://www.cl.cam.ac.uk/xeno(3); Amazon's Simple Storage Service: http://aws.amazon.com/s3(2) http://occi-wg.org/(1)

VI. POTENTIAL ISSUES OF CLOUD COMPUTING

In the last few years, cloud computing has grown from being a promising business concept to one of the fastest growing segments of the IT industry. But as more and more information on individuals and companies is placed in the cloud, concerns are beginning to grow about just how safe an environment it is. T. Dillon et al say about some issues in their paper [13]. In this section we also describe all potential issues related to cloud computing in brief.

1) Security: Where is our data more secure, on our local hard driver or on high security servers in the cloud? Some argue that customer data is more secure when managed internally, while others argue that cloud providers have a strong incentive to maintain trust and as such employ a higher level of security. However, in the cloud, our data will be distributed over these individual computers regardless of where our base repository of data is ultimately stored. Industrious hackers can invade virtually any server and there are the statistics that show that one-third of breaches result from stolen or lost laptops and other devices and from employees' accidentally exposing data on the Internet, with nearly 16 percent due to insider theft. In cloud computing, a data center holds information that end-users would more traditionally have stored on their computers. This raise concerns regarding user privacy protection because users must outsource their data. Additionally, the move to centralized services could affect the privacy and security of users' interactions. Security threats might happen in resource provisioning and during distributed application execution. Also, new threats are likely to emerge. For instance hackers can use the virtualized infrastructure as a launching pad for new attacks. Cloud services should preserve data integrity and user privacy. At the same time, they should enhance interoperability across multiple cloud service providers. In this context, we must investigate new data protection mechanisms to secure data privacy, resource security and content copyrights.

2) Privacy: Different from the traditional computing model, cloud computing utilizes the virtual computing technology, users' personal data may be scattered in various virtual data center rather than stay in the same physical location, even across the national borders, at this time, data privacy protection will face the controversy of different legal systems. Attackers can analyze the critical task depend on the computing task submitted by the users.

3) Reliability: Servers in the cloud have the same problems as our own resident servers. The cloud servers also experience downtimes and slowdowns, what the difference is that users have a higher dependent on Cloud Service Provider (CSP) in the model of cloud computing. There is a big difference in the CSP's service model, once we select a particular CSP, we may be locked-in, thus bring a potential business secure risk.

4) Legal Issues: Regardless of efforts to bring into line the lawful situation, as of 2009, supplier such as Amazon Web Services provide to major markets by developing restricted road and rail network and letting users to choose "availability zones". On the other hand, worries stick with safety measures

and confidentiality from individual all the way through legislative levels.

5) Open Standard: Open standards are critical to the growth of cloud computing. Most cloud providers expose APIs which are typically well-documented but also unique to their implementation and thus not interoperable. Some vendors have adopted others' APIs and there are a number of open standards under development, including the Open Grid Forum's (OGF's) Open Cloud Computing Interface (OCCI). The Open Cloud Consortium (OCC) is working to develop consensus on early cloud computing standards and practices.

6) Compliance: Numerous regulations pertain to the storage and use of data require regular reporting and audit trails, cloud providers must enable their customers to comply appropriately with these regulations. Managing Compliance and Security for Cloud Computing, provides insight on how a top-down view of all IT resources within a cloud-based location can deliver a stronger management and enforcement of compliance policies. In addition to the requirements to which customers are subject, the data centers maintained by cloud providers may also be subject to compliance requirements.

7) Freedom: Cloud computing does not allow users to physically possess the storage of the data, leaving the data storage and control in the hands of cloud providers. Customers will contend that this is pretty fundamental and affords them the ability to retain their own copies of data in a form that retains their freedom of choice and protects them against certain issues out of their control whilst realizing the tremendous benefits cloud computing can bring.

*8) Long-term Viability:*We should be sure that the data we put into the cloud will never become invalid even our cloud computing provider go broke or get acquired and swallowed up by a larger company. Gartner says, "Ask potential providers how we would get our data back and if it would be in a format that we could import into a replacement application".

VII. Types of Cloud Computing

There are three types of cloud computing, these are public cloud, private cloud and hybrid cloud. The brief is given below.

1) Private cloud: It is a proprietary architecture subscribed by an organization, which provides hosted services to the users within the organization. This is protected by the firewall to form a barrier against outside the world to access hosted services from the private cloud.

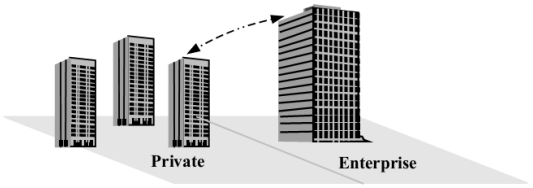


Figure 7: Private cloud

2) Public cloud: It is not proprietary of any organization; the services provided in these clouds can be accessed by any organization.

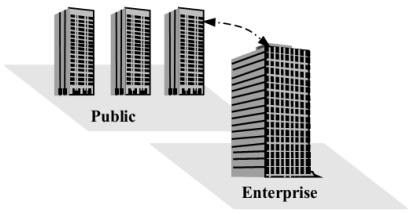


Figure 8: Public cloud

3) Hybrid cloud: In hybrid cloud, the services are offered to the limited and well defined number of parties.

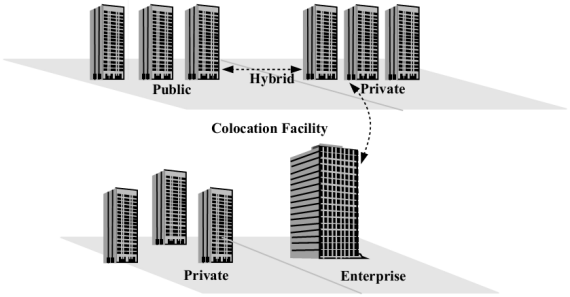


Figure 9: Hybrid cloud

VIII. Some Examples

Some examples of emerging cloud computing technology are Microsoft: Window Live Service, Windows Azure [14]; Google: Google Does, Google APP Engine [15] and [16]; Amazon: Amazon Simple Storage Service (S3), EC2 (Elastic Compute Cloud) [17], [18]; IBM: Blue Cloud [19], Apple: Mobile Me [20] etc.

IX. Applications and Challenges of Cloud Computing

A. Applications

The system has proven to be favored by the users over time and we now have many other players in the arena. A famous one is Google Apps, which offers email, calendar, document editing and more in the cloud. Even Microsoft, which arguably benefited most from local computing, is increasing its focus on cloud computing services now [21]. The applications of cloud computing are practically limitless. With the right middleware a cloud computing system could execute all the programs a normal computer could run. Potentially, everything from generic word processing software to customized computer programs designed for a specific company could work on a cloud computing system.

B. Challenges

Although the cloud computing technology is emerging we think there are several challenges in cloud computing technology. These are described briefly below.

1. Regulatory Compliance: When outsourcing to a provider, customers are responsible for the security and integrity of their own data, even when it is held by a third party provider.

2. Dependency: It is only possible to use applications or services that the provider is willing to offer.

3. Data Location & Privacy Restrictions: US & EU have different privacy standards, subject to differing laws.

4. Recovery: Data segmentation makes back-ups more difficult.

5. Data Storage: Cloud computing does not allow users to physically store of their data, so data storage is done by the provider.

6. Data security and privacy protection: The security of user data is considered to be the security problem of computing platforms, security problem of computing platform is an important issue of cloud computing. Cloud computing infrastructure with a multi-tenant properties, manufacturers generally cannot guarantee that the data of two different users to achieve physical separation. In addition, considering the massive expansion (scalability) requirements, the physical location of the data may not be guaranteed.

7. Data access and storage model: Now that the storage models provided by big vendors need to adapt too many different usage scenarios. Thus, they may favor to simple memory model or a simple hierarchical model which based on binary object. Although it has brought significant flexibility, it also increase the burden to the application logic explains the relationship between different data elements.

8. Lack of standards and vendor locking: Most vendors have defined standards based mechanisms e.g. HTTP, REST (REpresentational State Transfer), SOAP (Simple Object Access Protocol) etc. to access and use its services. However, the standard of development services in cloud computing is just rising and now the lack the function of write once and run everywhere.

9. Services Interoperability: Currently, cloud computing doesn't have enough support for the interoperability of services, this have a lots problems for the service of cross-platform or the services between different service.

X. Futures of Cloud Computing

J. Weinman says in his paper about the futures of cloud computing [20] and here we describe about some important future scopes as well research options. The system administration, configuration and network management will become an important field bursting with innovation. Trends of large vendors entering into cloud computing will be accelerated. All major Integrated Development Environments (IDEs) will offer Cloud deployme-nt options. Platform-as-a-Service will take its first steps into the mainstream. A next generation of Middleware for the Cloud will rise in dominance over traditional J2EE application servers. Cloud computing is widening, but focus on an open platform mainly. Windows Azure is mostly a better platform of Exchange. Google would increase the area of investment in the enterprise; more business users will use Google Apps. The first batch of SaaS 1.0 companies will face the risk of bankruptcy. The number of firms who abandon the use of its own server increased significantly. Private cloud computing services have been popular. Business Intelligence (BI) will be SaaS's next target. SAP or Oracle will enter Platform-as-a Service area. Enterprise adoption and usage of social networks will be faster and so on.

XI. Conclusion

This paper presents all about of cloud computing which is a new emerging technology in present world. Although there are several issues and challenges in cloud computing technology, a huge scope for research and we can say that it is a development trend in near future. It is predicted that this technology brings for us an infinite capability of computing, fast micro processor, huge memory, high-speed network, reliable system architecture etc. by solving the existing issues and challenges and we will enter a new era of next generation computing through cloud computing technology.

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