The Structure of Cloud Engineering

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ABSTRACT
Cloud computing is innovative model in which the information is permanently stored on the servers and manages the different resources for the requested users to provide on-demand services. In order to create the more useable and economic value based cloud computing, the principals, goals and structure of the cloud engineering is vital important. Cloud engineering is an interdisciplinary field of engineering that focus on cloud services. To understand the structure of cloud engineering, four components are given in this paper such as Base; Tools and Techniques; cloud development life cycle; and Management. Base component provides knowledge about various principles, methods and taxonomy of the cloud computing. Tools and Techniques component sets up and defines the various tools, techniques, utilities and libraries used for the implementation. The cloud development life cycle component is the iterated life cycle model for development and delivery of cloud. The Management of cloud computing solution is done from multiple prospective such as design and run time cloud management; configuration, operational, asset and risk management. These components give complete set of knowledge and are discussed one by one in the paper.

General Terms
Cloud Computing

Keywords
Cloud, Cloud service, Cloud engineering, Cloud development life cycle

1. INTRODUCTION
In the starting of era of electronic computer, the available programming and software development techniques were programming-centered and not effective. There was need of some scientific and systematic approach for software development. This situation leads to origin of “software engineering” term. But now days most organization must continue to use its local resources to operate its daily systems and to store its data but these organization don’t use their resource and service efficiently and most of time they remain ideal. This leads to technology where one organization shares its service, resource and store its data on another organization server’s known as cloud technique. So, whenever capacity or service is required at short notice it can be accessed by using linked server capacity by paying some considerable fee for such facilities. Here comes the need and role of cloud engineering. Cloud engineering is the study and applied research of the application of the engineering to “cloud”.

This section gives the brief knowledge of basic terms used in the cloud technology such as cloud, cloud computing and cloud services. A new engineering discipline “cloud engineering” is introduced and explored various aspects related to cloud engineering such as definition, advantages and focus in section-2. In the section-3, the structure of cloud engineering is explored in details.

1.1 Cloud
Clouds are a large pool of easily usable and accessible virtualized resources such as hardware, development platform and services. Cloud is an internetwork of different types of server which share resources. A very simple view of cloud network is shown in figure-1.

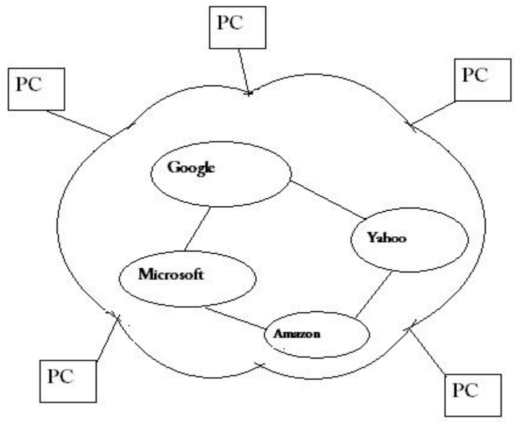

Fig 1: cloud network

A cloud may be public, private, community or hybrid type and managed by the organizations or a third-party. When a cloud is made available in a pay-per-use manner to the public and service being sold as Utility Computing, it is known as Public Cloud. The Private Cloud refers to internal datacenters of an organization that are not made available to the public. The community cloud is a cloud infrastructure that is shared by several organizations and supports a specific community that has shared concerns around mission, policy and compliance considerations [1]. The hybrid cloud is formed by combining the private and public cloud that represents a unique entity.

1.2 Cloud computing
Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort [2]. This paradigm relies on a number of existing technologies such

as internet, virtualization resource, grid computing, and web services. Thus, Cloud Computing is the combination of "software as a service" and utility computing. The aim of the cloud computing is to provide scalable and inexpensive on-demand computing infrastructures with good quality of service levels [3] [4].

Cloud computing has been identified as emerging computing paradigm for delivering computing service for the upcoming decades and receiving enormous attention in the industry due to result of the current economic crisis, business drove promises and expectations such as lower upfront IT costs, opportunity to create and market a new business model [5]. A coherent methodology, which could support companies to embrace the Cloud, is still lacking. That has held back progress both on provider and on consumer side. This leads to presented innovative approach that has the potential to create transparency for the promising IT paradigm of Cloud Computing.

1.3 Cloud services

The cloud computing is emerging as a model that use "everything as a service" and which in turn provided as cloud services. Virtualized physical resource, virtualized infrastructure, virtualized middleware platforms and business applications are being provided and consumed as service in the cloud. For example, a business solution model is either being built by using cloud service or being provided as a cloud service. The cloud service has stack of services which is arranged from top to bottom on the three layers that are, Hardware, system and application layer as depicted in figure-2.

Each component in this stack provides different types of service to cloud. These cloud computing services has much better than the traditional service provisions in context of reduced upfront investment, expected performance, high availability, infinite scalability and tremendous fault tolerance capability. In terms of their provisions, the cloud services are divided into six categories, which are Infrastructure as a service (Iaas), Network as a service (Naas), Platform as a service (Paas), Database as a Service (Daas), Identity and policy management as a service (IPMaas), and software as a service (Saas) [6].

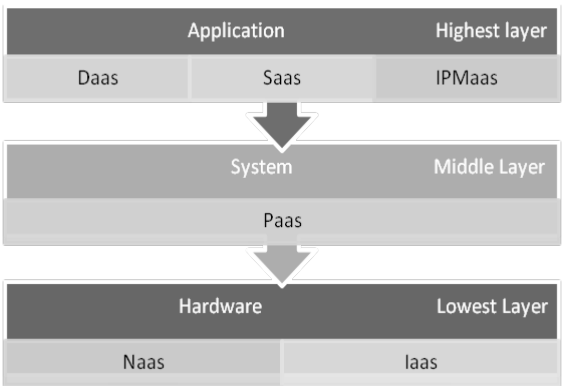

Fig 2: Layered Structure of cloud services

This layered structure is similar to structure of single computer. Each layer of the structure can be provided as the service for public use. At the hardware level, hardware of cloud computing system is composed of several commodity of personnel computer of servers. This structure has adequate capacity in each component to share for public use. Similarly, in the system level, the service focuses on the platform provision for users to run their own application. For the application level, it is the most prosperous one due to the large amount of service provided fill in this level [6]. Below Table1 shows the name of the service which is listed from the low level (top) to high level (bottom), the function belongs to that service and several top cloud vendor organization.

Table 1: Service, their function and vendor organizations

Services	Function	Vendor
Iaas	Provides Hardware components	Amazon, Google, window, IBM
Naas	Internet & mobile Services	Verizon, Vodafone, Telstra, at&t
Paas	Provides OS & System Software	Gogrid, force, amazon, Google
Daas	Provide and manage set of Data	Datadirect, Strikeiron
IPMaas	Manage users' identity & service policy	Pingidentity, Tricipher, IBM
Saas	Application software	CISCO, Microsoft, flicker, workday

Cloud service is application running in the cloud and accessed through the internet or intranet. Cloud computing allows services providers to develop, deploy and run application that can easily grow in capacity, work rapidly and never fail.

2. CLOUD ENGINEERING

Now days most organization must continue to use its local resources to operate its daily systems and to store its data but these organization don't use their resource and service efficiently and most of time they remain ideal. This leads to technology where one organization shares its service, resource and store its data on another organization server's So, whenever capacity or service is required at short notice it can be accessed by using linked server capacity by paying some considerable fee for such facilities. There is no need for advance planning, budgeting, procurement, training, housing and administration costs [7]. Cloud engineering allows the organization to bypass these external organizations and their often limiting requirements and stipulations. Here comes the need and role of cloud engineering. Cloud engineering allows for access to storage power and capacity on an "as needed" basis.

Now it is right time in this paper to define the term "Cloud engineering". Sometimes the term "cloud engineering" is also known as "Cloud service engineering" due to the cloud engineering is an interdisciplinary field of engineering that focus on cloud services such as Saas, Paas, Iaas, Daas, Naas, IPMaas. Cloud Service Engineering is a discipline that combines business and technology thinking for purposes of engineering cloud services. Cloud engineering is the study and applied research of the application of the engineering to cloud. Cloud engineering is the evolving discipline to facilities the adoption, strategization, operationalization, industrialization, standardization, productization, commoditization and governance of cloud solution leading towards a cloud Ecosystem [8].

The term "cloud engineering" with reference to cloud computing had been sparsely used in discussion and presentation from the mid of 2000's. The concept of Cloud engineering was officially introduced in April 2009. A discussion about whether it is convergence or divergence of traditional IT related engineering discipline initiates interest and debates in the first IEEE cloud conference in 2009. Various aspects and terms of the cloud engineering have been extensively covered in a number of industry events and conferences. Concept and three new aspects of the cloud engineering are proposed by the Stefan tai in [9].

The biggest benefit of using cloud engineering is that it helps in reducing the average engineering efforts, cost and time to create, deploy and maintain a cloud computing solution. It also minimizes the risk and average number of defects per cloud solution. By using the cloud engineering discipline, an organization can improve the scalability of business model in terms of solution and markets and allows the organization to bypass these external organizations and their often limiting requirements and stipulations. Furthermore, cloud engineering features "virtualization," employing a number of different virtual servers and representing a sophisticated way of scaling capacity.

2.1 Characteristics of Cloud engineering

The tremendous potential of Clouds lies in making effective use of Clouds as a distributed computing model in a business model and that therefore the development of Cloud services must incorporate valuation in terms of business criteria. Compositions and configurations of select cloud services for business purposes constitute a service-oriented business value network (SVN) [9].

Hence, Cloud Engineering in particular addresses the following three characteristics:

1. Everything in a cloud is considered as a service.
2. Each Service has some costs and value.
3. Services constitute Value Networks.

There are very large numbers of things that are either consumed or provided on-demand in the cloud is known as service of cloud. Services in the cloud include physical resources, compute power, storage capacity, bandwidth, programming environment, execution environments, office to social networking applications and human intelligence. Let us briefly introduce the services with respect to cloud engineering. Software as a service of cloud engineering allows for simple access to software power and flexibility without the need to worry about ongoing maintenance and licensing. Certain platforms can be accessed through cloud engineering using specific software applications are available as needed. Data storage is a handled very differently through cloud engineering due to data is replicated across different cloud environments for optimum benefit and security [7].

User of cloud services will have to pay some value or cost for their actual service usage. The development of applications as "everything-as-a-service" and where each service has a cost and value, model which results in service-oriented business value networks (SVNs) [9]. Now days, many Cloud Computing environments are of a hybrid nature, integrating private and public resources and composing value-add services.

2.2. Focus of cloud engineering

Focus of the cloud engineering is on the six traditional IT related engineering discipline such as the software engineering, system engineering, web engineering, platform engineering, reverse engineering and service engineering. These engineering disciplines give their methodology and concept for the engineering of a cloud solution. This relation is pictorial depicted in figure-3.

The main focus of cloud engineering is on designing the cloud network, plan the architecture of complex cloud network, integrate the clouds and supervise the development of cloud computing solution.

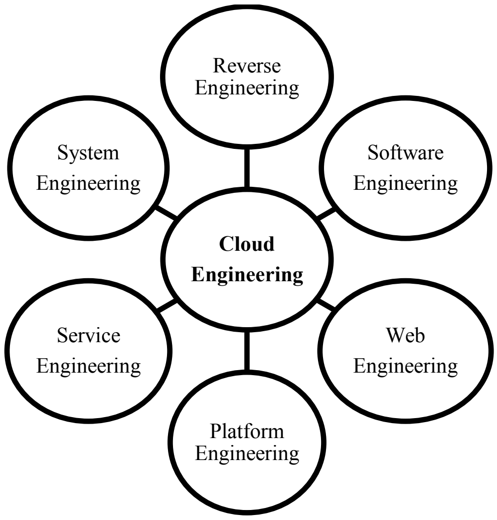

Fig 3: Focus of Cloud engineering

3. CLOUD ENGINEERINMG STRUCTURE

The structure of cloud engineering will provide the complete set of knowledge that provides a rich set of practices guide, disciplined techniques and methods. This structure is very similar to another engineering discipline such as software engineering, web engineering and platform engineering. This structure has four components or element which is Base, Tools & Techniques, Cloud development life cycle and Management (CDLC) is well depicted in figure-4.

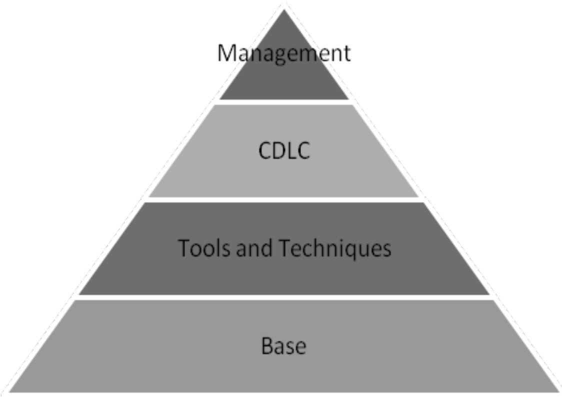

Fig 4: Cloud engineering components

Let us discus the each components of this structure one by one.

3.1 Base

The base component provides the fundamental knowledge and concept about cloud computing problem. This component forms the base for development of good cloud. This component tries to find, understand and then analysis the reasons for why adopting the cloud computing solution of any network problem. It searches the tentative pros such as cost savings, scalability, agility, disaster recovery, device independent, application accessibility, ease of use, large-scale multi-tenancy, and cons from end-user point of view by adopting this network such as security loss fear, privacy loss fear, internet dependency, unavailability of service, difficulty in migration, data loss.
It lists the various principles and rules such as rules for customer servers and applications run in the cloud without modification, end-to-end security principle, integration principle between the corporate data center and cloud environments, support for existing management tools, extensibility to multiple clouds and virtualization environments. It also discusses the methods such as abstraction, automation, elasticity available under this network and choosing the efficient, reliable, cost effective methodology from them, for the implementation of cloud computing solution. It gives the detailed knowledge about the metrics available for cloud computing problem such as model metrics. This component tells the organization structure of cloud i.e. how and what is structure by which, the various servers are connected with each other in a cloud such as functional, matrix, product, horizontal, vertical structure. It also provides complete knowledge about basic building block used in the cloud such as virtualization, workload management, self-service, network access, resource pooling, elasticity and chargeback.

The base of cloud computing is virtualization. Virtualization provides a logical view of computing resources, rather than a physical view and it partitions a single physical server into multiple logical servers. Once the physical server is divided, each logical server can run an operating system and applications independently on it. In the workload management, spin up and down machine resources according to workload so the user only pay for the actual usage. Resource pool is in basic term, a large pool of easily usable and accessible virtualized resources such as hardware, platforms and services. These resources can be dynamically reconfigured to adjust to a variable workload, which help in achieving the optimum resource utilization. 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 SLAs.

Flexibility is the one of the building block used for large enterprises for the ease of deploying a full service set without having to set up base infrastructure to support which is more attractive than cost savings. Cloud computing service internal models are often self-service in nature. In the past, customer had to partner with IT to develop the application, provide an execution platform, and run it. Now, much like Amazon and IT departments define use policies for automated platform and infrastructure services with line-of-business-owners developing applications on their own to meet those requirements.

One of the issues in cloud computing is chargeback which means pricing consumed resources on a granular basis. Amazon posts its prices publicly for all which tells how much for compute, how much per gigabyte sent over the network, etc. Chargeback in the cloud computing arena is the same kind of highly granular pricing associated with use of internal resources.

It gives the practice guide for cloud realization such as defining and measuring the cloud's service offerings, creating dynamic workload and resource management. This also helps in implement the strong visibility and reporting procedures. Figure 5 depicted the some functions performed by the Base component.

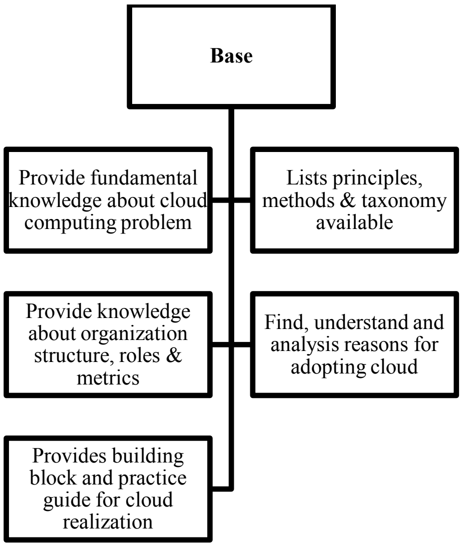

Fig 5: Base component functions

3.2 Tools and Techniques

This component sets up and defines the various techniques, utilities and libraries such as commercial virtualization, service oriented architecture (SOA), client broadband, sophisticated client algorithms, data storage techniques, data management techniques, programming model techniques, task scheduling techniques, and load balancing technique as depicted in figure 6. These techniques play a significant role in the revolutionary phase of development of the cloud computing solution and based on the practices in the areas of service provisioning and solution design.

Virtualized technique is the technique that helps the user get service anywhere through any kind of terminal from a cloud. The services which it required come from cloud instead of visible server. The virtualization technique works on the handling of how the image of the operating system, middleware, and application procreated and allocated to part of the physical server stack away [10]. Virtualization in cloud can be of five types such as full, partial, operating system level, para virtualization, hardware assisted virtualization. This technique also provides assistance in reuse licenses of operating system, middleware and software applications.

Service oriented architecture is that software, which assists in addressing multi component, reusability, extensibility and flexibility [10]. It is a powerful technique that allows engineers to dynamically integrate and compose existing service components or services into new cloud services. Several big companies such as Google, Microsoft, and Amazon have the capability of providing services instead of directly selling the software to the user. Those organizations that desire cost cuts through choosing to rent rather than to purchasing surely requires this technique.

Client broadband is required so that client CPU bandwidth support significant client computation. Sophisticated client algorithms are designed for some specifically client and it is implement using HTML, CSS, AJAX, REST. Data storage techniques are designed to provide efficient, reliable access to stored data using large clusters of commodity hardware. In a cloud network, an enormous amount of data is stored and access when required in a very efficient manner. Generally data storage techniques are implemented in kernel part of the operating system or in a user space library.

Data management techniques used for generating, modifying and managing data stored in a cloud. Data may be stored in a sparse, distributed, persistent multidimensional sorted map. Programming model techniques used to support distributed computing on large data sets on clusters of computers. Developers have a wide range of programming models to choose from in creating cloud-based applications such as Amazon's Elastic Compute Cloud (EC2), Google App Engine (GAE) and SaleForce.com.

Load Balancing is a method to distribute the workload across one or more servers, network interfaces, hard drives and other computing resources so that it is equally allocated to computing hardware. The Load Balancing will allow customers to create more robust, scalable, and high availability configurations in the cloud in a matter of seconds. The key idea is to spin up and down machine resources according to workload so the user only pay for the actual usage.

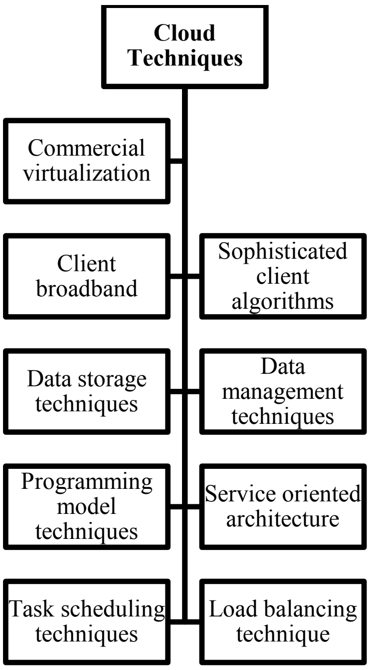

Fig 6: Cloud Techniques

There are two types of available access models: passive listener model and active worker model. Passive listener model uses a synchronous communication pattern where client pushes request to the server and synchronously wait for the processing result. To scale the resource according to the work load, use a monitor service that send NULL client request and use the measured response time to spin up and down the size of the machine resources. On the other hand, Active worker model uses a asynchronous communication patterns where the client put the request to a queue, which will be periodically polled by the server. After queuing the request, the client will do some other work and come back later to pick up the result. The client can also provide a callback address where the server can push the result into after the processing is done [11].

Cloud tools are a set of tools that enable a developer to build, deploy, manages and testing an application on cloud without having to download any application or software to their desktop. Dropbox, zoho, evernote, mobileme, hootsuite, instagram and rackspace are the current available private cloud tools in the market.

3.3 Cloud Development life cycle (CDLC)

Like other engineering discipline, the cloud engineering discipline also have own life cycle model for the systematic development of the cloud. The CDLC is the iterated life cycle model for development, deployment and delivery of cloud. It is the simplest and flexible process model, which states that the phases are organized in a linear order and processed in isolated manner. This paper discusses each phase of CDLC one by one. In this model, a cloud development begins with "understand requirement and analysis" phase. Upon successfully demonstrating the requirement, the "Architect" phase begins. The "Quality Assurance and verification" phase starts after the "Implementation and Integration" is complete, and "Monitor, Migrate & Audit" begins after the "Deploy, Testing & Improvement" is complete. The figure-7 depicted the linear order of the various activities of CDLC to obtain desire cloud.

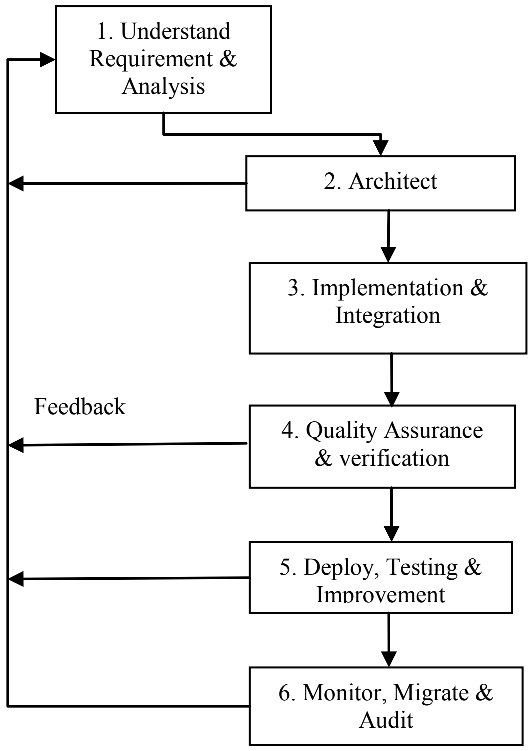

Fig 7: The CDLC

3.3.1 Phases of CDLC

The "Understand Requirement and analysis" phase of this life cycle evaluates and understands the needs of end user. This is done by knowing the complaints of exiting user, network solution, management and customers of the current system. When this complaint is seriously studied, they highlight new requirements and deficiencies. It searches for the tentative cloud computing solution and define cloud computing strategy. It also searches for the various benefits that come by adopting the cloud network solution.

“Architect” phase prepares the plan about development and implementation map of cloud known as cloud architecture blue print, implementation plan and transition plan etc. the cloud blueprint is a uniform abstract description of an XaaS offering. In general, existing XaaS offerings fall into one of these types: complete and monolithic, complete and customizable, or incomplete. The three types of blueprints available in the market place can be differentiating depends on the types of their XaaS offerings. Third phase of CDLC is the “Implementation and Integration”. This phase is related to actual construction of the cloud computing solution and then integration of various clouds. It deploys various resources and applications to the cloud and gives the cloud training to end user so that user can easily adopt the new network solution. This phase is less complex as compared to “Architect” phase.

“Quality assurance and verification” phase is related to ensure the quality of cloud network by audit the cloud and, verify the performance, availability, elasticity of cloud network at the service level against specification and requirement. It also provides assurance to relevant stakeholders that privacy requirements are met.

In the “Deploy, Testing and Improvement” phase various platform service provider organizations significant reduces the deployment cost of the application by pre-building and pre-configuring a stack of application infrastructure. Stax, heroku, engine yard, force.com are the several available cloud deployment providers in the market. Testing test the various functionality of the servers and their services, that comes between the cloud network and end user. Testing evaluates the service availability on scalability, uptime etc. it also checks the computing capacity and adapt quickly to dynamic loads, and their service or application will take advantages of cloud infrastructure. It also provides adequate training and mentorship-providing a broad base of fundamental security, data privacy and risk management knowledge.

“Monitor, Migrate and Audit” phase discusses the total cost and value that a user bears while evolving and moving to cloud approaches from traditional service-oriented environments and also integration with legacy/existing systems. Microsoft's VP of Online Services, a well executed cloud migration tool available by Microsoft. A new transition plan is prepared for migration that considers the hardware, software and network necessary requirement for the migration of the current application in business and technical environment to cloud computing network. Among these phases, the second, fourth, fifth and sixth phase has the feedback process to first phase. These phases of CDLC are yet to be explored and require many refinements.

3.4 Management

To take full benefits of cloud computing network, need to choose the right management solution. The Management of cloud computing service is done from two different prospective of design time and run time cloud management. The run time management space is important as compared to design time due to a service provider needs to have some form of gateway that requests are channeled through to provide centralized capabilities like security, billing, metering, traffic shaping, etc. The design-time management is only concerned with service design and development. The run time management of cloud deployment has transparent access to and control over all aspects of a cloud deployment including the underlying scripts, input parameters, real-time monitoring, and automatic or manual response.

It also performs the function of configuration management, operational management, asset management, risk management, storage pool management, centralized monitoring and resource usage tracking. Configuration management is the management of prebuilt, dynamic, multi cloud server template. It also discovers and stores configuration information for cloud resources and allows administrators to have clear visibility into what they have. Operational management is the management of cloud computing solution so that it can operate its service when it is required. Risk management is done due to minimize the risk of unavailability of cloud service and risk of failure of server.

Storage pooling management is a way to consolidate and manage all of organization’s physical and virtualization storage resources in one place and to track, allocate those resources as needed. Storage pooling is a key requirement needed for delivering on the cloud computing model. Earlier, pooling has been used successfully in primary storage environments but now pooling is done on capacity-optimized secondary storage area. Centralized monitoring and resource usage track is done for the proper monitoring of the total resource consumed and remained by the service in a cloud.

Various policies are built in this component such as security policy, privacy policy, compliance policy, service level agreement, promoting trade policy. Many resources and templates are available to aid in the development of information security policies and standards [12]. Security policy is an important issue in the cloud due to using of an external cloud service provider for service results in a loss of data security. The wide quality range of corporate IT security, trusting information assets to a recognized cloud service provider could very easily increase the security of those assets. A cloud computing security team should first identify the information security and business requirements unique to cloud computing, SaaS, and collaborative software application security [12]. Clouds could possibly increase security for the majority of their users.

Privacy policy of cloud hides the sensitive information such as personally identifiable information, Information on religion, race, health, union membership, sexual orientation, job performance, financial information, biometric information or any other information that may be considered sensitive and Information uniquely traceable to a user device. Policies should be developed, documented, and implemented, along with documentation for supporting standards and guidelines. To maintain relevancy, these policies, standards, and guidelines should be reviewed at regular intervals or when significant changes occur in the business or IT environment [12].

Management component developed and maintain standard such as distributed management task force (DMTF), European telecommunication standard institute (ETSI), national institute of standard and technology (NIST), Open grid forum (OGF) [13]. Standards in terms of security management are also developed such as Information Technology Infrastructure Library (ITIL), ISO/IEC 27001/27002 and Open Virtualization Format (OVF).

This component manages the cloud computing network so that it conveniently access the private, public, community and hybrid cloud's resource pool from one dashboard where end-user can provision and launch servers in minutes, as well as manage and automate them. The main objective of the management component is to deployment, automation, and monitoring, auditing and cost control of the cloud computing service. It also allocates and de-allocate the various physical and virtualized data and service to end user when it is required by them. Management component manage the rapid growth and relationship between various physical and virtualized resources across multiple environments. Figure 8 depicted some objective of the management component.

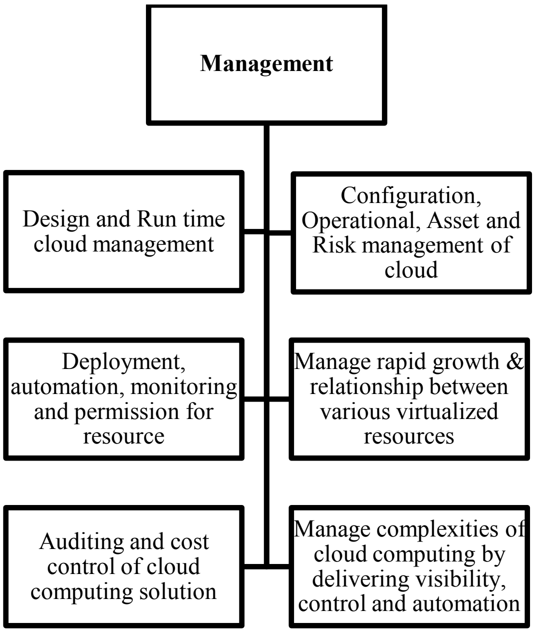

Fig 8: Management component objectives

It also monitors the health and problem determination across a physical and virtualized infrastructure. This component manages the complexities of cloud computing by delivering visibility, control and automation across dynamic, virtualized environment.

4. CONCLUSION AND FUTURE WORK

The cloud engineering is emerging as a new engineering discipline for the development of cloud computing solution. Cloud engineering in its own domain requires extensive research on specific areas and dealing with unique challenges such as multi-tenancy, development support for cloud pattern, cloud business continuity services. Cloud engineering is relative a new paradigm so it has lots of potential for future work and research. As a component of cloud engineering structure, cloud development life cycle (CDLC) is emerging as a new development life cycle model like the System development life cycle model (SDLC). The structure of the cloud engineering and phases of Cloud Development Life Cycle (CDLC) is yet to be explored.

5. REFERENCES

[1] SearchVirtualDataCenter.co.UK, available at http://searchvirtualdatacentre.techtarget.co.uk/news/1510117/Community-cloud-Benefits-and-drawbacks

[2] Michael glas and paul Andres. Oct 2010. An Oracle white paper in enterprise architecture- achieving the cloud computing vision. CA-U.S.A.

[3] Harjit Singh Lamba and Gurdev Singh. July 2011 Cloud Computing-Future Framework for e-management of NGO's. IJoAT ISSN 0976-4860. Vol 2 No 3. Department Of Computer Science, Eternal University, Baru Sahib, HP, India.

[4] Dr. Gurdev Singh, Shanu Sood, Amit Sharma. June 2011. CM- Measurement Facets for Cloud Performance. IJCA. Volume 23 No.3. Lecturer, Computer science & Engineering, Eternal University, Baru Sahib (India).

[5] Joachim Schaper. 2010. Cloud Services. 4th IEEE International Conference on DEST, Germany.

[6] Minqi Zhou, Rong Zhang, Dadan Zeng, Weining Qian. Services in the Cloud Computing Era: A Survey. Software Engineering Institute, East China Normal University, Shanghai, China. NIICT, Kyoto, Japan.

[7] Applied Cloud Engineering (ACE), available at www.appliedcloudengineering.com

[8] FZI Cloud Computing Wiki, www.cloudwiki.fzi.de

[9] Stefan Tai, KIT and FZI Karlsruhe, 2009. Cloud Service Engineering. 18th IEEE International Workshops on Enabling Technologies, Germany.

[10] Cloud Computing, available at http://www.cloudcomputingtechnology.org

[11] ARCHITECT ZONE, available at http://architects.dzone.com/news/cloud-computing-patterns

[12] Krešimir Popović, Željko Hocenski. May 24-28, 2010. Cloud computing security issues and challenges. Institute of Automation and Process Computing, Kneza Trpimira, Opatija, Croatia, MIPRO.