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Cloud Computing Architecture Supporting e-Governance

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***Abstract*—With the development of parallel computing, distributed computing, grid computing, a new computing model appeared. The concept of computing comes from grid, public computing and SaaS. It is a new method that shares basic framework. The basic principles of cloud computing is to make the computing be assigned in a great number of distributed computers, rather then local computer or remoter server. The running of the enterprise's data center is just like Internet. This makes the enterprise use the resource in the application that is needed, and access computer and storage system according to the requirement. The development of high speed Internet access, Web 2.0 applications and Virtualization techniques have made Cloud computing a leading edge technology. A user in 'Cloud' runs web based application over Internet via browser with a look and feel of desktop program. Cloud computing provides dynamically scalable and virtualized resources as a service over the network at a nominal initial investment. Data-center works as backbone in Cloud computing where a large number of servers are networked to host computing & storage needs of the users. The area which needs more attention is Latency Optimization for cloud architecture to work as ubiquitous as expected. Many data intensive applications produce enormous amounts of data which travel on cloud network. As the cloud users grow, cloud architecture should accommodate movement of voluminous data to avoid data congestion in the network. In this paper, an intelligent & energy efficient Cloud computing architecture is proposed based on distributed data-centers to support application and data access from local data-center with minimum latencies. It was found that the proposed architecture is efficient for business entrepreneurs, suitable to apply for e-Governance and provides a green eco-friendly environment for Cloud computing.**

***Keywords*— Cloud computing; e-Governance; cluster computing; green computing; cloud architecture**

I. INTRODUCTION

Computer scientists have always been attempting and innovating a new technology that efficiently & effectively utilizes the contemporary underlying hardware resources for the benefit of the science and business community. Starting from mainframes to recent virtual machines on 'Clouds', computational history experienced a trend of alternatively convergent and divergent patterns for the use of computing resources. Mainframe/Mini Computers processed users programs centrally on time sharing concept. The deep penetration of cheap Personal Computers affected almost every corner of computing thus diverging the resources.

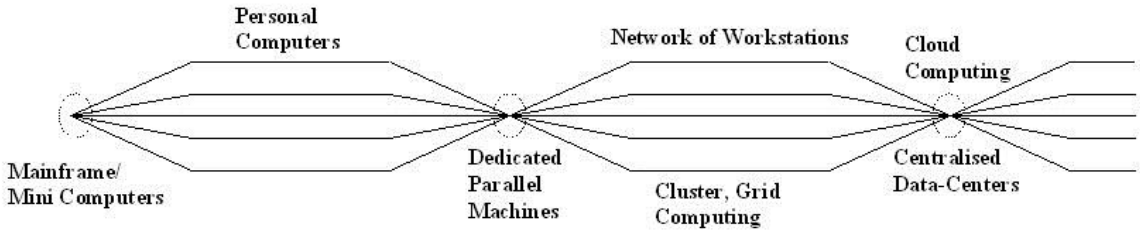

Figure 1. Convergent and Divergent Trends in Computing History

Later, by again converging the computing resources as shown in Fig. 1, dedicated parallel machines run parallel programs faster than contemporary PCs. As these parallel machines were very expensive, a major computational change was observed as divergence in resources which categorized as distributed computing such as Network of Workstations

(NOW), Cluster computing, Grid Computing etc. In present scenario, Cloud computing uses centralized resources in form of data-center. The trend in use of resources alternatively, i.e., centralized and distributed seems to continue.

A. Cloud Computing

Cloud computing is use of scalable computing resources over Internet on a pay-as-you-go basis [1]. It provides a cost-effective IT solution to business & scientific community. Economically the main attraction from Cloud computing is that customers only use what they need, and pay for what they actually use. Organisations neither need to purchase expensive hardware such as servers, storage, networking equipments etc. nor require manpower for development of complex IT solutions in-house. Resources as a service are available over Cloud at any time and from any location via the Internet [9]. Passive 'Consumers' have now become 'Prosumers' by using Service Oriented Architecture (SOA) and Web 2.0 applications such as social networking sites, blogs, hosting services etc. One can choose services from pool of available services and negotiate price through Service Level Agreements (SLAs). Among the popular Cloud service providers are: Amazon [5], Google [6], Microsoft [7] etc.

Three main types of service levels as delivery models are:

1) Software as a Service (SaaS) : The clients may opt for ready customized application, but do not have control over background environment such as operating system, hardware or network parameters.

2) Platform as a Service (PaaS) : In this types of services, clients have control over change in application and hosting environment such as system software. But SaaS does not provide control over operating system, hardware and network parameters.

3) Infrastructure as a Service (IaaS) : The clients can create a virtual processing environment by specifying choice of processing power, storage, network parameter etc. and have control over operating system and application environment.

B. Virtualization Technology

With virtualization techniques, multiple operating systems can concurrently run on a single physical system. A user can opt for his choice of operating system and other hardware configuration called virtual machine (VM) and run his application by sharing underlying hardware resources. It is the 'Virtual Infrastructure Management Software' (VIMS) that centrally manages many VMs on a single physical system. In user's perception each VM is a single, logical bunch of resources as shown in Fig. 2. Virtualization techniques provide cost-effective & efficient utilisation of IT infrastructure. Presently, Xen (http://www.xen.org) [10] and VMWare (http://www.vmware.com) [11] are two leading virtualization technology providers.

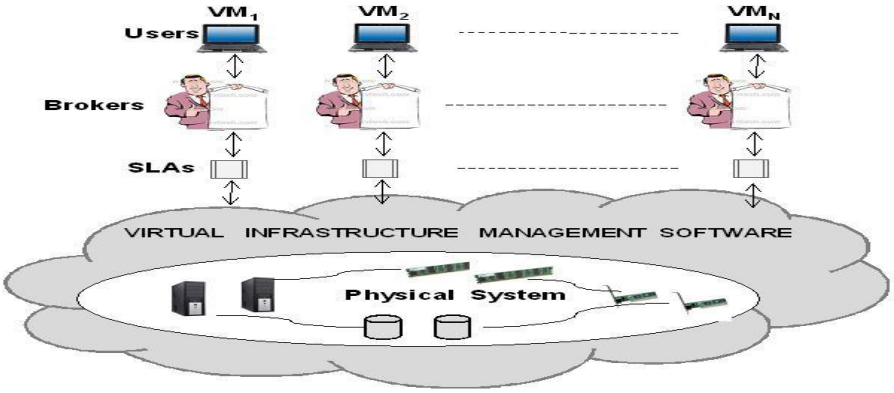

Figure 2. Virtual Machines in Cloud Architecture

C. e-Governance

e-Governance is use of IT infrastructure to ease governance activity such as administration, revenue services, various services to citizens, policy formation etc. e-Governance improves the efficiency of government functioning by removing redundancy at different levels. Citizens get advantage from several eservices like income tax, pension, services related to municipal corporation and agriculture etc. The four main categories of e-Governance applications and the services fall under these categories are :

- Government to Government (G2G): Administration, Policy formation etc.
- Government to Business (G2B): Taxation, Tender etc.
- Government to Consumer (G2C): Land record, Birth certificate etc.
- Government to Employees (G2E): Income tax, Pension etc.

Transforming ongoing national e-Governance plan of governments to Cloud architecture would yield the following benefits :

- Uniform e-Governance architecture all over the country as against the heterogeneous architecture due to procurement of IT infrastructure from autonomous government agencies.
- Governments need not have expensive IT setups, pay for software licenses and maintain them leading to a substantial cut in the government's annual budget for IT infrastructure.
- Governments can concentrate on making e- Governance convenient for the intended users instead of mere focus on technical and operational overheads to maintain IT infrastructure.

II. RELATED WORK

Continuous research work is being carried out worldwide to address the issue of Cloud computing architecture. Some researchers identify Cloud computing as virtualization of previously existing data centers while some others nominate data-centers as backend resources of newly adopted Cloud computing paradigm. Fang & Yin[2] correlate Cloud architecture with Business Process Management (BPM). Business process activities are modelled over platform layer and combined with application layer. A strategy to manage complex and unpredictable workload entering cloud is proposed by Paton et al [3]. As all computing & storage resources are managed centrally, despite workload balance, the system is susceptible to network congestion. Database & Gupta [4] propose a Cloud architecture for radio frequency identification. The data captured by radio frequency reader is sent to data processing system present in the cloud. A substantial time delay may be observed if radio frequency reader and cloud resources are physically located at long distance. A common trend of centralized resources at the Cloud provider's location is present in almost all existing Cloud computing architectures leading to increase in latencies.

III. PROPOSED CLOUD ARCHITECTURE

Due to world-wide hype and rapid growth in associated technologies, Cloud computing clients continue to multiply. The large number of service requests to full fill the demands of millions of users will broaden the latency problem. Cloud service provider physically may be far away from the clients, compelling data to travel from several mediums and network equipments, thereby imposing a time delay in getting Cloud services. Existing Cloud providers use centralized data-center to host computing & storage needs of the clients. In this study, an intelligent & energy efficient Cloud computing architecture is proposed based on distributed data-centers which form a client's instance in nearest neighbourhood and fulfil client's request in optimized latency.

A. Cloud Computing Model

In the proposed Cloud architecture data-centres work in master-slave paradigm. Nearest data-centres form a computing zone and users may opt for creating their instances in multiple zones.

The main entities involved in proposed architecture are :

1) Master/Slave Data-Centre: Master data center is located at Cloud provider's administrative premises. User's accounting on pay-as-you-go basis is completed here. Slave data-center are geographically scattered to serve user's requests in minimum physical distance.

2) Users/Brokers : Users directly communicate or via brokers submit requests which automatically reaches at master data-center. Master data-center creates user instance at appropriate slave data-center considering minimum latency.

3) Service Level Agreements (SLAs): Quality of Service (QoS) and pricing negotiations are settled through SLAs. Master data-center scans SLA each time to host needs of the users.

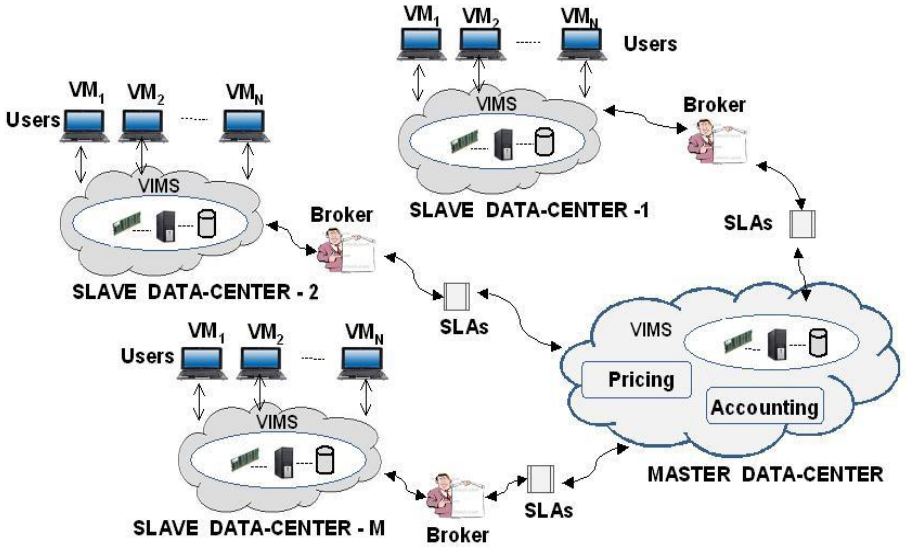

Figure 3. Proposed Cloud Architecture

B. Informal Description of Algorithm

After receiving a request for creating an instance, master data-center look for the availability of resources in the user's local data-center. If desired resources are available, then user gets his required instance and run his application with minimum latency. Master datacenter searches other slave data-centers of same zone for resources if they are not available on the location of the user. If resources are not available even in same zone and user has opted for multiple zones then master
data-center looks for resources in other zones.

C. Formal Description of Algorithm

If we denote SDCij as slave data-center in ith zone and at jth location (i=1..M, j=1..N), -center, then the algorithm in proposed Cloud architecture for allocating instances to user MDC as master data-center and Upq is an user in pth zone and at the location of qth slave data is :

Algorithm Create Instance
Request for instance from user Upq → MDC
MDC → if resources available in SDCij
(i = p, j = q)
create instance (Uij) ;
else if resources available in SDCij
(i = p, j = 1..N, j → q)
create instance (Uij) ;
else if multiple zones = 'yes' search for resources
in SDCij (i = 1..M, i →p, j = 1..N)
if resources available, create instance (Uij);
else make a fresh request Upq → MDC ;
End of algorithm.

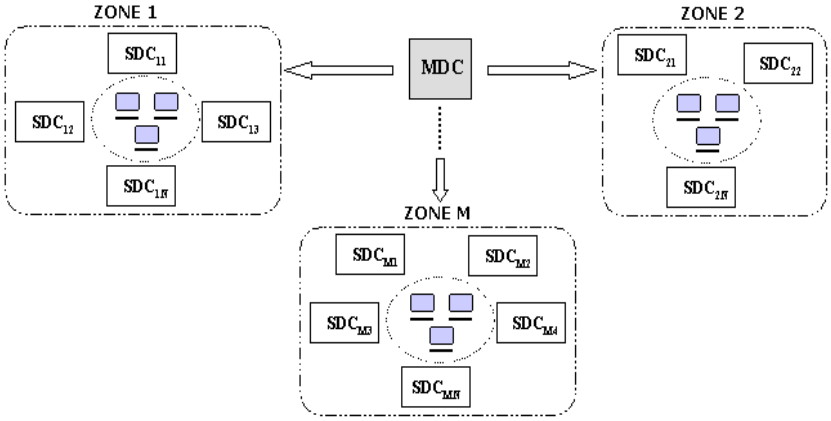

Figure 4. Creation of Instance Based on User's Geographic Location

D. Advantages of Distributed Data-Centers in Cloud

- Users get quick response to their requests in minimum latency
- Data-centers may be formed with commodity hardware as against expensive hardware in Centralized data-center.
- Entrepreneurs may form local data-center on their existing IT infrastructure for security measures, thus forming a hybrid Cloud.
- A large number of services and network equipments are clustered in centralized datacenter requiring more electricity, air conditioning etc., whereas distributed datacenter require less power consumption, air conditioning etc., therefore creating an eco-friendly green computing environment.

E. Suitability of Distributed Data-centers in e-Governance

- Distributed data-center may prove to be very effective in e-Governance as nature of government functioning is distributed
- Master data-center may be formed in capital of a state and slave data-center may be formed either at division or district places.
- Users may get a direct connectivity through fiber optical cable to local data-center thereby providing a maximum bandwidth.
- Governments may host their own Clouds, making local data-centers on the existing IT infrastructure.

- Government may increase revenue by hosting services on own Clouds and enforcing tax deduction at source in all business transactions.

IV. EXPERIMENTAL RESULTS AND COMPARISON

Experiments were carried out of the proposed architecture on Cloud simulator [8] which has provision for forming different data centers, virtual machine instance migration, energy consumption model etc. By running an application initially from central data center and then from several geographic locations on different number of data centers, about 21% improvement was observed in latencies as shown in Fig. 5. User's instances created as virtual machines are migrated

across physical servers of data center for load balancing purposes. Less number of virtual machine migrations were reported as compare to central data center as computing resources are distributed across geographic locations. Maximum migrations occurred within zone of user's locality than inter-zone migrations. Barker & Shenoy [12] show data of read/write experiments for a latency sensitive multimedia application running on a single data center. We simulated a multimedia application running on platform consists of distributed data centers which outperforms about 12% the results [12] of in terms of response time similar to as shown in Fig. 5.

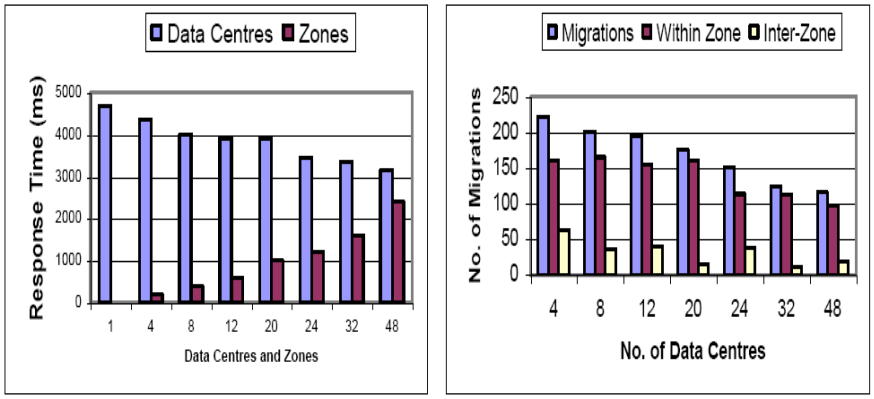

Figure 5. Comparison of Response Time and No. of Migrations.

Data center usually consists of computing, storage & network devices almost in thousands of numbers. In addition to huge amount of electricity consumed by these devices, huge electric power is also needed for cooling systems. As a result data center emits more carbon dioxide (CO_2) in a locality than permissible emission standard of the government. Cloud

architectures proposed by several authors including [3] and [4] are based on central data center. On the other hand, in the proposed distributed data centers carbon emission would be within permissible limit as the resources are scattered in wide geographical area.

V. CONCLUSION

Scientific and commercial computing have seen several architectural combinations of available contemporary computing resources. In the similar way as Grid computing gained much attention from scientific community, Cloud computing is being popular among business community. The architectural design of Cloud computing is still in its infancy and needs exploration towards the efficient utilization of large scale IT infrastructure. In this paper, an effective Cloud computing architecture is presented based on distributed data-centers which yields access to application & data among users in minimum latencies and create an energy efficient & eco-friendly green computing environment . Possibilities of using existing IT setups as local data-center make proposed architecture cost-effective for organizations

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