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Research Paper

A fully security included Cloud Computing Architecture

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Abstract

Many developers have designed their own architecture for installing the cloud computing infrastructure. The existing cloud computing architectures differs in many ways. Security has been the serious issue as client related data and processing is undertaken using the infrastructure provided by third party service providers varies greatly. It is necessary to know the extent of inclusion of security into the cloud computing system and then find the best architecture that includes best and tight security system. In this paper, a comparison of existing architectures from the perspective of inclusion of security infrastructure within cloud computing system is presented along with a comprehensive architecture that is included with every aspect of security taking into account the most of the vulnerabilities.

Keywords: *Cloud Computing, Security Infrastructure, Cloud Computing Architectures, Enforcing Security Among Cloud Computing Systems.*

1. Introduction

Cloud computing is basically service model deployed over internet to provided services to the end users. The main objective of cloud computing technology is to ensure availability, high reliability and scalability of infrastructural facilities which include hardware, software, platforms, services and software which could be distributed to different computing locations. No standard definition as such has been defined and being followed as yet. A cloud computing platform is expected to provide reliable services in distributed environment. The infrastructure which is used for building the cloud needs to be scaled seamlessly. Every cloud should satisfy 5 different characteristics which include Ubiquitous network access, Pooling distributed resources, on demand service, compute extent of service provided and the ability to scale up as necessary. Every cloud must support there delivery models that include Infrastructure as a Service, Platform as a Service, and Software as a Service. The cloud computing platforms should be either deployed as Private cloud, public cloud, hybrid cloud and community cloud. Conceptually a cloud is completely service oriented. Anything required by the cloud is delivered as service. Hardware, software, platform, application software, system software, and utility are provided in terms of the service. Many cloud computing facilities have been created providing different kinds of services. One of the gravest concerns is lack of standard API and usage model. Cloud computing as such emerged out of the technologies that have come up over the time that include Distributed Computing, Utility computing, Grid Computing, Cluster computing, and Virtualization. Designing a proper architecture which shall be used for the development or the expansion of the cloud infrastructure, proving the services and resources as per the quality as stated in service level agreements is most important issue that must be addressed. One of the features of a cloud is to ensure that the confidentiality of the user data, process, software, applications etc. is not lost. The cloud computing architecture must support various types of users (providers, enterprises and regular users) and should reflect the issues of scalability, infrastructure, storage, security, services and platforms. The architecture must deal with requirements of all types of users and also confirming to the individual security requirements that may differ from user to user. This paper presents comparative analysis of the existing architectures and brings out the extent to which security enforcement as per the users requirement has been covered and also present an architecture that show the way user defined security requirements have been considered in relation to data storage and retrieval, resource allocation, multi clouds that satisfies the service level agreements.

2. Related Work

Various kinds of components are considered into a cloud computing system architecture which essentially explains the way the components are structured and the way the communication happens among the components. The components considered and placed in the architecture include cloud resources, services, middleware, application and system software. Nothing about the hardware as such is described in architecture. The architecture explains the properties of the software objects and the relationships between the objects. The architecture that explains the cloud computing infrastructure shall deal with various aspects that include Xaas Structurers, platform adaption, structuring cloud services, structuring cloud components, relationship between various components, Communicating between the objects, middleware that address the heterogeneity that exists among the communicating objects or to work like a broker between the user and the backend computing system, Deploying and managing security components and to check various legal issue especially when related to exporting data across the continents[1].
Many components exist within the cloud infrastructure. Data storage and retrieval is made available as a service the user. When

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it comes to the data confidentially of the same is important. Every component has an architecture that is built into overall cloud computing architecture. Many storage devices that are either supported on the servers or the network storage devices are clustered to form the total storage. Dedicated software running on one of the server is made responsible to manage the storage in terms of allocation, storing the user data and retrieval of the data as per user requirements. The software also deals with providing access rights to the user for availing the data services and revoking the same when the service is completed. Security has been the most important issue when it comes to data storage and retrieval and also transmitting the same to the end user over the internet. Security is also the issue when the Data transfer from the user to the cloud is implemented. Cloud storage is not just the data supported on a server as in a conventional system.

Cloud storage as such includes network devices, storage devices, servers, applications, public access interface, client programs and similar such systems. A sub-system is implemented that manages the storage in the cloud computing environment .Clustered storage architecture is generally implemented for providing efficient storage services and also to support scalability and fault tolerant data storage and retrieval systems.

The cloud storage resources are generally organized as a cluster, a grid or a distributed file system. The connecting network and the storage management software together provide the data storage services to the end users. Providing the user the easy access and high performance data services are the main objectives of cloud computing systems when it comes to the data storage and retrieval. The storage infrastructure provided in cloud computing systems is homogenous and supported on homogenous platforms while that not being the case now. A heterogeneous cloud storage infrastructure management has been presented [2]

Customers enters into service level agreements (SLA) with cloud computing service providers for want of various kind of service that are related infrastructure, platform and software provisioning. The services required and the quality of the services required differs a lot from user to user. Resource management systems generally do not follow SLA for managing the resources leading to some kind of rendering less quality services to the end users. SLA based resource allocation provides very high quality of fata storage services.

Customer driven approaches are mostly needed for providing quality services to the end users. The customer oriented service management, management of computational risk, autonomic resource management needs to be integrated into market base resource management. This will help in adapting to the rapidly changing services requirement scenario. An architecture has been presents that considers the management of the requires in accordance with SLAs. Architecture has been proposed which is based on market driven policies and virtualization technologies which supports in providing flexible allocation of services **[3].**

Virtualized services which are dynamically scalable are provided to the users through a service model supported by cloud computing technologies. No standard as such exists as on date for implementing cloud computing solutions. Much architecture is being used for building cloud computing systems. The requirements of the users are to be found first and then classify the same based on some criteria. It has been shown that some features required by the users such as the requirements for storage, software, platform, securing the data etc., play a vital role in defining the architectures which should be used for building cloud computing infrastructure [4].

As said earlier providing data storage and retrieval related services has been one of the most important services being offered by many of the service providers. Google drive, one drive etc., are some of such services. A separate architecture has been on anvil to support such facility. Several storage technologies such as HDFS (Hadoop distributed file system), GFS (google file system), MapReduce, Big Table etc. are to be considered before storage architecture can be finalized. A method that improves the conventional file storage system based on eye-OS WEB operating system has been presented that not only implements distributed storage and also achieves the control to make the system fault tolerant [5].

Many clouds are in use these days and each cloud provides some services. The user requirements can only be serviced sometimes through the services provided by a set of cloud computing systems. Inter-cloud operations are required in that case. The architecture involving multiple clouds must address multiple providers, multiple domains, heterogeneous applications and the need for application integration, supporting legacy services and interoperability.

A cloud computing system makes the users independent of physical hardware, platform, distributed computing platforms and networking technologies. NIST Cloud Computing Reference Architecture (CCRA) is one of such architectures that have been offered for implementing inter-cloud services. On the basis NIST, an inter-cloud architecture has been proposed that focuses on interoperability and integration.

The architectures is built around multiple service models that include SaaS, Paas, Iaas into one multi-layer that is incorporated with inter-layer interfaces, inter cloud control and a Management system that facilitate interaction between the applications that have been hosted on to the cloud, and also interaction between the clouds. An architectural framework has been presented that provides the basis for building multilayer cloud services, optimised provisioning of computing, storage and networking resources. Architecture is presented that facilitate cloud interoperability and integration [6].

A cloud can be constructed involving multiple providers using the resources that spread across multiple domains including the legacy infrastructures and services. Resources are made available to the users on demand through virtualisation of the resources. To convert existing infrastructure into cloud based infrastructure, multiple clouds needs to be created. An architecture that deals with multiple clouds with interface between the clouds needs to be developed.

The multiple clouds developed must be interoperable. New service provisioning models, security models are required to provide services to end user on demand. Virtualisation is one mechanism that helps in moving the existing infrastructure or add-ons into cloud based infrastructure.

There are significant benefits that one will accrue when migration of the existing infrastructures or WEB based services to cloud based infrastructure and services is undertaken especially considering elastic scaling and on-demand provisioning.

A number of functionalities are to be added in terms of addition of services that can operate on multiple clouds. These additional functionalities are to be added into inter-cloud architecture. The inter-cloud architecture should address various issues that include the following:

1. Provide the services considering each of the cloud independently and also have a mechanism that measures the usage of the resources by end users
2. Integration and interoperability of multiple clouds including the integration of legacy infrastructure
3. Provide the services considering Multiple clouds (cloud Federation)

An architectural framework has been presented for operating a system that uses multiple clouds. Many users world over are moving from traditional client server based computing to cloud based computing due to the inherent services that are being offered. On demand service provision is one such criterion. The use of cloud computing infrastructure is evident while at the same time many and different clouds are expected to be created and operated. It becomes necessary to provide services to the end users considering multiple clouds at the same time as a matter of federation.

AT times same service can be availed from multiple vendors. Reference architecture (RA) is required when services are to be provided through either of the clouds which are established using inter-cloud interaction. A multi cloud reference architecture (RA) has been presented that allows a user to use a services provided by any of vendors.

For example a data storage service offered by either google or Microsoft. A comparison of the RA presented is made as against RA of National Institute of Standard Technology (NIST)[7].Cloud computing is all about sharing the resources such as processors, servers, storage, memory, bandwidth, services, applications that can be provided as services on demand and release the same on completing the service.

The allocation and de-allocation is done with minimal of management requirements. After the era of WEB based processing, cloud computing has come in a big way. Cloud computing has come into force due to amalgamation of many old technologies such as SOA, Grid Computing, distributed computing, and virtualisation. Resources that are connected to several servers which are geographically spread across are represented as a pool of computing resources which are made available on demand.

The resources typically comprise memory, storage, processors, bandwidth etc. The resources in the pool can be either be made to shrink or expand in real time so that the desired levels performance, scalability, reliability, latency, sensitivity, security is ensured. The resources are made available to the user on demand as logical unit called "Cloud Computer".

The cloud model as such can be composed using four deployment models (public, private, Hybrid, community), three service models (Iaas, PaaS, SaaS), and 5 essential characteristics (on-demand self-service, Broad network access, resource pooling, rapid elasticity, measured service).

A cloud provider usually enters into service level agreements that not only include pricing but also quality of service that will be provided to the end users. SLA also includes the penalties that the service provider takes if the service provider fails to provide the quality of the service that they have committed to. The service provider is equally concerned with running the cloud computing facility by consuming minimum energy and optimum resources utilisation through constant monitoring and taking corrective actions wherever required.

The concept of software defined clouds has been presented that helps configuring the cloud optimally by extending the concept of virtualisation to all the pooled resources. The concept of virtualisation as such is extended to only physical machines earlier. The demands of QoS can be met through software defined clouds. SDC can manage various aspects of cloud computing such that QoS requirements can be met with. Architecture has been presented using which SDC can be implemented that caters for mobile applications that are cloud based.

The architecture has been evaluated from two perspectives that include bandwidth allocation, energy efficient VM placement [8]. The architecture is developed over software defined networks (SDNs, Server and network virtualization, software-defined and middle box networking. It has been shown the way these different technologies are combined together to form SDC.

3. Review on existing architectures

Gerald Kaefer [1] has recommended an architecture shown in figure 1 and Figure 2.It can be seen from Figure-1 and Figure-2 that the issue of security is enforced on the side of the cloud just be either providing a desired service or storage.

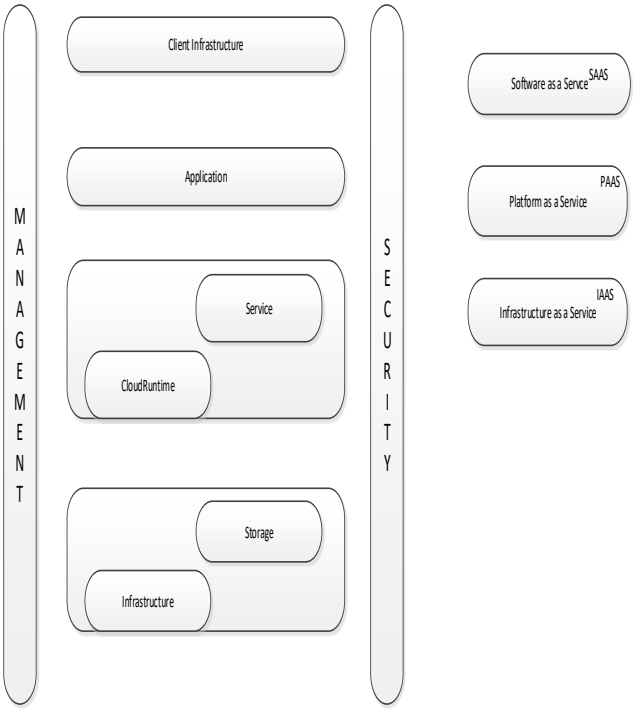


Fig. 1: Grald Kaefer Cloud computing Architecture – Presentation -1

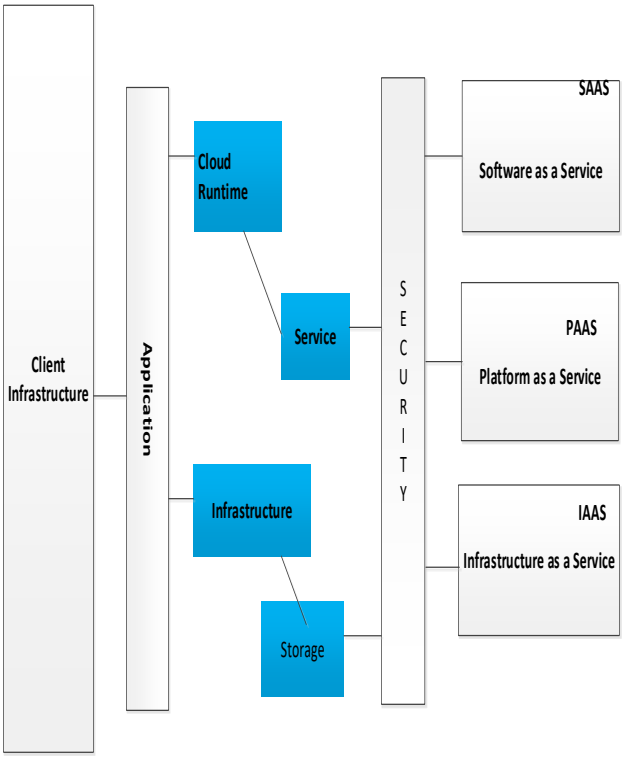


Fig. 2: Grald Kaefer Cloud computing Architecture – Presentation -2

The architecture proposed by Dejun Wang et al., [2] is shown in the figure

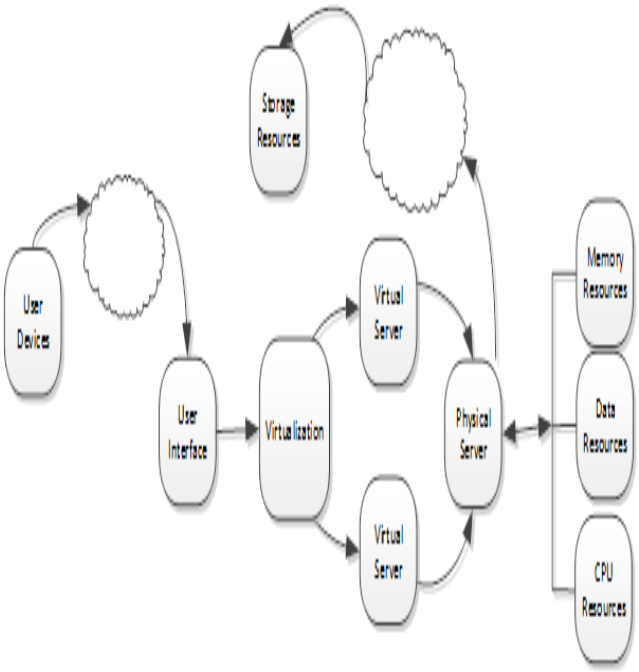


Fig. 3: Dejun – Cloud Computing Architecture

The architecture proposed by Raj Kumar Buyya et al., [3] is shown in figure 4. From the architecture it can be seen that it is the client who is responsible for ensuring the security. The software required for securing the data has been provided as a callable service.

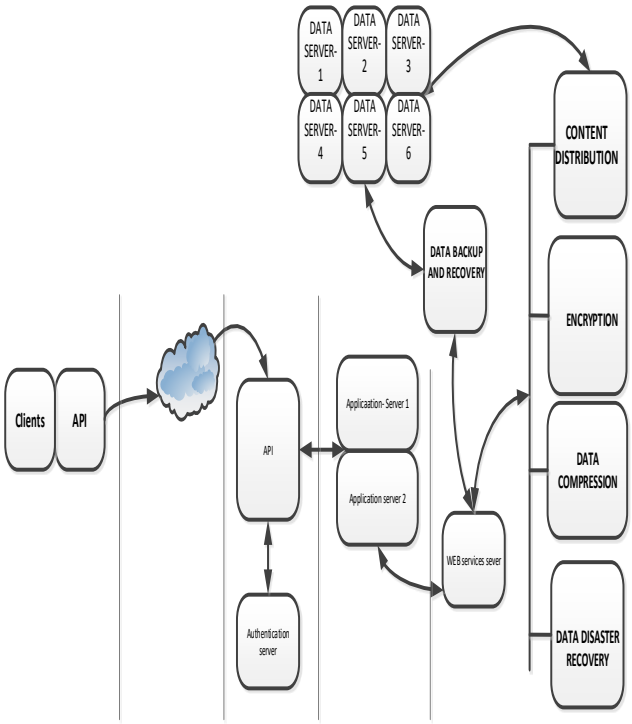


Fig. 4: Raj Kumar Buyya – Cloud computing architecture

Bhaskar Prasad Rimal et al., [4] have proposed architecture which is shown in figure 5. From the figure it can be seen that security is provided to be interfaced with all types' delivery models (SaaS, PaaS, Iaas). It the responsibility of all the three services to ensure the provision of the security to the users data. However the enforcement of security is done at the cloud side and the security is enforced without the need for any user to trigger a security service request.

The architecture proposed by Kun Liua et al., [5] is shown in figure 6. The architecture just explains the way the data is handled between the user and the cloud. No security feature as such has been incorporated into the architecture

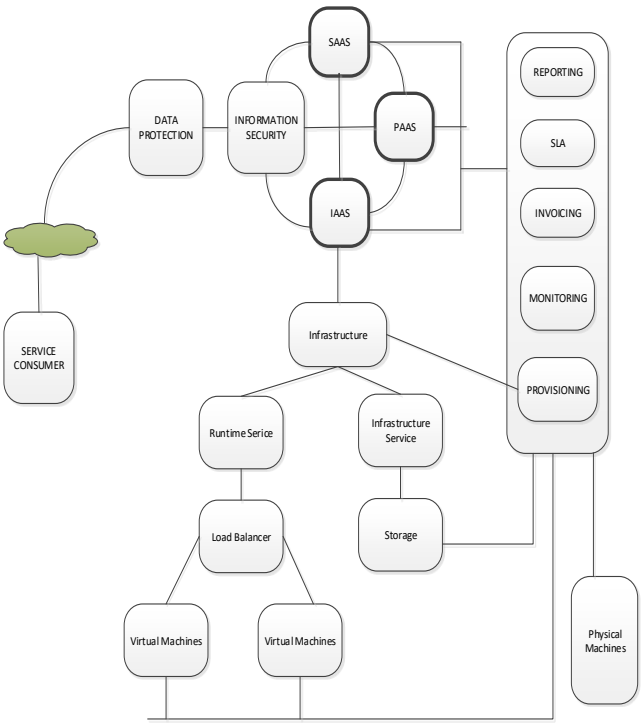


Fig. 5: Cloud computing architecture - Bhaskar Prasad

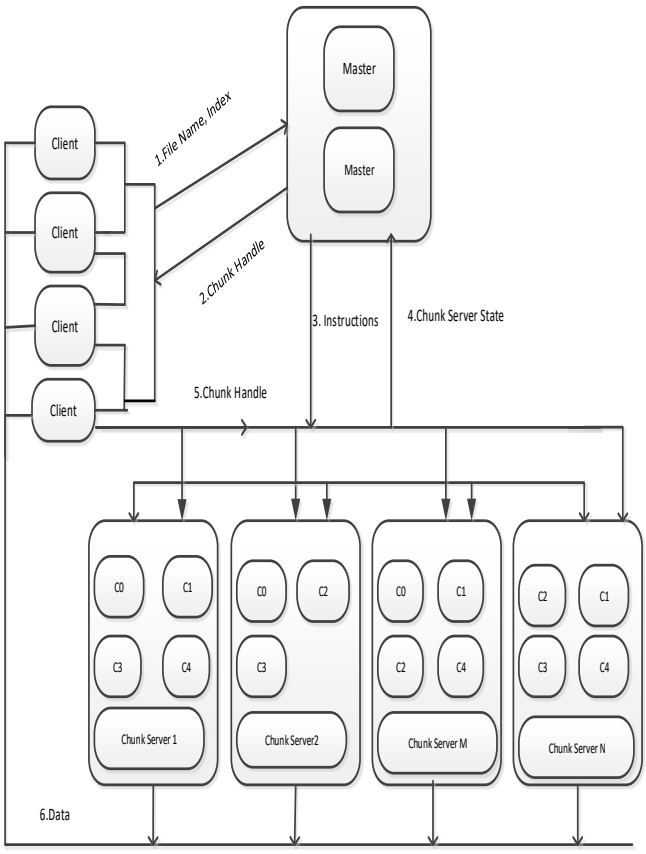


Fig. 6: Kin Liua – Cloud computing architecture

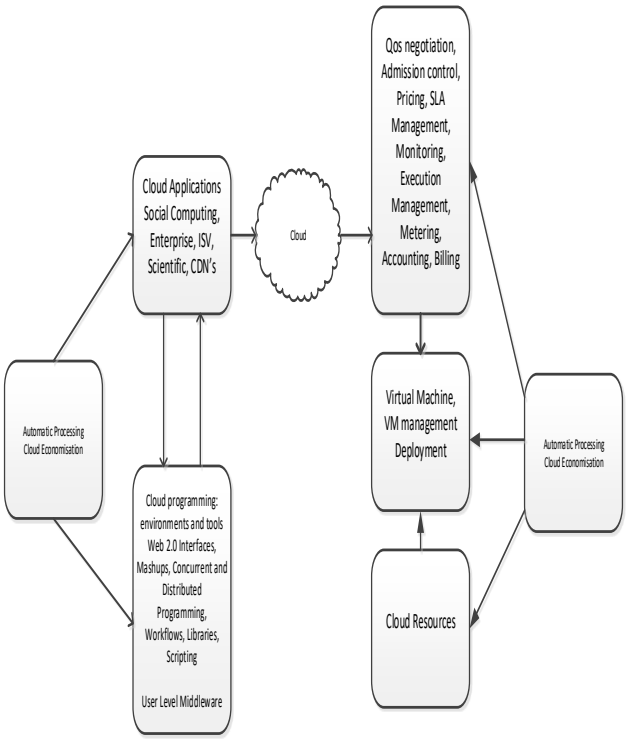


Fig. 7: cloud computing architecture - Yuri Demchenko

Yuri Demchenko et al., [6] have proposed an architecture which is shown in Figure 7. No security provision as such has been incorporated into the architecture. The architecture presented by Demeke Gebresenbet Bayyou et al., [7] is shown in the figure 8. this architecture no security provision has been made as such.

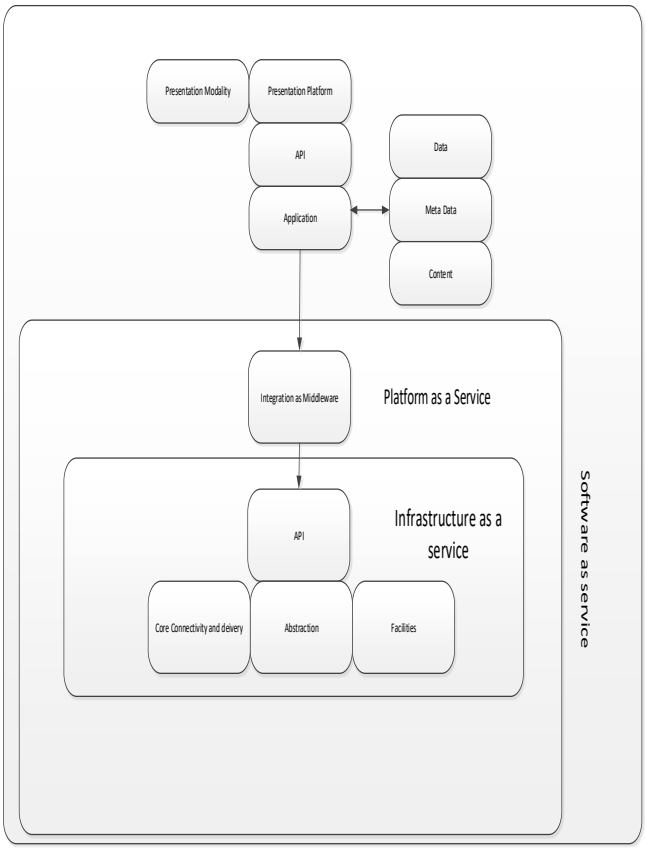


Fig. 9: Cloud computing architecture - Demeke Gebresenbet Bayyou

The architecture proposed by Raj Kumar Buyya et al., [8] is shown in figure 9. No security provision as such is made into the architecture.

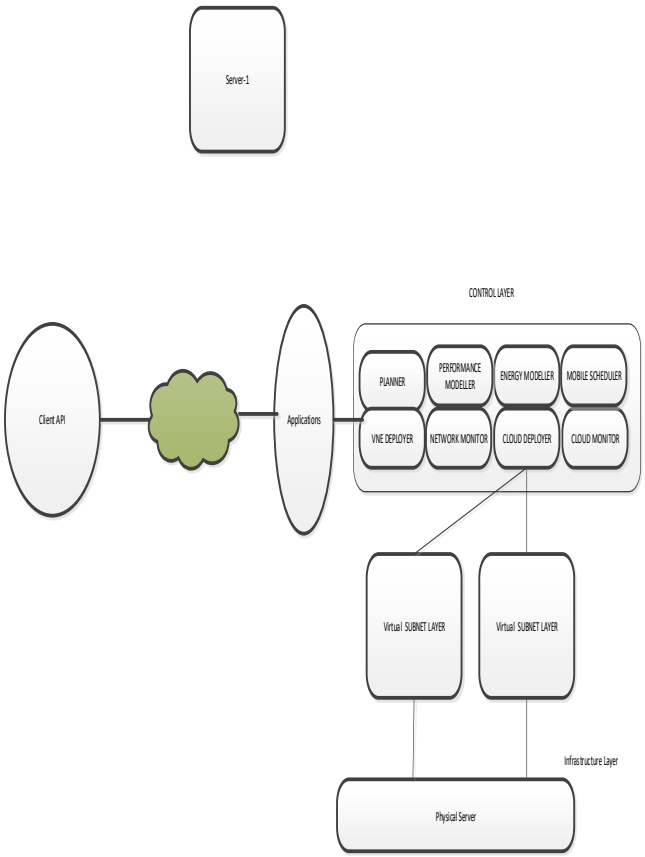


Fig. 8: Cloud Computing Architecture - Raj Kumar Buyya

4. Comparison of architectural Models

The architectural models presented in the literature are compared to find the extent to which security is implemented. The comparison has been shown in Table-1. From the Table it can be shown that none of the architectures meets all the security requirements especially the consideration of the users defined security enforcement. The new architecture that meets most of the security requirements are presented in the next section.

5. A comprehensive cloud computing architecture for enforcement of all-round security within cloud computing system.

Any cloud computing system should support the following such that total and comprehensive security can be enforced within cloud computing system.

1. Authorization and authentication from the client side
2. Availability of a service on the cloud such that the user application can call the same whenever security enforcement is needed. The user through the callable interface can define the kind of security infrastructure and polices that must be taken into account for the enforcement of the security
3. Security enforcement within delivery models that comprises Iaas, Paas, Saas
4. Security enforcement at storage level
5. Security enforcement at virtual Migration Level
6. Security enforcement at process management level including scheduling

An architecture that meets all the above stated security related environment is shown in figure 10.

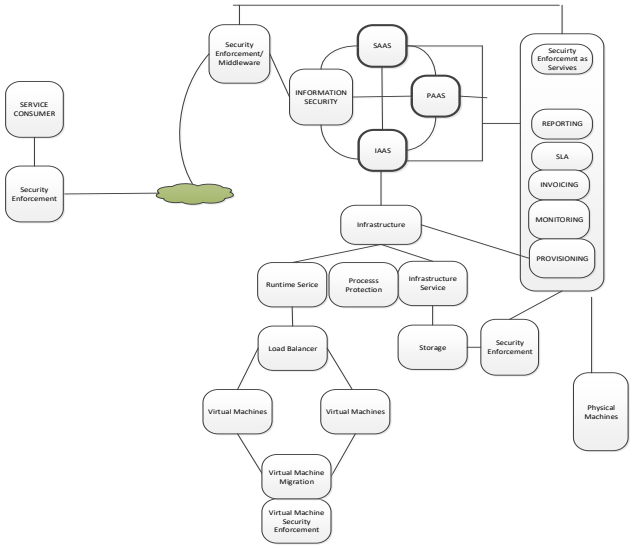


Fig. 10: A fully security enforced cloud computing architecture.

6. Conclusion

Cloud computing architecture must be designed to cater for the security requirements as defined by the user. Inclusion of security in to the system should not lead to performance degradation leading to guarantees provided in SLA for delivering secured services. Security enforcement must be considered from the point of view of data communication, storage, retrieval, data migration, resource allocation etc. The architecture proposed has comprehensive coverage of all security related issues.This is a text of acknowledgements. Do not forget people who have assisted you on your work. Do not exaggerate with thanks. If your work has been paid by a Grant, mention the Grant name and number here.

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Table 1: Comparing Cloud Computing Architectures from the perspective of Security

Reference Number	Author	Type of architecture	Data Communication	Data storage	Data retrieval	Virtual Migration	Process execution	Middleware	Software as a service	Platform as a service	Infrastructure as service	Security enforcement as service	Multi-cloud security
1.	Gerald Kaefer	Standard	-	√	√	-	-	√				-	-
2.	Dejun Wang	Clustered storage	-	-	-	-	-		-	-	-	-	-
3.	Raj Kumar Buyya	SLA based Architecture	-	-	-	-	-	-	-	-	-	√	-
4.	Bhaskar Prasad	Standard	-	-	-	-	-	-	√	√	√	-	-
5.	**Kun Liua**	Data storage	-	-	-	-	-	-	-	-	-	-	-
6.	Yuri Diatchenko	Reference Multi Cloud	-	-	-	-	-	-	-	-	-	-	-
7.	Demeke Gebresenbet Bayyou	Reference Multi Cloud	-	-	-	-	-	-	-	-	-	-	-
8.	Rajkumar Buyya	Software Defined	-	-	-	-	-	-	-	-	-	-	-