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A Survey of Cloud Computing: Designing, Applications, Security Issues and Related Technologies

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ABSTRACT
Cloud Computing has recently evolved as compelling paradigm for delivering and managing resources as service over the internet. IT industry is much more affected by this technology owing its ability to provide more benefits and permits enterprises to start from the small and enhance resources only when there is a rise in service demand. Although cloud computing is providing many facilities but there are many issues which is yet to be addressed. In this paper, we present a survey of cloud computing, its key concepts, state-of-the-art implementation and research issues as well. The objective of this paper is to provide better understanding of cloud computing and identify important research directions in this burgeoning area of computer science.
Keywords – Cloud Architecture, Cloud Computing, Data Center, Hypervisor, Virtualization,

I. INTRODUCTION

In the last few years, owing unprecedented success of internet has made computing resources ubiquitously attainable. And this lead to emergence of new concept called "Cloud Computing". Nowadays, researchers are also showing more interest in this area because of its capability to provide reliable, powerful and cost-efficient cloud platform and can assists the one to gain more profits from this paradigm. Owing its unlimited benefits, Cloud Computing is now being more adopted by every business organizations, colleges/institutes and many IT fields.

Cloud Computing is not treated as single entity. CC is made of two terms: Cloud – It is a metaphor of "Internet" means utilization of internet based technology and Computing – It means use of computing technology. CC enables the user to access the resources anytime from any platform such as Smartphone, Mobile Computing Platform and the desktop. Many companies are providing services from the cloud. Some of the examples are Google, Microsoft and Salesforce.com etc

In cloud computing, the traditionally role of service provider is divided into two phases: the *infrastructure providers* who manage cloud platforms and lease resources as per usage-based pricing model, and *service providers* who rent resources from one or many infrastructure providers to serve the end users.

A Cloud Computing infrastructure is basically consisting from three elements as follows: Clients, Datacenter and Distributed Servers (See Fig. 1).

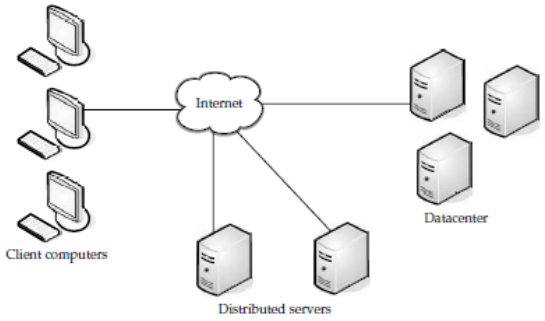

Figure 1: Elements of Cloud Computing

- Clients – Clients are the terminal from which user perform certain task. Examples are PDAs, Smartphone and Desktops etc.
- Datacenter – A datacenter is a multitude of servers that host the applications needed by an organization. Today trend is of virtualized servers that are creation of multitude servers on one scalable machine through a program called hypervisor.
- Distributed Server – In distributed servers, one or more central servers store file which can be accessed with proper authorization rights by remote clients in the network.

II. OVERVIEW OF CLOUD COMPUTING

2.1 Definition

The Cloud Computing is still evolving and there exists no wide accepted definition. Based on our expertise, we tend to propose an early definition of Cloud computing as follows:

"Cloud Computing is a way to provide computing resources virtually over internet that can provisioned

and released as per user need with least management effort and human interaction with service provider."

2.2 Example

A simple example of Cloud computing concept is Yahoo email, Gmail or Hotmail etc. There is no need to use software and server to utilize them. What you need is simply an internet connection and one can start sending emails. All are available on the cloud whether server or email management software and is completely managed by cloud service provider Yeah, Google etc.

2.3 Cloud Computing Terminology

Cloud Service Provider (CSP) – Cloud Service Provider is a third party vendor that provides application delivery, monitoring, hosting and other services via cloud computing. An organization can have contractual agreement with multiple CSPs depending upon the required cloud solutions.
Multi-tenant – Here tenant means single customer. It provides the ability to share the same application while running on the same operating system using same hardware and data storage mechanism.

2.4 Characteristics of Cloud Computing

Cloud Computing offers several features which are distinct from traditional service computing, that we summarize below:
On-Demand Self-Service – Resources such as server time or network space can be accessed and utilize easily by user when needed, from any place and any time via global network without human intervention with service provider.

Broad Network Access – System capacities are available to customers via the network and can be accessed from different devices like Desktop Computers, Mobile Phones, Tablets and Laptops.

Resource Pooling – Computer resources of provider are grouped in order to serve multiple users using multi-tenant model. The mechanism of processing power distribution or amount of memory operated in such a way that system dynamically assigned these parameters as per user's requirements.

Rapid Elasticity – One of the important features of CC is the computing resources can be provisioned rapidly and released without human intervention when no longer needed, thus lower the operating cost.

Measured Service – CC basically works on the principle of usage based model and may vary from service to service. Measured services lower the operating cost as it charges users on pay-as-you-go basis.

2.5 Some Existing Definitions

Various definitions have been proposed to explain the concept of cloud computing. Some of them are given below as:

According to Wikipedia – **"***Cloud computing is Internet based development and use of computer technology (computing) whereby dynamically scalable and often virtualized resources are provided as a service over the Internet. Users need not have knowledge of, expertise in or control over the technology infrastructure "in the cloud" that supports them."*

According to NIST – **"***Cloud Computing is a model for enabling ubiquitous, 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 interaction."*

According to the IEEE Computer Society – **"***Cloud Computing is a paradigm in which information is permanently stored in servers on the internet and cached temporarily on clients that incorporate desktops, entertainment centers, table computers, notebooks and handhelds etc."*

According to Gartner Group – "*A style of computing in which massively scalable IT-related capabilities are provided "as a service" using internet technologies to multiple external customers."*

According to Fast Cloud Group – "*As a new style of computing in which dynamically scalable and often virtualized resources are provided as a pay for use service over the internet or an intranet network. Users need not have knowledge of, expertise in, or control over the technology infrastructure in the "cloud" that supports them."*

According to Armbrust – "*Cloud Computing refers to both the applications delivered as services over the internet and the hardware and system software in the datacenters that provide those services"*

According to Buyya – "*Type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on Service Level Agreement."*

2.6 Related Technologies

CC uses the concept of certain technologies that makes it flexible, reliable and usable. These technologies are listed below:

2.6.1 *Grid Computing*

Grid Computing is distributed computing in which large number of computer from remote areas which are connected with one another to realize common objectives. These resources are heterogeneous and geographically distributed. Grid computing generally breaks larger tasks into smaller pieces which are distributed to CPUs residing within the Grid.

2.6.2 Virtualization

Virtualization is a technique that permits to share single physical instance of a resource or server among multiple tenants and organizations. The multitenant design offers virtual isolation among the multitude tenants and so the organizations will use and customize the application like they each have its own instance running.

2.6.3 Utility Computing

Utility Computing is predicated on pay-per-usage model. Utility computing provides resources on demand as a metered service. On demand provisioning of resources and utility pricing, service providers can truly maximize exploitation and assuage their operating costs.

2.6.4 Autonomic Computing

Autonomic computing focuses at constructing computing system capable of self management that is behaving according to internal and external observation without human intervention. The objective of Autonomic Computing is to overcome the management complexity of today's computer system.

III. LITERATURE REVIEW

Salvatore et al. worked on Service Level Agreements over Quality of Services (SLA-QoS) that outlines procedure to provide SLA based QoS on hazard and risky cloud environment.

Lee et al. suggest assessing SaaS in a quantifiable method. For instance, different vendors can judge the level of various services and can calculate return on investment.

Wang et al. suggest an automatic optimization scheme for cloud storage called AOSC which uses data chunking, placement and replication to achieve more stable and foreseeable performance.

Younge et al. propose a concept of Green Cloud structure for increasing efficiency per watt within a Cloud. The proposed framework utilizes power-aware scheduling techniques over an exclusive virtual machine design.

Li et al. presented an approach to find optimal deployments for huge data centers and clouds. It applies a combination of bin-packing, mixed integer programming and performance models in order to make the taken decisions affect the various strongly working together goals, which will include the pleasure of different service level harmonies for many different applications.

IV. CATEGORIES OF CLOUD COMPUTING

Cloud Computing can be categorized on two ways: Location based and on the basis of Service offered. *A Location Based Service refers* to the way in which a customer is offered exclusive services in terms of geo-location. Another category is on the basis of *Service Offered* which explains what type of service can be obtained from cloud (See Fig. 2).

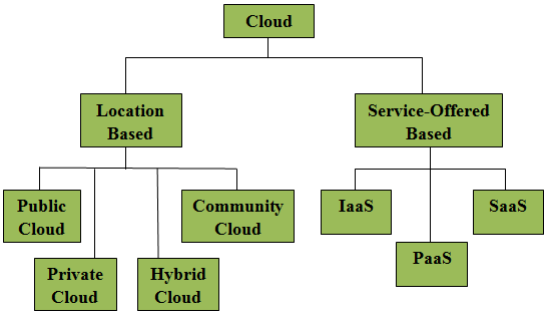

Figure 2: Classification of Cloud

4.1 Location Based

4.1.1 Public Cloud

In public cloud, a service provider offer resources as service to a large group of independent customers such as general public. In public cloud, services may be offered on a pay-per-usage mode means cost incurred on the basis of capacity that is used. Public Cloud also called External cloud.

In other words, public cloud is one in which computing infrastructure is hosted by the cloud vendor at the vendor's premises. Prime example incorporates Amazon EC2, Google Apps, Salesforce.com and Microsoft Office 365.

4.1.2 Private Cloud

Also called Internal Cloud, a private cloud is a cloud in which computing infrastructure is dedicated to a particular organization. Private cloud networks is not shared with other organization and can provide internal services like data storage as well as external services to the public or other users. Example of Private Cloud includes Eucalyptus, Elastra, VMware and Microsoft.

Private clouds are of two types:

- On-Premise Private Clouds – On-Premise Private Cloud is a cloud which is hosted within an organizations own facility.
- Externally Hosted Private Clouds – In this model, clouds are used by one organization that is hosted by a third party specializing in cloud infrastructure.

4.1.3 Hybrid Cloud

Hybrid cloud is combination of public and private cloud infrastructures so as to achieve a maximum of cost reduction via outsourcing whilst maintaining the desired degree of control over (e.g. – sensitive data by employing local private clouds).

4.1.4 Community Cloud

Community Cloud is shared by several organizations and supports a specific community that has shared concerns. Community cloud may be managed by the organization or a third party and may exist off-site. For example, G-Cloud is the special case of community cloud. This type of service is provided by one or more agencies, for use of all and government agencies.

4.2 Service-Offered Based

4.2.1 Infrastructure-As-A-Service (IaaS)

IaaS is a service model that enabled user to provision processing, storage, networks and other fundamental computing resources offered to customer on demand that owned and hosted by service provider.

In IaaS computing infrastructure, user is able to deploy and run arbitrary software that can include applications and operating systems. The service provider offers too *Application Program Interface* (API) that enable the user to start, stop, and access and configure their virtual servers and storage. It is also rendered as *Utility Computing* owing its utilization of pay-for-what-you-use model. Some of the popular examples of IaaS Providers are Amazon EC2 & S3, Microsoft Azure Platform etc.

4.2.2 Platform-As-A-Service (PaaS)

PaaS offers platform layer resources incorporating software development framework and operating system support. Google App Engine, Force.com and Microsoft Windows Azure are some of example of PaaS.

4.2.3 Software-As-A-Service (SaaS)

SaaS provides on demand applications over the internet. Some examples of SaaS are Salesforce.com, SAP Business ByDesign and Rackspace.

V. CLOUD ENVIRONMENT ROLES

In cloud environment, the roles can be spotted similar to the role distribution in Service Oriented Architectures and especially in Virtual Organizations.

Cloud Providers provide clouds to the customer either through virtual machines, dedicated APIs or direct access to resources.

Cloud Resellers aggregate cloud platforms from cloud providers to provide a larger resource infrastructure to their customers or to provide enhanced features.

Cloud Adopters enhance services and capabilities by exploiting cloud platforms from cloud resellers or cloud providers.

Cloud Consumers make direct use of cloud capabilities, however not to reform the services and capability they offer but to make use of direct results.

Cloud Tool Providers offers supporting tools such as virtual machine management, programming environments etc necessary to run the applications.

VI. RELATED WORK

In this section, we will review current projects on cloud computing and virtualized distributed system.

6.1 Global Virtual Workspace and Nimbus

A virtual workspace is a computing environment that is dynamically available to authorized clients through invoking grid services. The virtual workspace offers the following access interfaces as: *Workspace Factory Service* has only one operation called *Create* that required two parameters – Workspace Metadata and deployment request for that Metadata. After its creation, workspace is designated as a WSRF *resource.* The workspace could be inspected and managed via the *Workspace Service Operations. Group Service* permits an authorized client to manage a set of workspaces at one time.

6.2 Violin: Virtual Inter-networking on Overlay Infrastructure

Violin is based on virtual network technology that creates high order virtual IP networks. Some benefits are:

- Creates virtual machine and IP network that connects virtual machines
- Customization of virtual topology and services, application services, operating system services, packages and libraries.
- Containment of negative impact by uninflected virtual network addresses space.

6.3 The In-VIGO System

The In-VIGO consists of three layer of virtualization including traditional Grid computing model:

- The first layer consists of virtual resource pools. Virtual computing Grid includes some primitive components like virtual data, virtual machines, virtual applications etc.
- In second layer, Grid applications are wrapped as Grid services that can be connected as needed to create virtual Grids.
- In order to modify displaying by completely different access devices, the third layer

aggregates Grid services by commercialism their virtualized interfaces.

6.4 Virtuoso: a system for virtual machine marketplace

The Virtuoso system is developed by Northwestern University and aims to make a marketplace for resource usage. Resource suppliers may sell their resources to consumers within the variety of virtual machine and virtual network. In this era, the customer acquires a remote virtual machine, memory size, configured with inclined processor type and data storage resources. On the basis of need, customer can install and configure whatever software demanded on virtual machine.

6.5 COD: Cluster-on-Demand

The Cluster-on-Demand is to use to implement a virtual cluster with main focus to separate the cluster usage form the cluster management. The virtual cluster comprises of subsets of cluster nodes configured for some common denotation, involved with user accounts and storage resources, user specified software environment and a private network space.

6.6 OpenNEbula

The OpenNEbula is a virtual infrastructure engine which allows the dynamic deployment and re-allocation of virtual machines from pool of physical resources. The OpenNEbula system extends the advantages of virtualization platforms from a one physical resource to a pool of resources, decoupling the server, not solely from the physical infrastructure however additionally from the physical location.

6.7 Amazon Elastic Compute Cloud

The Amazon Elastic Compute Cloud (EC2) offers Web service interfaces that deliver resizable compute capacities to customers in the compute cloud. Users may rent and configure virtual machines and data storage readily and exploit the computing capacities remotely.

6.8 Eucalyptus

The EUCALYPTUS (Elastic Utility Computing Architecture for Linking Your Programs to Useful Systems) is an open source software infrastructure for executing Elastic/Utility/Cloud Computing using computing clusters and workstation farms. In addition, it incorporate several interesting features like compatible interfaces with Amazon's EC2, simple installation, deployment and management, support virtual privet network for users.

VII. STATE-OF-ART TECHNOLOGIES

This section present the state-of-art implementation and key technologies currently used for cloud computing.

7.1 Architectural Design of Data Center

Data center provides the facility to house computer system and associated components such as processing power and storage. Generally, it incorporates redundant data communications connections, redundant or backup power supplies, environmental controls and security issues.

Design of data center basically follows the layered approach that has been tested in some of the deployed data centers (See Fig. 3). The basic layer of data center constitute from three layers as: Access, Aggregation and Core layer. In *Access layer*, servers in racks physically connect to the network. The *Aggregation layer* offers functions like location service, domain service, server load balancing and more. The core layer provides connectivity to multiple aggregation switches and provides a resilient routed fabric with no single point of failure.

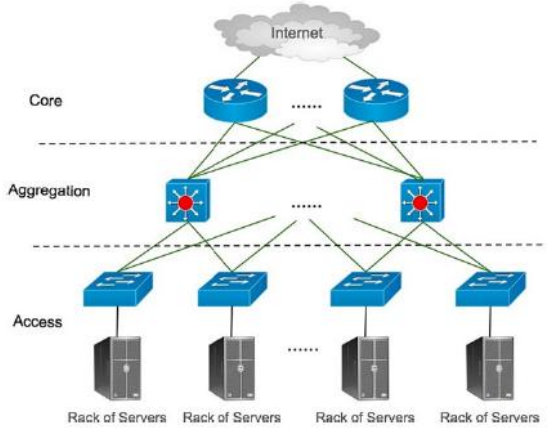

Figure 3: Data Center Design

7.2 Distributed File System over Cloud

This can be perceived from Google File System (GFS) that is a proprietary distributed file system developed by Google to provide efficient, reliable access to data using large clusters of commodity servers. Files are divided into chunks of 64 megabytes and usually appended to a read and only extremely rarely overwritten or shrunk. Comparing traditional file systems, GFS is designed and optimized to run on data centers to provide extremely high data throughputs, low latency and survive individual server failures. Induced by GFS, open source Hadoop Distributed File System (HDFS) stores large files across multiple machines. It achieves reliability by replacing the data across multiple servers.

7.3 Distributed Application Framework over Cloud

Google has introduced a software framework to support distributed computing on large data sets on clusters of computers called MapReduce. HTTP-based applications are usually conform to some web application framework such as Java EE. MapReduce consists of one Master to which client applications submit MapReduce jobs. The open source Hadoop MapReduce project is inspired by Google's work. Currently, many organizations are using Hadoop MapReduce to run large data intensive computations.

VIII. OPPORTUNITIES

Cloud computing has offering many benefits. For better understanding we can categorize them according to fields as business, individuals, researchers and governments that are summarized below.

8.1 Opportunities for Business

Businesses will cut back their IT overhead by migrating computing functions to the cloud. This might lower value barriers for startup companies by not requiring expensive IT hardware and infrastructure purchases within the early stages of growth. Cloud elasticity additionally permits businesses to get hold of solely the services and computing power that they really use. This could forestall the matter of buying excess infrastructure capacity which will go unused or having deficient infrastructure to accomplish key work needs. Cloud computing may also alter additional businesses in data-intensive fields to access high supercharged computing resources, serving to level enjoying field between smaller and bigger companies.

8.2 Opportunities for Individuals

Cloud computing can offer users with unlimited access to data files from remote areas using internet. Modifications that users make to files and data stored on the cloud from location or device will be updated when the user accesses the files and data from different location or device.

8.3 Opportunities for Researchers

CC can enable larger collaboration between scientists and researchers both domestically and internationally. It can also offer scientists with more computing power permitting them to run high-powered simulations that were previously restricted solely to those with supercomputing access. CC may also cut back the quantity of your time that researchers and scientists got to started IT infrastructure and increase the time spent on playacting analysis.

8.4 Opportunities for Federal Government.

CC has ability to cut down federal government IT expenses by a considerable margin. A big part of the IT federal budgets is spent on infrastructure and maintenance. VM migration may greatly reduce these costs helping to reduce taxpayer funding for these activities.

IX. RESEARCH ISSUES

Cloud computing has been broadly adopted by many IT industry as well as business enterprises in recent times. But the research on it 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 issues of cloud computing is given below:

9.1 Service Level Agreement

Service level agreement permits many instances of one application to be replicated on multiple servers if would like arises. Depending on priority scheme, the cloud could minimize or shut down a lower level application. An enormous challenge for the cloud users is to gauge SLAs of cloud venders. SLAs to create a defensive defend against proceedings whereas providing smallest assurances to customers. So there are some necessary problems such as information protection, outages and worth structures that require to be taken under consideration by the users before signing a contract with a provider.

9.2 Virtual Machine Migration

Virtualization may provide important benefits by enabling virtual machine migration to balance load across the data center. Virtual Machine Migration permits to move an entire VM from one machine to another and continue operation of the VM on the second machine. VM machine migration has emerged from process migration techniques. Recently, Xen and VMware have materialized which incorporates extremely short downtimes ranging from tens of milliseconds to a second. Most important advantage of VM migration is to avoid hotspots however it is not straightforward.

Some of the silent benefits of virtualization in cloud computing is as follows:

- *Elasticity and Scalability* – Starting up and shutting down VMs involves less effort as opposed to bringing servers up and down.
- *Workload Migration* – With less effort, one can shift the workload by process of migration instead of workload migration across physical server at different locations.
- *Resiliency* – One may isolate physical sever failure from user services through VM migration.

9.3 Server Consolidation

Server consolidation is an effective method to maximize resource exploitation while reducing energy consumption in cloud computing environment. One approach used to consolidate VMs is Live VMmigratioin technology that resides on multiple servers onto single server so that remaining servers can be set to an energy-saving state. The problem of optimally consolidating servers in a data center is often formulated as a variant of the vector bin-packing problem that is an NP-hard optimization problem. Several heuristics have been proposed for this problem.

9.4 Novel Cloud Architecture

Recently, clouds are implemented in big data centers and operated centrally. However there are economical pros but it comes along with limitations such as high energy expenses and initial investment for constructing data centers. If we talk about small data centers, it eliminates the problems of energy, power, cooling system and more over economical and geographically easily distributed.

Another research is on using voluntary resources for hosting cloud application. Voluntary resources assist to create clouds which are better and most appropriate for non-profit applications like scientific computing. However it is offering some benefits but management of such heterogeneous resources is a challenge and building such architecture is research problem.

9.5 Energy Management

Another major issue in cloud computing is to improve energy efficiency. It has been evaluated that the price of powering and cooling accounts for 53% of the total operational expenditure of data center. The main objective is not solely to decrease cost in data centers but to meet government rules and standards as well.

Designing energy-efficient data centers has recently received considerable attention. This problem can be approached from several directions. For example, energy efficient hardware architecture that enables slowing down CPU speeds and turning off partial hardware components has become commonplace. Energy-aware job scheduling and server consolidation are two other ways to reduce power consumption by turning off unused machines. Recent research has also begun to study energy-efficient network protocols and infrastructures. A key challenge in all the above methods is to achieve a good trade-off between energy savings and application performance. In this respect, few researchers have recently started to investigate coordinated solutions for performance and power management in a dynamic cloud environment.

X. CONCLUSION

Cloud computing has now been consider as next generation architecture of IT industry is a talk of the town these days. The enhancement of cloud computing is rapidly changing the landscape of information technology and ultimately turning the utility computing into a reality. However it offers a large variety of features but many challenges incorporating energy management, automatic resource positioning, information security are only attracted the research community. There are still many issues to be addressed.

In this paper, we have surveyed the cloud computing, state-of-the-art implementation of cloud computing covering its essential concepts, designing, silent features, key technologies and research directions as well. As the development of CC technology is still at an early stage, we hope our paper will provide better understanding of the cloud computing and various research issues thereby bolstering further research in this field.

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