Analysis for Exploring Scope of Mobile Agents in Cloud Computing

Aarti Singh[1], Manisha Malhotra[2]

[1]Associate Prof., MMICT & BM, MMU, Mullana, Haryana, India

[2]Research Scholar MMICT & BM, MMU, Mullana, Haryana, India

Abstract

The Cloud Computing has emerged as a new computing paradigm which aims to provide reliable, customized, dynamic computing environments focused towards better quality of service and IT infrastructure availability without much financial burden. This paper, explores the cloud computing epitome from various aspects, reviews state of art implementations as well as its inherent challenges and explores the potential scope for research. This work also analyses the possibilities of amalgamating mobile agents in cloud computing, since both these technologies are promising and commercially useful thus the idea is to resolve challenges pertaining in cloud computing by harnessing mobile agent technology.

Keywords: *Cloud Computing, IaaS, Mobile Agents, PaaS, SaaS.*

1. Introduction

Cloud Computing (CC) is the fifth generation of computing after mainframe, personal computer, client server computing and the World Wide Web (WWW). It's a buzzword in IT based corporate world nowadays. CC is a model in which resources (e.g., CPU and storage) are provided as general utilities that can be leased and released by users through the Internet in an on-demand fashion. The cloud offers several benefits like fast deployment, pay-for-use, lower costs, scalability, rapid provisioning, rapid elasticity, ubiquitous network access, greater resiliency, hypervisor protection against network attacks, low-cost disaster recovery and data storage solutions, on-demand security controls, real time detection of system tampering and rapid re-constitution of services[21]. Because of its appealing features, it's becoming a temptation for small and medium business organizations. Also organizations such as Amazon, Google, IBM are putting their maximum potential towards developing CC based product and services for their users at negligible cost.

The IT Industry had been already fagging towards the research of cloud at lavish pace, academicians has also started realizing importance of this field. This is evident from conferences, workshops, seminars organized on this theme as well as numerous research papers on various aspects of cloud computing. This paper aims to review the research already been done and highlights the research challenges which still require attention. This paper is structured as follows: Section 2 discusses basic terminology of cloud computing; Section 3 outlines the layered architecture and types of clouds; Section 4 depicts the demand of cloud computing in agent technologies also explains the role of agents in this computing; finally Section 5 concludes the review by summing up the future research directions.

2. Cloud Computing Terminology

The Cloud computing came in lime light in 2007, its popularity has increased swiftly since then due to its ability to offer flexible dynamic IT infrastructures, good QoS(Quality of Service), computing environments and configurable software services[17]. Although CC has attracted much attention but still there are no widely accepted definition for it. Several reasons have contributed to this situation [3]:

- CC involves researchers and engineers from various backgrounds, e.g., grid computing, software engineering and databases. They work on this computing from their own and different viewpoints.
- Technologies which enable CC are still in progressing stage, for example, Web 2.0 and Service Oriented Computing.
- Existing computing clouds still lack large scale deployment and usage, which would finally justify the concept of CC. understand

For better understanding the concept of CC, first the term cloud should be explored. Term Cloud stands for - *Common Location-independent Online Utility service, available on-Demand*. It is a pool of virtualized computer resources which support large variety of different workloads, including batch-style back-end jobs and interactive, user-facing applications.

The literature survey highlighted that CC has been perceived in many different ways by the researchers. Some of the existing definitions are quoted here to elaborate the concept from various perspectives.

According to engineering definition by Aron [1] '*Cloud computing is providing services on virtual machines allocated on top of a large physical machine pool*'. In business perspective *it is defined as a method to address scalability and availability concerns for large scale applications.* Larry Ellison, CEO Oracle highlighted that the most interesting thing about *cloud computing was that we had redefined it to include everything that we were doing already* [7]. Armbrust (2009) [7] elaborated that cloud computing uses the Internet and central remote servers to maintain data and applications and has been broken down into three segments: "applications", "platforms", and "infrastructure".

CC still seeks its formal definition. In an earlier review[25] authors tried to uncover similar terms used in various definitions of CC and concluded that *scalability, pay-per use model, and virtualization were the only terms on which all definitions agree*. Thus they suggested that "Clouds are a large pool of easily usable and accessible virtualized resources which can be dynamically reconfigured to adjust to a variable load, allowing optimum resource utilization[29]. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized Service Level Agreement (SLA)".

Till date definition provided by *National Institute of Standards and Technology* (NIST) is the most appropriate and succinct definition [7] covering all aspects of CC, thus it is considered as the standard definition and is as follows:

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider's interaction.

2.1 Characteristics/Appealing features

CC is equipped with many appealing features contributing towards its commercial applicability and popularity[23]. Some of them are as follows:

- **On Demand Service:** It provides the ability to build, deploy and schedule the services on demand. Usage of services and resources is controlled, reported and measurable at both ends.
- **Scalability:** A service provider can easily manage its services on large scale as per the requirement.
- **No Initial Investment:** It eliminates the need for investment in building an infrastructure for small organizations. Business organizations can lease resources from the cloud according to their requirement and pay on usage basis.
- **Elasticity:** It is defined as the ability to scale the resources in both directions i,e. scale in or scale out. This is the core concept behind existence of CC , organizations can increase their resources at any time depending on their requirement and may release them when not required any further. This results in overall cost cutting and less maintaince requirements.
- **Abstract Resource Sharing:** Whenever the resources available with a provider get exhausted and further demand arises, it gets the resources from other providers and satisfies the request. Customer is unaware of the real location of services.
- **Ubiquitous Network Access:** Cloud computing is inherently ubiquitous since it is spread over the internet and thus can be utilized anywhere anytime.

3. Cloud Computing Architecture

Architecture of cloud computing mainly comprises of four layers: Hardware, Infrastructure, Platform and Application. Figure 1 given below provides the architecture of cloud computing. These four layers facilitate three different types of cloud services i.e. Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). These layers are described in detail as follows:

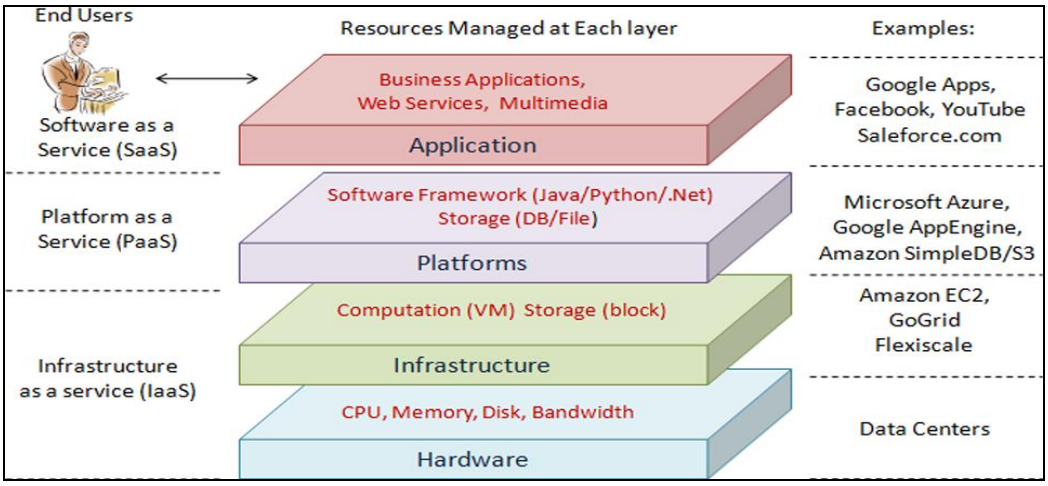

Fig 1: Architecture of Cloud Computing [28]

1. **Software as a Service (SaaS):** This service allows the consumer to use desired softwares from the cloud infrastructure. SaaS is a model of software deployment whereby a provider licenses an application to customers as a service for on demand usage. The software applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email). The consumers has no need to manage or control the cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings. SaaS therefore alleviates the customer's burden of software maintenance, reduces the expense and improves the operational efficiency of software purchases by on-demand pricing. One example of SaaS is the Salesforce.com CRM[1](Customer Relationship Management) application.

   - **Inherent issues:** SaaS is rapidly emerging as the dominant delivery model for meeting the needs of enterprise IT services. Still most of the industries does not adopt this model due to lack of transparency about storage and security of their data. SaaS is a software deployment model where applications are remotely hosted by the application or service provider and made available to customers on demand, over the Internet. According to the Forrester study (2009)[7], security concerns are the most commonly cited reason why enterprises are not interested in SaaS. Consequently, addressing enterprise security concerns has emerged as the biggest challenge for the adoption of SaaS applications in the cloud. However, to overcome the customer concerns about application and data security, vendors must address these issues head-on. There is a strong apprehension about insider breaches, along with vulnerabilities in the applications and system's unavailability that could lead to loss of sensitive data and money. Such challenges are discouraging enterprises from adopting SaaS applications within the cloud.

2. **Platform as a Service (PaaS):** This layer is responsible for providing resources such as Operating System and software development frameworks. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and hosting environment configurations. Major purpose of PaaS is the delivery of a computing platform and solution stack as a service. It facilitates the deployment of applications without the cost and complexity of buying and managing the underlying software layers. It provides the facilities required to support the complete lifecycle of building and delivering web applications and services. An example of this would be GoogleApps[2] and Microsoft Azure[3]. This layer lies above IaaS on the stack and abstracts away everything up to OS, middleware, etc. This offers an integrated set of developement environment that a developer can tap to build their applications without having any clue about what is going on underneath the service. It offers developers a service that provides a complete software development lifecycle management, from planning to designing and building applications to their deployment, testing and maintenance.

[1] http://www.salesforce.com/uk/crm/products.jsp
[2] http://code.google.com/appengine
[3] http://www.microsoft.com/windowsazure

- **Inherent Issues:** Although PaaS hides all the platform and hardware complexity form the developers, it increases chances of hacking of the system. Since the actual platform is far away somewhere on a cloud, hackers may leverage this loophole for malware command execution.

3. **Infrastructure as a Service (IaaS):** This layer provides the consumers with processing facility in the form of virtual machines (VMs),storage blocks, networking and other fundamental computing resources so that the consumer may deploy and run arbitrary softwares, including operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls). IaaS completely changes the way of developers deploy applications. Instead of spending large funds on their own data centers, hosting companies or co-location services and then hiring operations staff to get it going, they can just go to Amazon Web Services EC2(Elastic Compute Cloud)[4] or one of the other IaaS providers, get a virtual server running in minutes and pay only for the resources they use. With cloud brokers like Rightscale, enStratus, etc., they could easily grow big without worrying about things like scaling and additional security. In short, IaaS and other associated services have enabled startups and other businesses focus on their core competencies without worrying much about the installation and management of infrastructure. IaaS is the delivery of computer infrastructure (typically a platform virtualization environment eg Xen [7,22], Vmware [15]) as a service. Rather than purchasing servers, software, space for data center or network equipments, clients instead buy those resources as a fully outsourced service. IaaS completely abstracts the hardware beneath it and allows users to consume infrastructure as a service without bothering about the underlying complexities. Internal structure of IaaS is shown in Figure 2.

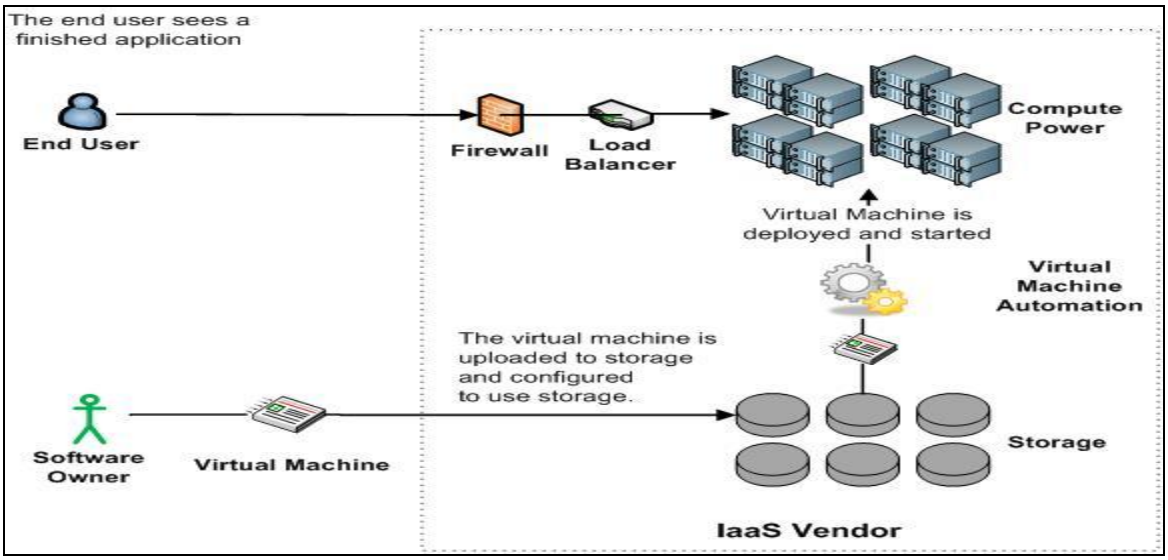

Fig 2: Infrastructure as a service [7]

[4] http://aws.amazon.com

- **Inherent Issus:** IaaS only provides basic security (perimeter firewall, load balancing, etc.) but applications moving into the cloud actually need higher levels of security at the host.

3.1 Deployment Models

Various deployment models are currently been employed and shown in Figure 4, their details are as follows:

- **Private Cloud:** The cloud infrastructure is operated dedicatedly for an organization. It may be managed by the organization or a third party and may exist on/off premise. A private cloud offers the highest degree of control over performance, reliability and security. However, they are often criticized for being similar to traditional proprietary server farms [7] and do not provide benefits such as no up-front capital costs. This is also known as internal cloud.

- **Community Cloud:** The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g. security requirements, policy, and compliance). It may be managed by the organizations or a third party and may exist on/off premise.

- **Public Cloud:** Public clouds offer several key benefits to service consumers [11] and providers, including no initial capital investment on infrastructure and shifting of risks to infrastructure providers. However, public clouds have lack control over data, network and security settings, which hampers their effectiveness in many business scenarios.

- **Hybrid Cloud:** The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds). In a hybrid cloud, part of the service infrastructure runs in private clouds while the remaining part runs in public clouds. Hybrid clouds offer more flexibility than both public and private clouds. Specifically, they provide tighter control and security over application data compared to public clouds, while still facilitating on-demand service expansion and contraction. On the down side, designing a hybrid cloud requires carefully determining the best split between public and private cloud components.

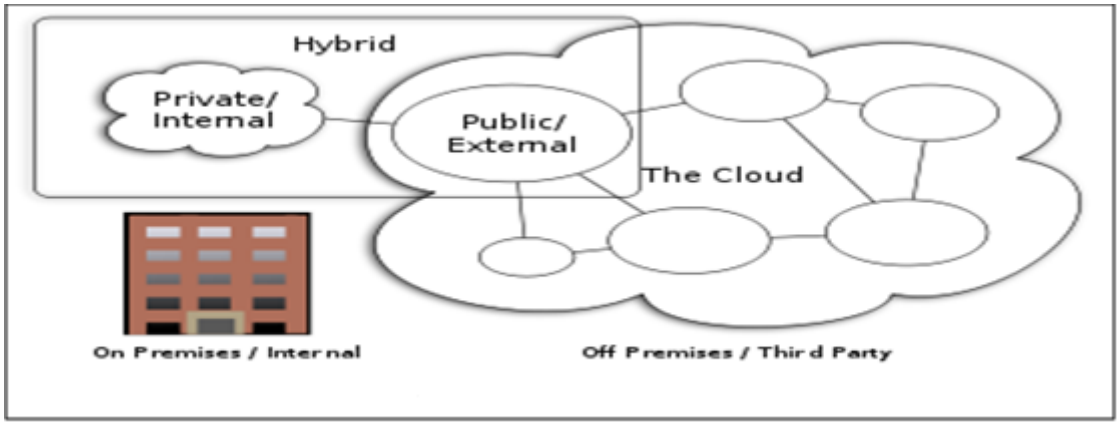

Fig 3: Types of Cloud Computing [16]

However for most service providers, selecting the right cloud model is dependent on the business scenario. For example, computation-intensive scientific applications are best deployed on public clouds for cost-effectiveness.

CC has gained lot of popularity and has become a buzzword in corporate world, with information technology as its backbone. Lot of work is currently going on, in various dimensions of CC still there are some research challenges prevailing in this area. Next section highlights the open research challenges customary in CC.

3.2 Open Research Challenges

Research Issues may be categorized as Technological Issues and Business Issues and which are discussed one by one below:

A: Technological Issues- This domain focuses on the cloud computing technology. Researches in this area are focused on inherent components and mechanisms driving it. Technological issues involve:

1) **Scalability in Cloud Computing:** Cloud Computing has recently emerged as a scalable delivery platform. Cloud scalability is reflected by its capability to dynamically increase or decrease the number of server instances assigned to an application depending on the usage demand of application. When web services are deployed in a cloud each service can be scaled over multiple servers. However service cost of response time of server and quality of service needs to be paid attention.
2) **Resource Allocation:** In cloud computing, resources are provided as service, as per the demand of the user, confining to the SLA[31]. Due to large resource requirements, resources have to be shared and since the resource demanded are heterogeneous and unrelated, it will definitely lead to wastage of resource if they are not scheduled and distributed properly. Therefore resource allocation and management is one of the main issue of cloud computing.
3) **Load Balancing:** Load Balancing has always been a research subject whose objective is to ensure that every computing resource is distributed efficiently and fairly leading to improved utility[25]. Presently there are many load balancing algorithms, but they lack efficiency and still need improvement.

4) **Data Security and locality:** While storing data on cloud, one major concern is of security of data. Customers must have the assurance that their data is completely secure and can't be accessed by anyone except the legitimate owner[27].
5) **Ensuring Quality of Service by migration of Virtual Machines:** This issue is concerned with service providers to ensure the better quality of services by appropriately deciding which VM to allocate for a particular task. QOS can effect processing time of the data center, total VM cost, data transfer cost and overall response time. So here the problem is to optimize the cost and execution time[30].

B: Business Issues- This domain concerns the business models and implications of cloud computing technology. Researchers in this domain treat cloud computing as a black-box technology which can generate business value to both service providers and consumers. It mainly involves:

1) **Return on Investment (ROI) Cost/Benefit:** This sub domain focuses largely on users' side. Researchers aim at quantifying the cost and benefit for migrating computing tasks onto the clouds [11]. Such efforts can further help users while choosing cloud services.
2) **Pricing/Billing:** It mainly focuses on providers' side. Researchers focus on developing pricing and billing models for cloud providers in order to retain customers at the same time guarantee profits for the providers [7,24].
3) **Trustworthiness in the cloud:** Cloud brokers are the bridge between the customers and cloud service providers[19,20]. Customer depends heavily on the cloud broker and deciding the right cloud broker and evaluating its trustworthiness are major challenges.

After exploring CC in depth, now we turn our attention towards mobile agent technology to find its scope and applicability in CC. Next section explores mobile agents and highlights the reasons for amalgamating these two technologies.

4. Scope of Mobile Agents in Cloud Computing Paradigm

A Mobile Agent (MA) is a software module that autonomously migrates from machine to machine in a heterogeneous network, interacting with services at each machine to perform some desired task on behalf of the user. MA can be used as mediators between users and devices. For example if a user wants to control a device but does not have the software for this task, may download the agent having knowledge of the communicating protocol [10]. Our interest in MA is not motivated by the technology but rather by the benefits agents provide for the creating distributed systems and some of their features [8] are as follows:

- Overcomes Network Delay
- Can work Asynchronously and Autonomously
- Dynamic in Nature
- Cooperative in nature
- Robustness
- Fault Tolerance
- Protocol Encapsulation
- Social
- Reactive/Proactive

Mobile agents have widely been employed in semantic web services, e-commerce based applications, sensor networks and wireless networks and they have proved themselves beneficial. Now this technology is attracting researchers working in cloud computing, since it may provide solution to challenges still existing in CC. Researchers [2,15,26] are already realizing that employing mobile agents in this computing can provide better solution for issues prevailing in this field.

Figure 4 given below illustrates usage of mobile agents in cloud computing. Traditionally user requests are sent directly from cloud to WWW which leads to increase in network traffic and increased response time. Instead if mobile agents are employed for providing various services, then network traffic may be reduced while at the same time reducing response time since MA can replicate themselves as and when desired and can transmit over the network from one machine to the other and perform the operations locally on the distant machines rather than sending requests and waiting for the response.

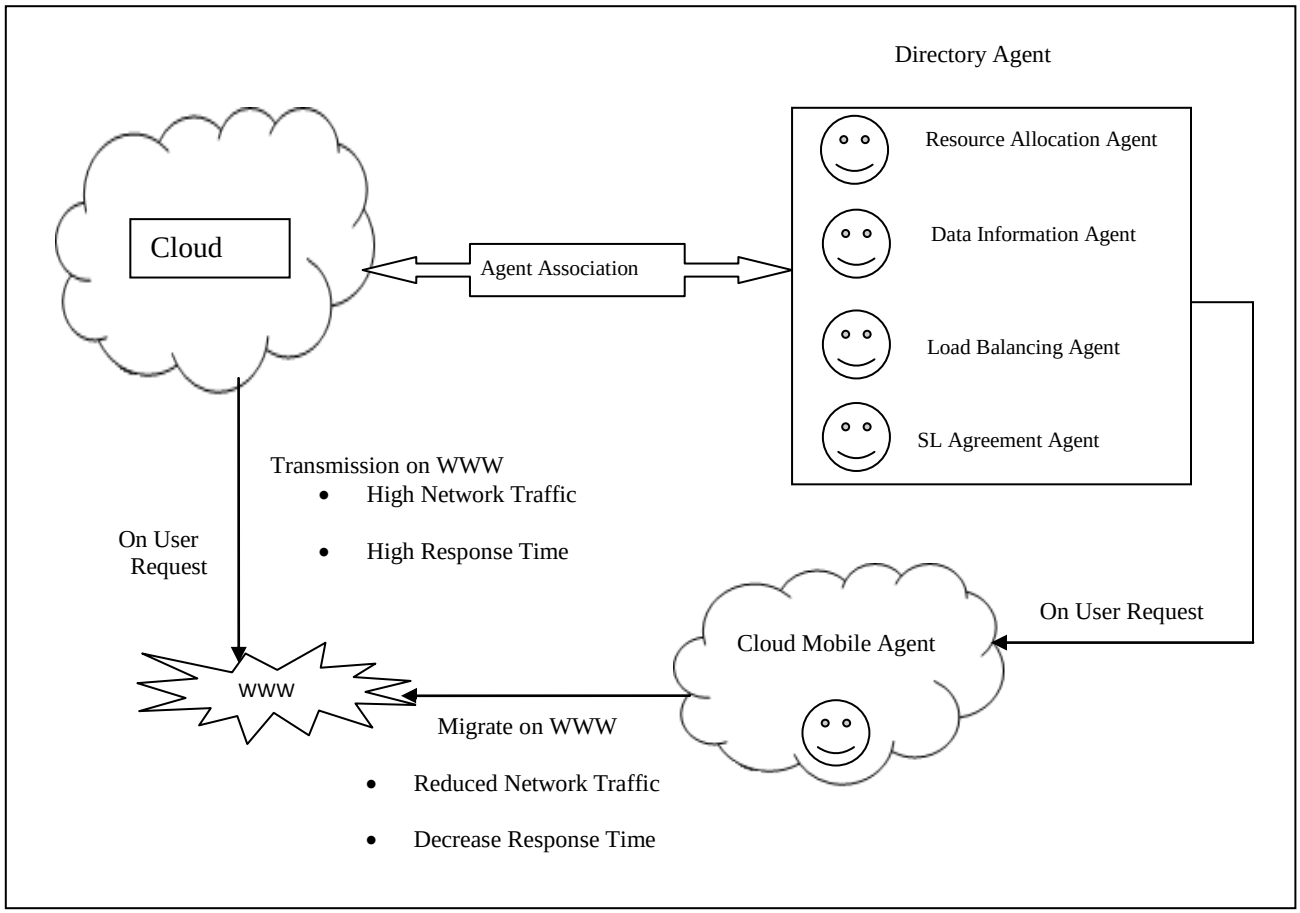

Fig 4: Amalgamation of Mobile Agents in Cloud Computing

5. Conclusions

Cloud computing is a field with lot of potential for research and commercial applicability. This paper reviewed the recent advances of Cloud Computing. Various definitions of cloud

computing were discussed and the NIST working definition was found to be the most useful as it described cloud computing using a number of characteristics, service models and deployment models. The research challenges have been elaborated to provide directions for future research. This field although gaining lot of attention is still new and requires rigorous research efforts to overcome existing challenges. Mobile agent technology has been explored and its applicability in CC is analyzed. It is observed that there is wide scope for amalgamating mobile agents in this computing paradigm and due to their features they will surely help surmount the research backlashes of CC.

References

[1] Aaron, K.: "Welcome to new era of Cloud computing". From wasington technology. http://www.emacromall.com/techpapers/TheNewEraofCloudComputing.pdf.

[2] Anand, S., Gupta, S., Fatnani, S., Sharma, V., Jain D.: "Semantic Cloud for Mobile Technology". In International Journal of Computer Applications (0975 – 8887) , 2010, Volume 8– No.12.

[3] ArchieIndian White paper (2010) . http://microreviews.org/types-of-cloud-computing.

[4] Armbrust, M., Fox, A., Griffith, R., Joseph, A., Katz, R., Konwinski, A., Lee, G.D., Patterson, A., Rabkin, I., Stoica, M.,: "Above the Clouds: A Berkeley view of cloud computing".http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf.

[5] Assuncao, M., Costanzo, A., Buyya, R.: "Evaluating the Cost-Benefit of Using CloudComputing to Extend the Capacity of Clusters". In Proceedings of the 18th ACM international symposium on High performance distributed computing, Garching, 2010 Germany: ACM.

[6] Birje, M.N., Manvi, S.S., Prasad, B.: "Agent based Resource Brokering and Allocation in Wireless Grids". In IEEE International Conference on Services Computing, 2006.

[7] Boss, G., Malladi, P., Quan, D., Legregni, L. Hall, H.: "Cloud Computing". High Performance On Demand Solutions (HiPODS) by IBM, 2007

[8] Danny, B.: "Mobile Objects and Mobile Agents: The Future of Distributed Computing?". In Lange General Magic, Inc· Sunnyvale, California, 2011, U.S.A danny@acm.org,http://www.acm.org/~danny.

[9] Hirofuchi, T., Ogawa, H., Nakada, H., Itoh, S., Sekiguchi, S.:. "A Live Storage Migration Mechanism over Wan for Relocatable Virtual Machine Services on Clouds". 9th IEEE/ACM International Symposium on Cluster Computing and the Grid, GRID '09, 2009, pp. 460-465.

[10] Loke, S., W.: "Mobile Agent Technology for Enterprise Distributed Applications : An Overview and an Architectural Perspective". A report by the Co-Operative Research Centre program through Department of Industry, Science and Tourism of the Commonwealth of Government of Australia.

[11] Manvi, S. S., Birje, M.N., Prasad, B.: "An Agent-based Resource Allocation Model for computational grids". In International Journal of Multiagent and Grid Systems – 1 , 2005, pp 17–27.

[12] Matos, M., Sousa, A., Pereira, J., Oliveira, P.:Clon: "Overlay Network for Clouds". In Proceedings of the Third Workshop on Dependable Distributed Data Management, Nuremberg, 2009, Germany ACM.

[13] Napper, J., Bientinesi, P.: Can "Cloud Computing Reach the Top500?". In Proceedings of the combined workshops on UnConventional high performance computing workshop plus memory accessworkshop, 2009, Ischia, Italy: ACM.

[14] Niyato, D.: "Optimization-Based Virtual Machine Manager for Private Cloud Computing". In 3rd IEEE International Conference on Cloud Computing Technology and Science, 2011, pp 99-106.

[15] Ramaswamy, A., Balasubramanian, A., Vijaykumar, P., Varalakshmi, P.: "A Mobile Agent based Approach of ensuring Trustworthiness in the Cloud". In IEEE-International Conference on Recent Trends in Information Technology, MIT, Anna University, Chennai, 2011, pp 678-682.

[16] Singh, A., Malhotra, M.: "Agent Based Framework for Scalability in Cloud Computing". In International Journal of Computer Science & Engineering Technology Vol 3 Issue 4, 2012, pp 41-45. http://www.ijcset.com/docs/IJCSET12-03-04-066.pdf.

[17] Vaquero, M., Merino, L., Caceres, J., Lindner, M.: "A break in the clouds:towards a cloud definition". In conference on the Special Interest Group on Data Communications, a special interest group of the Association for Computing Machinery, 2008, ACM, USA

[18] Virtualization Resource Chargeback, www.vkernel.com/products/Enterprise ChargebackVirtualAppliance

[19] Vogel, W., Pearson, S.: "Taking account of privacy when designing cloud computing Services". In Proc. of ICSE Workshop on Software Engineering Challenges of Cloud Computing(CLOUD '09), 2009, Page(s):44 – 52.

[20] Wang, J., Zhao, Y., Jiang, S., Le, J.: "Providing Privacy Preserving in cloud computing". In International Conference on Test and Measurement, 2009.

[21] White Paper: Introduction to Cloud Computing. http://www.thinkgrid.com/docs/computing-whitepaper.pdf

[22] XenSource Inc, Xen, www.xensource.com.

[23] Yang, H., Tate, M.: "Where are we at with Cloud Computing?: A Descriptive Literarure Review". In Proceedings of 20th Australasian Conference on Information Systems, 2009, pp 807-819.

[24] Yeo, C.S., Venugopal, S., Chu, X., Buyya, R.: "Autonomic Metered Pricing for a Utility Computing Service". Future Generation Computer Systems, 2009.

[25] You, X., Wan, J., Jiang C.: "Analysis and Evaluation of the Scheduling Algorithms in Virtual". In International Conference on Embedded Software and Systems, 2009.

[26] Yuan, R., Michael, S.C., Martin, O.H., Greg, S.: "Multiagent-based adaptive pervasive service architecture". In Proceedings of the 3rd workshop on Agent-oriented software engineering challenges for ubiquitous and pervasive computing, 2009, ACM: London, United Kingdom.

[27] Yuefa, D., Bo, W., Yaqiang, G., Zhang, Q., Chaojinh, T.: "Data Security Model for Cloud Computing". In Proceedings International Workshop on Information Security and Application (IWISA) Qingdao, 2009, China.

[28] Zhang, Q., Cheng, L.: "Cloud computing: State-of-the-art and research challenges". Raouf Boutaba J Internet Serv Appl , 2010, 1: 7–18 DOI 10.1007/s13174-010-0007-6.

[29] Zhang, Z., Zhang X.: "Realization of Open Cloud Computing Federation". In IEEE International Conference on Intelligent Computing and Intelligent Systems, 2009.

[30] Zhenyu, L., Tun, L., Lizhi, C., Genxing, Y.: "Agent-based Online Quality Measurement Approach in Cloud Computing Environment". In School of Computer Science Shanghai Key Laboratory of Fudan University Computer Software Evaluating and Testing, 2010.

[31] Zhou, Y., Yang, Y., Liang, L., Sun, Z.: "An Agent-based Scheme for Supporting Service and Resource Management in Wireless Cloud". In 9th International Conference on Grid and Cloud Computing, 2010, pp 34-39.