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ENLIGHTENING THE CLOUD COMPUTING DOMAIN

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Abstract
Cloud computing is an emerging model of "computing as utility" to provide convenient, on demand access to shared pool of resources. In this paper, this grooming technology is presented in terms of its basic characteristics, services provided, models, and why cloud computing is a widely accepted in business and software enterprises.

Key words: Private cloud, public cloud, SAAS, PAAS, IAAS, Virtual Machines, Multi-tenancy

1.Introduction
Establishing a new business enterprise require distinct class of utilities like water, electricity, means of communication like telephones, mobiles etc and all these are the paid services on the extent of their utilization. Ubiquitous internet facility has made it possible to use computing as utility.
Cloud computing has made the dream of "computing as utility" to come true. Today is the era of IT and internet has converged everything-may it be hardware (servers, networks, storage etc) software (security and finance monitoring services, testing modules, customer relationship management CRM modules, ERP software etc), platforms, communications. All these services collectively called CLOUD.

Cloud computing provides a package of services on pay-as-you-use-basis similar to other public utilities. It delivers the computing as a ubiquitous metered service or leased service. Many big IT giants like Microsoft, Amazon, Face book, Google are already in the track of Cloud Computing, providing free online services to unlimited number of users across the world. It involves online management of data and information processing functions within the cloud while they are accessible from any PC, laptop, mobile device with a network connection in real time (internet)shown in figure 1. The process of providing the computer servers on a remote location to a variety of clients is called cloud hosting whereas cloud computing involves the use of those servers to process normal information.

Figure 1

2. How services are provided?

To provide cloud services, it involves:
Front end- Laptops, Tabs, Mobiles, computers, having unlimited internet access and a software to access the cloud. The software is a browser on user's cloud accessing device as in fig 1.

Back end – it refers to the cloud itself providing pool of services- applications, platforms, and infrastructure as depicted in figure 2.

Figure 2

3.Visual Model of cloud computing

Cloud computing is described in terms of

- Three service models
- Four deployment models
- Five essential characteristics

Cloud services have been emerged as three service models (Fig 3):
Software as a service(SaaS)-Also refers to Application as a Service(AAAS) includes applications, softwares, web applications, web Browsers, package of interrelated tasks, their definition, configuration files etc provided by the cloud which can be accessible from various client devices through APIs using various devices(mobiles, laptops, PCs, PDAs etc) with a network connection in real time. These applications are like utility computing that can be scaled up or down according to user's need. Any software uploaded on cloud can be accessed from any location by anyone (having access privileges to cloud services) without concerning about whom, where and how the third party is providing computing cycles or memory bits for its storage but is paying for it.

Platform as a service (PaaS)- The capability of cloud computing to provide a computing platform to its consumers to develop and deploy the applications along with their run-time management is referred as cloud's platform as a service. The application developer is no more required to buy and manage the underlying hardware and software but would have the control over the deployed application. Some researchers consider PAAS under SAAS but do not take it as a separate model of service. Cloud service providers provide compilers, computer languages, operating systems, web browsers, interpreters under PAAS as a service.

Infrastructure as a service (IaaS)-Variety of infrastructure resources processing power, storage media, networks, servers and other fundamental computing resources are provided virtually to the consumers of cloud services. IAAS is considered as a bunch of virtual machines VMs which are scaled up and down according to the application's need.

Based on specific requirements, there are four deployment models for cloud services (Table 1):

Public Cloud- it is a traditional cloud computing model which provides cloud Applications, Platforms, infrastructure services (SaaS, PaaS, IaaS) to general public through internet on self-service basis. These services may be free or pay-as-you-go based. The cloud spans over multiple administrative domains without any physical partitioning of resource allocations. These are generally owned and managed by some third party or by organization selling cloud services. Public cloud locations are generally off-premises. Face book and Google are the prominent examples modeling a public cloud

Private cloud- Cloud infrastructure and service model owned, managed and operated by a private organization for its purpose without providing its services to outsiders. The services are used solely by a single organization privately. It provides cloud services within the organization using its private networks, consisting of applications or virtual machines in the organization's own set of hosts and managed by the organization itself or by some third party. Private cloud may be located off-premises or on-premises. They are most secured but are expensive to manage.

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Community Cloud- when many organizations have similar requirements(mission, security requirements, policy) then they can share the infrastructure, data, applications, security requirements, policy concerns etc among themselves by having a community cloud. It is an expensive model as compared to public cloud since total cost is being shared among few organizations but offers high privacy, security and policy compliances.

Hybrid Cloud- A better approach is to use a combination of private cloud and public cloud to allow cloud bursting for some requirements. Cloud Bursting is a Technique where an enterprise normally employs local servers to run applications and dynamically harness cloud servers to enhance capability during period of workload stress [2]. It comprises of two or more clouds (public, private or hybrid) combined by a standardized technology, thus allowing data and application portability for improving load balancing. It uses physical hardware and virtualized cloud service instances together to provide single common service.

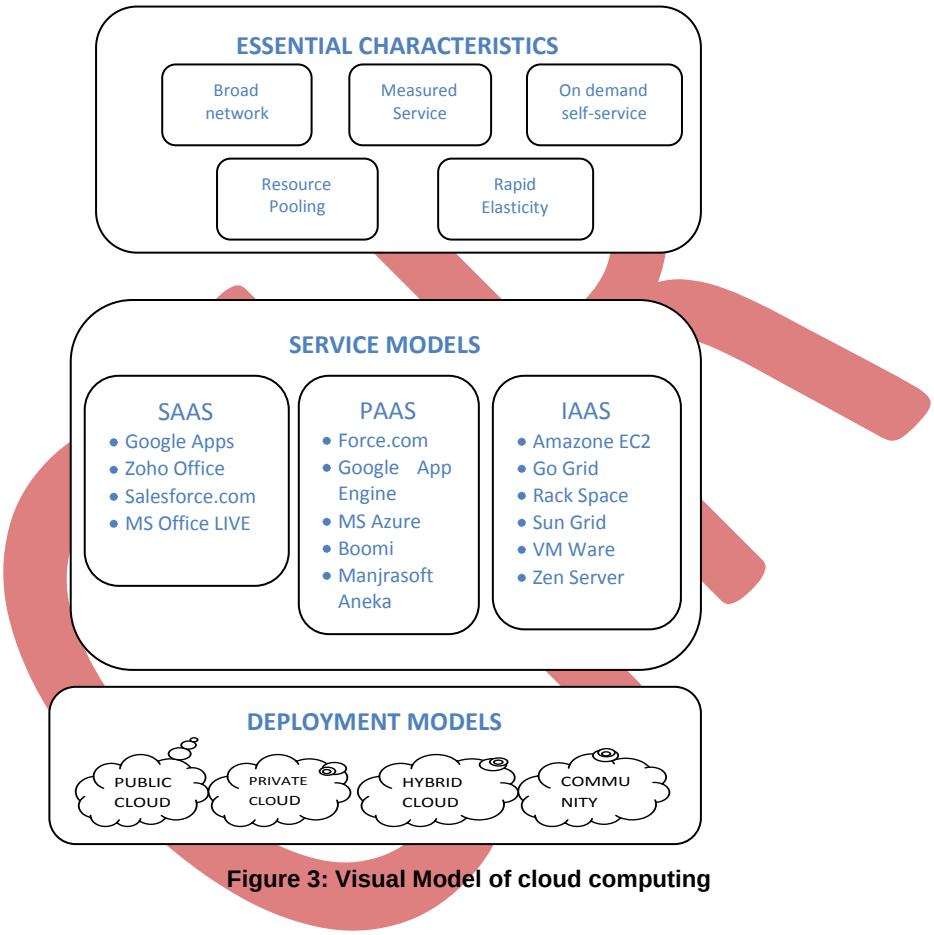

Figure 3: Visual Model of cloud computing

	Infrastructure			
	Managed by	**Owned by**	**Located at**	**Consumed by**
Public	Third Party	Third Party	Off-premise	Untrusted
Private / community	Organization or third party	Organization or third party	Off-premise or on-premise	Trusted
Hybrid	Both Organization & third party	Both Organization & third party	Both Off-premise & on-premise	Trusted & Untrusted

Table 1

The five essential characteristics exhibited by Cloud Computing make it different from traditional IT approaches.

1. **Broad network Access-** Cloud computing data and services are available through network, providing the cloud customers more agile and flexible service oriented architecture which can be accessed through standard APIs, thus promoting the use by variety of heterogeneous platforms (mobile phones, PDAs etc).

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2. **Measured Service-** the cloud approach allows optimized sharing of resources with the applications being capable of migrating from one server to another following virtualization technique. It provides services on subscription basis in pay-as-you-go model. Users have access to more compute power and to new applications at alluring prices. Customers do not own the physical infrastructure but they consume resources as a service and have to pay only for resources that they use. Thus the CAPEX on hardware and software deployment is converted into OPEX.
3. **On-demand Self-service-** The customers of cloud computing are capable of self-management or perform autonomic computing, without having to interact with the service provider nor even they are required to maintain the resources involved for their usage.
4. **Resource Pooling-**Virtualization technology allows cloud resources being shared and utilized to their maximum. Multiple customers pool among service provider's computing resources using a multi-tenant model. Moreover, the customers of cloud need not to worry about the location of resources as long as they have access to internet. This is called "location independence" of cloud resources. The **multi-tenancy** architecture of cloud computing allows sharing of infrastructure, data, applications, services etc among many different customers (may be they are from different organizations) while ensuring scalability, isolation, security, management, billing policies, service level agreements(SLAs).Figure 4 shows private cloud of ABC company with three business units each with different policy bounds on shared infrastructure.

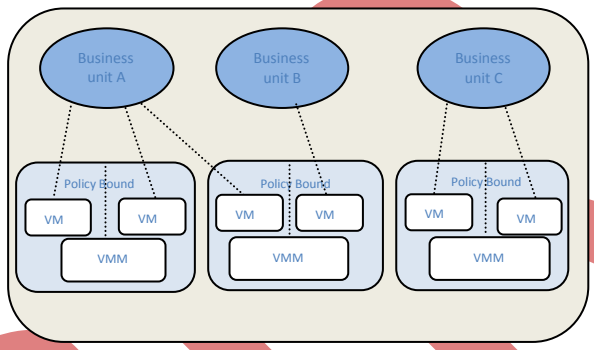

Figure 4

VM- Virtual Machine
VMM-Virtual Machine memory
Thus sharing of resources following multi-tenancy architecture allows for centralization of infrastructure where cost is less, increased Peak-Load capacity, utilization and efficiency.

5. **Rapid Elasticity and scalability-** the cloud computing service providers are focused on service delivery in flexible manner. As per the consumer's requirement, the capabilities can be rapidly and elastically scaled out and scaled in. The capabilities available for consumer as unlimited and are delivered on-demand seamlessly. It's the ability of cloud computing to add or remove resources at fine grain by closely matching the available resources with the workload requirement.

Few concepts are new in cloud computing from hardware provisioning and pricing point of view:

1. *Demand is unpredictable*-Appearance of infinite computing resources, available on demand in real time such that cloud users have no plans in advance about the extent of resources would be required in future.[3]
2. *Demand varies with time*- Enterprises can start their business from small scale and enhance further are per their needs increase.
3. *CAPEX to OPEX*- The cloud computing ability to pay for use of computing resources on short-term basis and release them when resources(machines and storage) are not required anymore. As the result, the enterprises can more concentrate on core business activities without worrying about the expense on infrastructure.

4.Cloud Computing Vs Other forms of utility Computing

Cloud Computing and utility computing are often confused as being the same. Some researchers consider utility computing as the part of cloud computing.

Cloud computing is not same as Grid Computing- Grid Computing is a collection of heterogeneous resources from multiple administrative domains that apply to solve a common problem. It is a form of distributed and parallel computing where a virtual computer consists of cluster of networked, loosely coupled computers which work in concert to perform a large task.

Cloud computing is not same as utility computing- Utility computing is a package of computing resources as a metered service, similar to traditional Utilities like water supply, electricity, internet facility etc. Depending on the level of abstraction and level of management of resources, various computing utilities are distinguished and further metering the service as per utilization.

Cloud Computing IAAS is considered as combination of Grid Computing and Utility Computing. Figure 5. In cloud computing, the resources are allocated and managed automatically without direct intervention of service provider. Here, any application needs three models- model of computation, model of storage and model of communication.

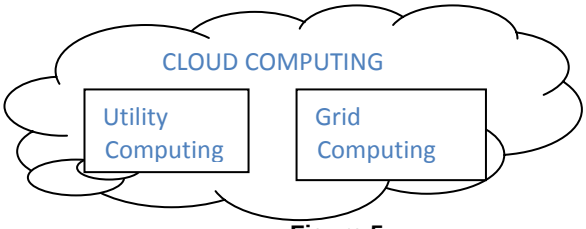

Figure 5

The three models are provided though virtualization along with the capability of handling the elastic requests in real time.
Cloud computing is similar to client-server computing- Since it distinguishes between service provider and service user.

5. A CLOUD COMPUTING SCENARIO- EXAMPLE

Suppose "ELIMIA" is a software development which develops programs to handle large pool of medical images of patients suffering from various heart and neural disorders. These images are sensitive and should not be shared with others, so must remain private and confidential. ELIMIA performs many different image processing techniques (image segmentation, Image Registration, Image Retargeting, Image Summarization, filtering etc) on stored images. These techniques are developed in-house, on site premises of ELIMIA i.e. on it private cloud but uses platform as a service (PAAS) of cloud A service provider to develop its applications. The actual processing of images are outsources to public cloud (say A). This cloud A has many application servers which the located at remote sites (say site A, site B, site C). These servers are bagged with ELIMIA's image processing softwares. The scenario is as follows (Figure 6):
IMAGE PROCESSING ***A***-The ELIMIA's image segmentation, Image Registration softwares are located on an application server of public cloud A located at remote site (say A).
IMAGE PROCESSING ***B***- Additional Image Processing software like Image retargeting, Image Filtering are stored on another remote server at location B
IMAGE PROCESSING ***C-*** Another server at site C of public cloud A is hired to perform remaining tasks of processing the images- Image Summarization, Image Searching.

Multiple servers are used to distribute the processing load to bring up the faster results. ELIMIA uses the hybrid model by retaining the sensitive research activities to ELIMIA's private cloud to develop and enhance the image processing softwares and data mining algorithms.

Each application server performs the processing tasks using its local disk (like DISK A of application server A). These processed images are temporarily stored on the server's local disks. The resulted images are archived by the cloud A on additional disks 1, 2,3,4,5 located at another remote location (say Z). These archives are managed and updated by the cloud's own *archive infrastructure division*.
Thus, ELIMIA consumes three services of Cloud A, 1. Platform-as-a-service (PAAS) - ELIMIA built and deploy their image processing softwares on the Cloud provider's application development platforms as required.
2. In Application as a service(AAAS), consumers uses software services provided by cloud service providers like email, inventory, payroll, invoice generation etc. In this ELIMIA uses various image processing softwares on cloud A service provider remote server sites.
3. Infrastructure as a service (IAAS of cloud provider provides disk storage, computing power via Cloud A's virtual environment

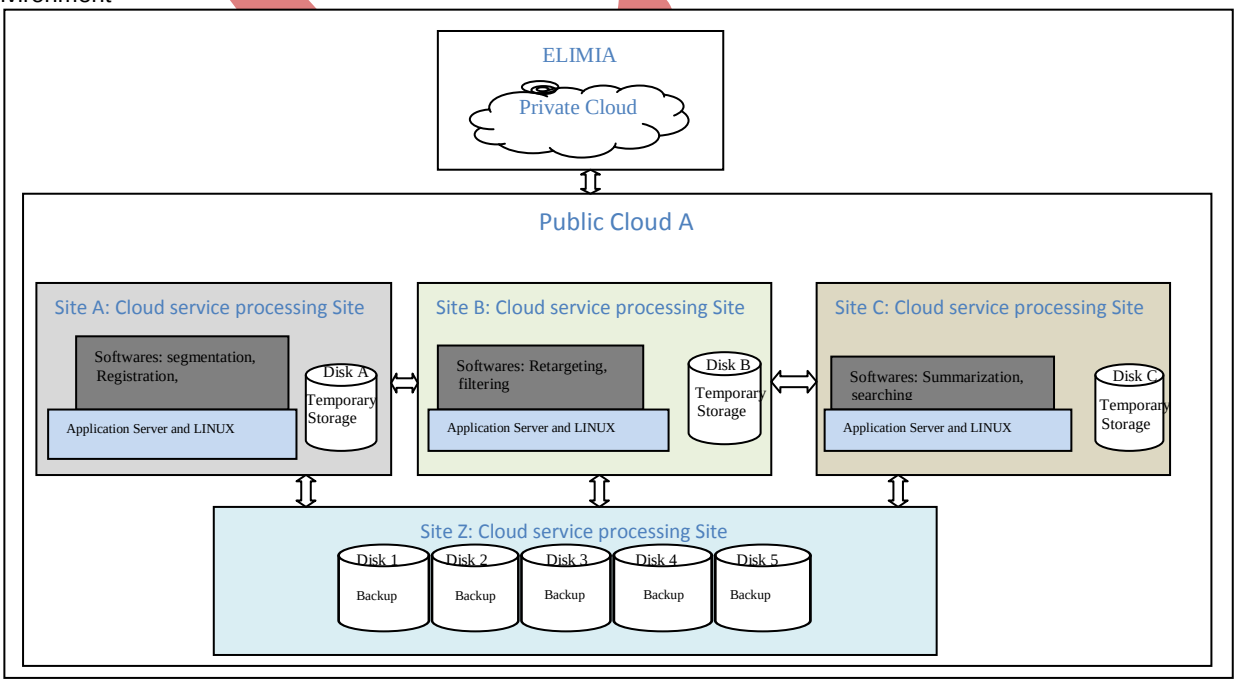

Figure 6: Cloud Computing scenario of Hybrid Cloud (with private cloud and public cloud A) for ELIMIA

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6. Why Cloud Computing?

A wide number of benefits are harnessed from cloud computing such that many business/ enterprises are adopting this new paradigm of computing as utility.

Better performance- organizations strive for same or better performance. Services like SAAS are installed on user computers as these are their own computer's softwares.

Faster and easier- Enterprises are capable to run their applications faster with ease of management.

Flexibility- requests are handled in flexible manner such that resource like servers, storage, and networking can be added and removed as per the requirements. This elasticity in requests is sometimes unpredictable in business. Cloud computing increases the ability to re-provision resources rapidly. Application programming interfaces (APIs) are used to access the cloud services and these are similar to the user interfaces for interaction between humans and computers.

Economical- Computing as utility has made it possible to convert capital expenditure (CAPEX) into operational expenditure (OPEX). To establish a new business enterprise, there is no need to worry about expenditure on infrastructure resources like machines, storage, networks etc as they are made well available through cloud computing. As a result core business activities are more concentrated. Cloud computing ensures better return on investment.

Scalability and elasticity- In cloud computing resources are provisioned to the customers as per the need on self-service basis and as a metered service. The business requirements do not remain fixed but are variable in nature, for example, during peak hours, more number of machines is required while for the remaining time many machines remain idle. Cloud computing ensures to handle such changing demands in real time.

Reliability- Cloud provides redundant sites to access resources such that the failure of one but the availability of other makes them reliable.

Location Independence-user can access the resources without worrying about the location where they reside, who is providing the service and how the service is provided.

Better Empowerment- In cloud computing, the power is shifted to consumers so they can better control the provisioning of the required resources as per their need. The level of control depends upon the type of service invoked by the cloud provider as per the requirement of the customers.

Convenient and on-demand access- The pool of resources are shared among multiple users without requiring the details of the underlying technologies with minimum management efforts and time to gain knowledge on resources.

A gateway to handle disasters- Loss of data, storage/disk crash, and natural disasters may result a big loss to software enterprise. Cloud computing provides the solution by having the copy of customers' data to restore the service which was disrupted due to system breakdown.

Increased security at much lesser cost- As data is centralized, private clouds provide better security over public clouds.

7. Conclusion

Cloud computing is very promising technology that helps companies reducing operating costs while increasing efficiency. In this paper, we presented this new era of technology along with different models on basis of services and deployment. An effort is made to make the concept more versatile through an example. The set of benefits presented has increased the scale of cloud computing as compare to other forms of computing specifically for business applications.

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