Cloud Computing Architecture: A Survey

Abstract— ***Now a day's Cloud computing is a complex and very rapidly evolving and emerging area that affects IT infrastructure, network services, data management and storage resources and applications. And because of this nature it is drawing much attention from academia and industry. Many vendors provide Infrastructure as a Service, Software as a Service, and Platform as a Service. Different vendors have implemented different architectures for their SaaS, IaaS and PaaS clouds. In order to give a vision of cloud computing architecture in this paper I present the different architectures that I studied including layered architecture, modelled architecture, reference architecture, virtualization architecture and network architecture.***

Keywords— ***Cloud computing, cloud computing architecture, SaaS, Paas, IaaS.***

I. INTRODUCTION

When the scalable and flexible IT-related capabilities are provided as a service to the external consumers using internet technologies then it is termed as cloud style of computing. Cloud computing is evolved from several concepts like virtualization, distributed application design, grid and enterprise IT management to enable a more flexible approach for deploying and scaling applications.

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Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources like networks, servers, data storage, applications, storage resources and services that can be rapidly provisioned and released with minimal management effort, more flexibly and cost-effectively without requiring cloud users to know the location and other details of the computing infrastructure. So End users can access cloud based applications through web browser, a light weight desktop or mobile app while the business software and data are stored on servers at a remote location. Cloud application providers strive to give the same or better service and performance as if the software programs were installed locally on end-user computers. This way of delivering IT services via the Internet enhances collaboration, agility, scalability, and availability for end users and enterprises. It also describes a broad movement toward the use of wide area networks (WANs), such as the Internet, to enable interaction between information technology service providers of many types and consumers.

Cloud computing exhibits the key characteristics[1] like empowerment of end-users of computing resources, agility improves with users' ability to re-provision technological infrastructure resources, application programming interface (API) accessibility to software that enables machines to interact with cloud software in the same way the user interface facilitates interaction between humans and computers, cost is to be reduced , device and location independence, virtualization technology allows servers and storage devices to be shared and utilization be increased. Multi-tenancy enables sharing of resources and costs across a large pool of users, reliability, scalability and elasticity via dynamic on-demand provisioning of resources, performance, security and maintenance.

Cloud Architectures are designs of software applications that use Internet-accessible on-demand services. Applications built on Cloud Architectures are such that the underlying computing infrastructure is used only when it is needed (i.e. at the time of processing of user request), draw the necessary resources on-demand (like compute servers or storage), perform a specific job, then relinquish the unneeded resources and often dispose them after the job is done. While in operation the application scales up or down elastically based on resource needs. Cloud computing Architectures must also encompass the software and devices that users utilise in order to invoke functions in the cloud, and intermediary functions.

The rest of the paper is organized as follows. Section 2 gives the overview of layered architecture. Section 3 gives the overview of the modelled architecture. Section 4 gives the overview of the reference architecture proposed by DMTF and

NIST. Section 5 gives the overview of virtualization architecture. Section 6 gives the overview of network architecture. Section 7 concludes the paper.

II. Layered Architecture

Cloud computing can describe services being provided at any of the traditional layers from hardware to applications and typically divided into three levels of service offerings[2][3]: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a service (IaaS). These levels support virtualization and management of differing levels of the solution stack. Fig. 1 shows layered architecture of cloud computing.

A. Software as a Service(SaaS)

Software as a service features a complete application offered as a service OnDemand. A single instance of the software runs on the cloud and services multiple end users or client organizations in their own data center. Some SaaS providers run on another cloud provider.'s PaaS or IaaS service offerings. Some of the well known SaaS examples are Oracle CRM OnDemand, Salesforce.com, and Netsuite.

B. Platform as a Service(PaaS)

Platform as a Service (PaaS) is an application development and deployment platform that encapsulates a layer of software and delivers as a service to developers over the Web. It facilitates development and deployment of applications without the cost and complexity of buying and managing the underlying infrastructure, providing all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely available from the Internet. This platform consists of infrastructure software, and typically includes a database, middleware and development tools. A virtualized and clustered grid computing architecture is often the basis for this infrastructure software. Someone using PaaS would see an encapsulated service that is presented to them through an API. For example, Google AppEngine is a PaaS offering where developers write in Python or Java. EngineYard is Ruby on Rails. Sometimes PaaS providers have proprietary languages like force.com from Salesforce.com and Coghead, now owned by SAP.

C. Infrastructure as a Service(IaaS)

Infrastructure as a Service (IaaS) is the delivery of basic hardware (server, switches, routers storage and network), and associated software (operating systems virtualization technology, file system), as a service over the network. Unlike PaaS services, the IaaS provider does very little management other than keep the data center operational and users must deploy and manage the software services themselves--just the way they would in their own data center. Some of the examples of IaaS are Amazon Web Services Elastic Compute Cloud (EC2) and Secure Storage Service (S3).

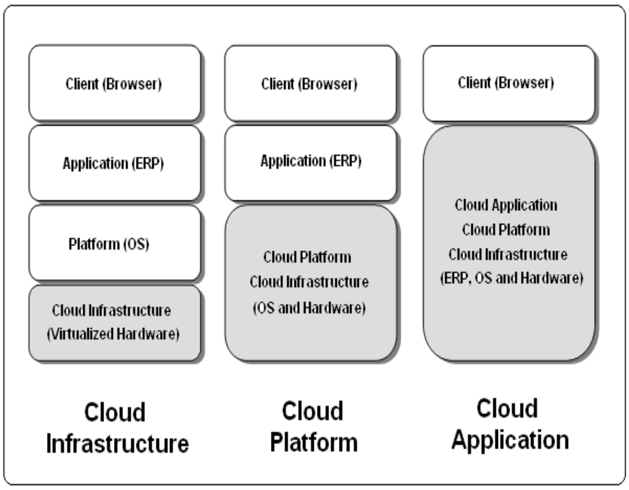

Fig. 1 Layered Architecture

III. Modelled Architecture

When moving from a standard enterprise application deployment model to one based on cloud computing, there are many considerations for cloud computing architects to make. IT organizations can choose to deploy applications on public, private, or hybrid clouds, each of which has its trade-offs. The terms *public*, *private*, and *hybrid* [3] do not dictate location. Fig. 2 shows modelled architecture.

A. Public Cloud

Public clouds are run by third parties, and applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks. Public clouds are most often hosted away from customer premises, and they provide a way to reduce customer risk and cost by providing a flexible, even temporary extension to enterprise infrastructure.

B. Private Cloud

Private clouds are built for the exclusive use of one client, providing the utmost control over data, security, and quality of service. The company owns the infrastructure and has control over how applications are deployed on it. Private clouds may be deployed in an enterprise datacenter, and they also may be deployed at a colocation facility. Private clouds can be built and managed by a company's own IT organization or by a cloud provider.

C. Hybrid Cloud

Hybrid clouds combine both public and private cloud models. They can help to provide on-demand, externally provisioned scale. The ability to augment a private cloud with the resources of a public cloud can be used to maintain service levels in the face of rapid workload fluctuations. A hybrid cloud also can be used to handle planned workload spikes, and to perform periodic tasks that can be deployed easily on a public cloud. Hybrid clouds introduce the complexity of determining how to distribute applications across both a public and private cloud.

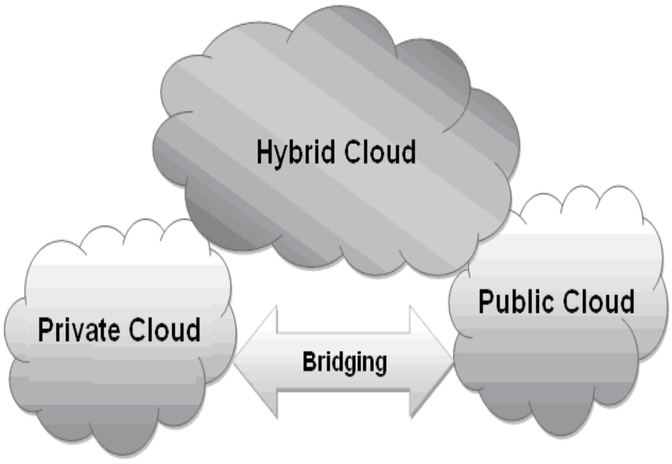

Fig. 2 Modelled Architecture

IV. ENTERPRISE ARCHITECTURE

Cloud services are one of the emerging trends in enterprise services [14]. Enterprise cloud services provide different types of services, for example, Business Process, Application, Platform, Infrastructure, Security and, of course, Integration as a Service. Enterprise cloud service framework is shown in Fig. 3 the enterprise cloud framework at a high level has business services and the mapping of them as part of a private, public, and community or hybrid cloud. Security and other services are layered upon these business services. Governance of enterprise services plays an important role as these services are segregated from the main enterprise. The service layers are to be defined in terms of strategy, designing, deployment, operation and termination.

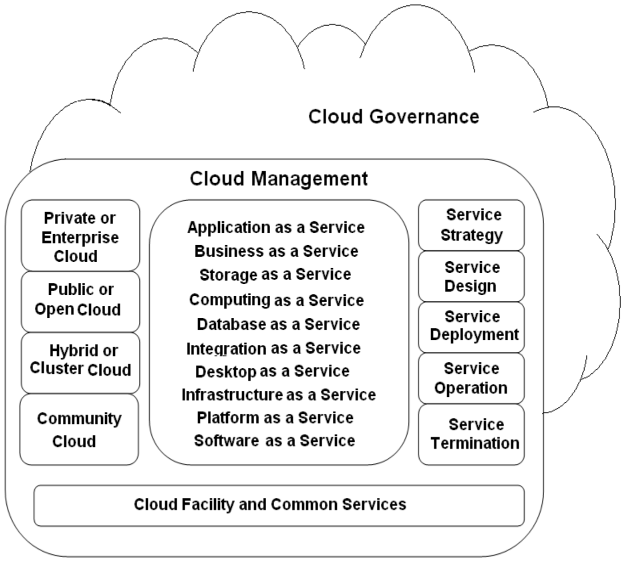

Fig. 3 Enterprise Service Architecture

V. REFERENCE ARCHITECTURE

There are two reference cloud architecture models [4], [5], [6], [7] proposed by two cloud computing standard organizations DMTF and NIST. These are DMTF Reference Architecture and NIST Reference Architecture.

A. DMTF Cloud Reference Architecture

The DMTF cloud architecture consists of three primary actors, or organizations, and a set of interfaces that uniquely describe how the actors interact to meet cloud service objectives. The *cloud service consumer* represents the end user i.e. an organization or an enterprise that subscribes to one or more cloud services. It interacts with the cloud services via user and programming interfaces. The *cloud service provider* delivers services to consumers. The scope of responsibility varies depending on the type of cloud service offering. The *cloud service developer* designs and implements service components, creating services using DMTF service templates, which are then provisioned or installed in the cloud. The DMTF reference architecture includes a provider interface layer, which specifies how the cloud service developer and consumer interact with the cloud service provider. This architecture differentiates between service endpoints that accept messages over a protocol based on some message exchange pattern, the data elements and operations that an interface can support. DMTF profiles represent extensions of the provider interfaces and artifacts, or combinations of them. The profiles provide the means to handle special cases, such as those of interest to a security manager or a contract billing administrator. Fig 4 illustrates high-level interactions between the actors to provide the cloud services in the DMTF framework.

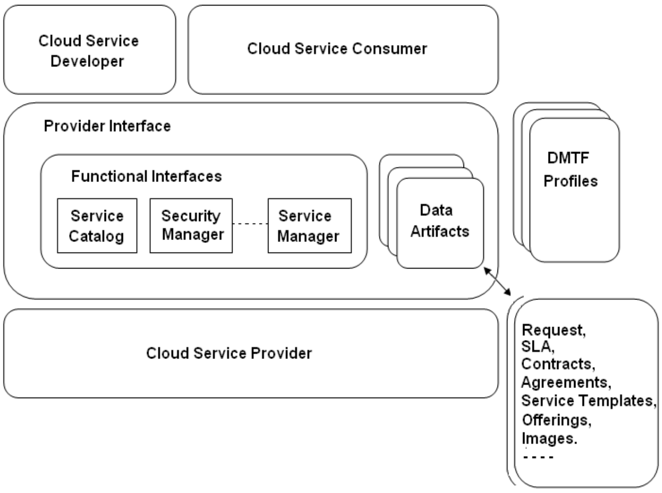

Fig. 4 DMTF Proposed Reference Architecture

B. NIST Reference Architecture

The NIST cloud reference architecture consists of five major actors or organizations and three types of cloud services. Each actor performs a set of assigned tasks and interacts with other actors to provide, maintain, and manage cloud services. The *cloud consumer* represents an individual or organization that can request services from one or more *cloud providers* using a *cloud broker* as an intermediary. The architecture supports three types of consumers consistent with the three types of service: SaaS consumers request applications; PaaS consumers develop, test, deploy, and manage applications hosted in the cloud; and IaaS consumers install, manage, and monitor services. The cloud broker represents an individual or organization that manages the use, performance, and secured delivery of cloud services to consumers. A *cloud carrier* represents an organization that provides an access network to the cloud infrastructure for hardware and storage devices. The cloud provider represents an organization responsible for making a service available to cloud consumers. A cloud provider sets up SLAs with cloud carriers and cloud consumers. The *cloud auditor* represents an individual or organization that performs independent assessments of the cloud provider's services, information systems operations, performance, and security on behalf of the cloud consumer. Fig. 5 illustrates high-level interactions between the major actors in the NIST framework for providing cloud services.

VI. VIRTUALIZATION ARCHITECTURE

Virtualization [11] was first invented and popularized by IBM in the 1960s, to run multiple software contexts on its mainframe computers. Because of server usage concerns it regained popularity in the past decade in data centres. Data centres and web farms consisted of multiple physical servers. A hypervisor[8] is implemented on a server either directly running over the hardware as shown in Fig. 6 called as *Type 1 hypervisor* [9] or running over an *operating system* (OS) as shown in Fig. 7 called as *Type 2 hypervisor* [9]. The hypervisor supports the running of multiple VMs, scheduling of the VMs [12] and providing them a unified and consistent access to the CPU, memory, and I/O resources on the physical machine. A VM typically runs an operating system and applications. The applications are not aware that they are running in a virtualized environment, so they do not need to be changed to run in such an environment. The OS inside the VM may be virtualization aware and require modifications to run over a hypervisor and such a scheme is known as paravirtualization.

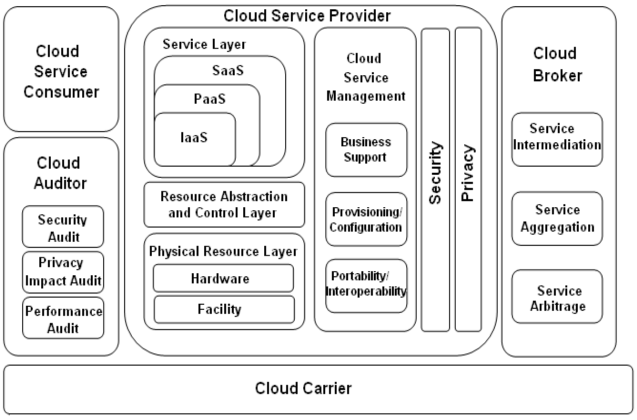

Fig. 5 NIST Proposed Reference Architecture

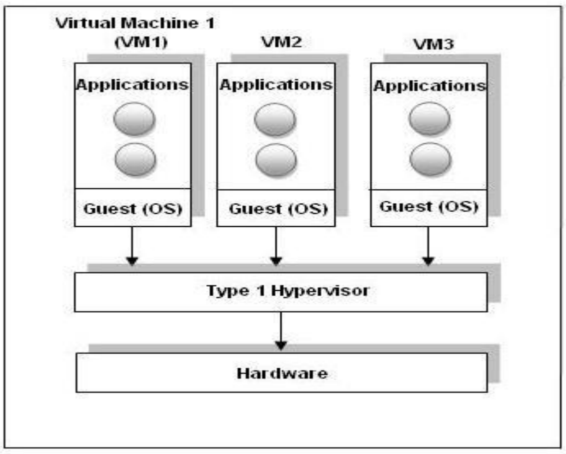

Fig. 6 Type1 Hypervisor

VII. NETWORK ARCHITECTURE

The cloud can be treated as a large data center run by an external entity providing the capability for elasticity, on-demand resources, and per-usage billing. Data-center architecture [10] as shown in Fig. 8 often follows the common three-layer network topology of access, aggregation, and core networks with enabling networking elements like switches and routers. From a functional perspective it adopt a three- tier architecture as shown in Fig. 9 this three-tier functional architecture has a web or *Presentation Tier* on the front end, an *Application Tier* to perform the application and business-processing logic, and finally a *Database Tier* to run the database management system, which is accessed by the Application Tier for its tasks .

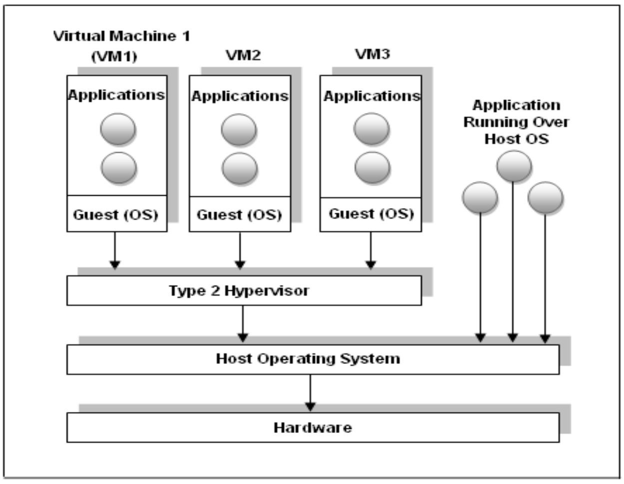

Fig. 7 Type 2 Hypervisor

In the architecture the servers can be connected through a 1-Gbps link to a *Top of Rack* (TOR) switch, which in turn is connected through one or more 10-Gbps links to an aggregation *End of Row* (EOR) switch. The EOR switch is used for inter server connectivity across racks. The aggregation switches themselves are connected to core switches for connectivity outside the data center.

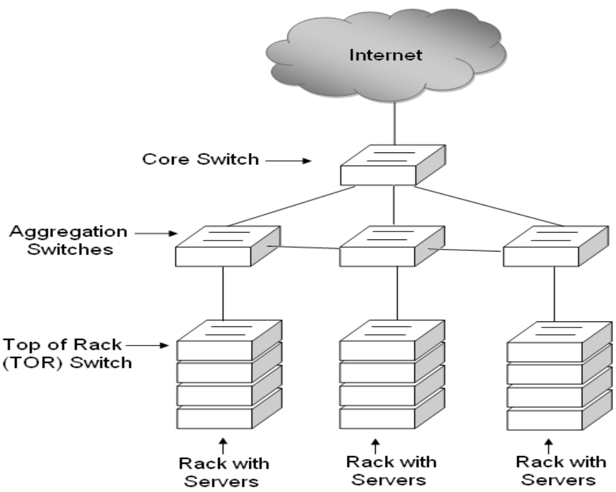

Fig. 8 Data Center Architecture

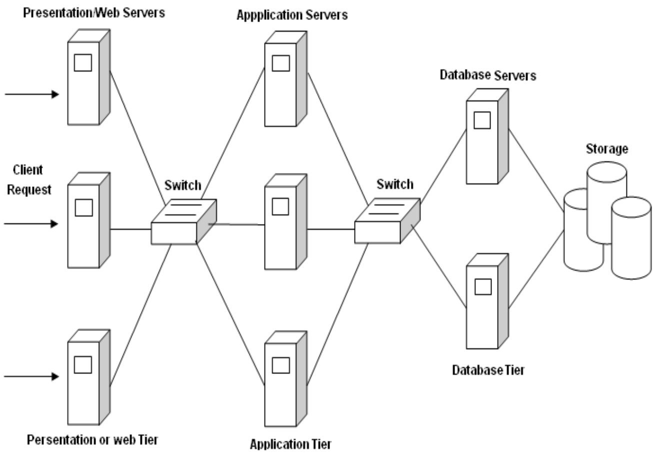

Fig. 9 Three-Tier Architecture

VIII. Conclusions

Cloud computing is getting popular and IT giants such as Google, Amazon, Microsoft, IBM have started their cloud computing infrastructure. However, current cloud implementations are often isolated from other cloud implementations. In this paper, I tried to bind together the multiple variations of the cloud computing architecture by giving overview survey of layered architecture, modelled architecture, reference architecture, virtualization architecture and network architecture.

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