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Towards a Cloud Computing Continuum

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Abstract

The current trend of developing distributed, location aware, heterogeneous computing intense and data sensitive applications is changing the frontiers of computing. A Cloud with just one datacenter is not sufficient today. Computing Architectures comprising of multiple datacenters spanned globally is the current day requirement. But limitations like security, interoperability, heterogeneity and effective interaction hamper this idea. The concept of establishing a Cloud Continuum is slowly developing among researchers & Organizations. This paper discusses how Cloud Computing environment has evolved from a minimal centralized architecture to more distributed Continuum. We also discuss a possible architecture that comprises of an ICT layer over a Cloud Federation.

Keywords: - Cloud Continuum, Fog Computing, Distributed Clouds.

1. INTRODUCTION

The advent of cloud environment is providing a range of attractive services to users. According to NIST, "Cloud Computing is defined as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computer resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [1]. Fig. 1 shows a basic cloud computing environment. Cloud can be delivered in 3 models namely SaaS, PaaS, and IaaS. It can be deployed as Public, Private & Hybrid Clouds. *Cloud computing* is an emerging paradigm which has become today's hottest research area due to its ability to reduce the costs associated with computing. Software used to build a cloud computing environment is Cloud Ubuntu: Ubuntu is the solution designed to create a cluster of machines based on Ubuntu server, which can be used in private and public hosting services. eNlight Cloud: Provides virtualization platform and integrates with the billing system for managing the entire infrastructure. **Microsoft Windows Server Hyper-V:** Microsoft does not offer a real platform exclusively dedicated to the creation of the cloud for hosting providers. The product is intended for this purpose, especially for private clouds.

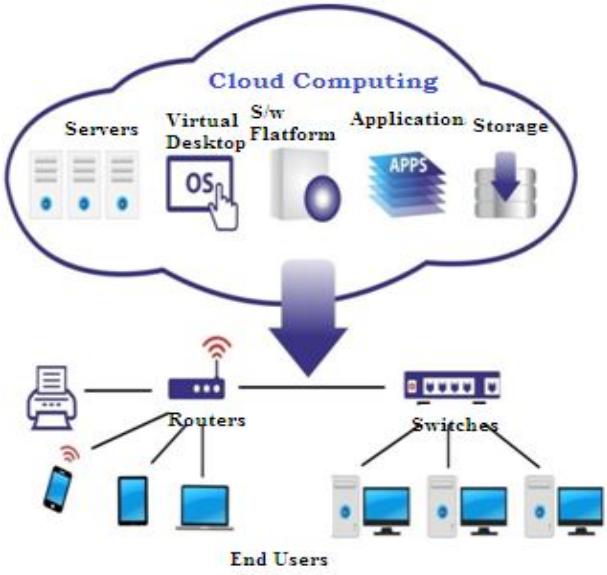

Figure 1: Cloud Computing Environment

Microsoft Windows Server Hyper-V: Microsoft does not offer a real platform exclusively dedicated to the creation of the cloud for hosting providers. The product is intended for this purpose, especially for private clouds.

Figure 2 depicts the summary of the survey conducted by us on the basic issues of the cloud computing. The client's primary concern is taken into account. Hence only the percentage of 4, 5 is being shown. The loss of capital to major companies that have invested in the cloud due to outages. Hence a Continuum is required [2].

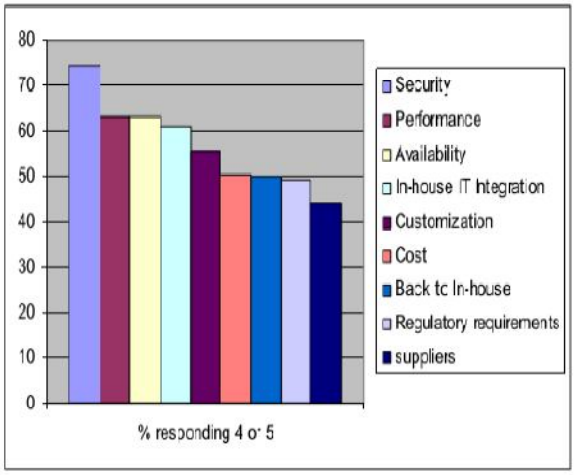

Figure 2. Graph depicting the concerns of clients on cloud computing issues

2. THE CLOUD CONTINUUM:

A continuum is a continuous system or range in which adjacent elements do not vary from each other in any marked degree although the endpoints of the system may be drastically different. Cloud Continuum is to provide a cloud service 24x7x365 that is without any outages. To achieve this present cloud infrastructure must evolve beyond a single centralized datacenter approach. A multiple and distributed datacenter approaches is required.
A serious challenge for distributed, context-aware and data sensitive applications running on a cloud, is that they require proximity to the users to meet very tough performance requirements [3].The IaaS Cloud paradigm suits for the above-mentioned applications but requirements like latency and bandwidth is a point of concern. The need for closer proximity has pushed the realization of large scale, robust and redundant computing environments as distributed clouds, where different datacenters are operated under a common IaaS interface by a single infrastructure provider.

3. GEO DISTRIBUTED CLOUD

Distributed clouds or Geo Distributed Datacenters came into existence. A Geo-Distributed cloud consists of multiple Datacenters deployed over regions (all across the globe) separated geographically [4][5]. This setup proves its worth in course grained localization but in most cases they are not economically viable. Figure 3 illustrates a geo distributed cloud.

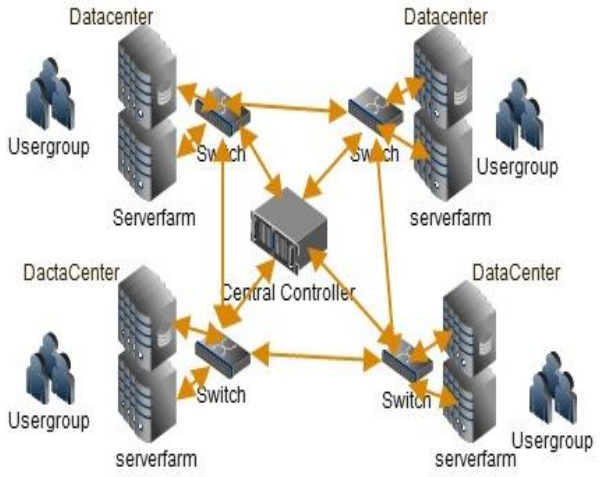

Figure 3: A Geo-Distributed Cloud

4. FEDERATED CLOUD

Cloud Federation is a computing model where multiple resources from independent Cloud providers are leveraged to create large-scale distributed virtual computing clusters, operating as within a single cloud organization [5]. Cloud Federation has a lot of advantages but, it brings several issues concerning the management of a multi-domain, multi-tenant, heterogeneous, distributed infrastructure: deployment, networking, run-time management, orchestration, security and privacy [6]. Figure 4. Represents a Federated Cloud.

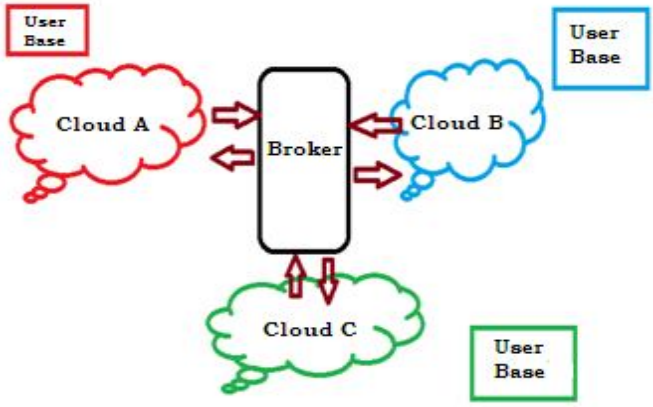

Figure 4: A Federated Cloud

5. FOG COMPUTING

Another advancement in cloud computing area is "Fog Computing". Fog computing means that rather than hosting and working from a centralized cloud, fog systems operate on network ends. It is a term for placing some resources at the edge of the cloud, instead of establishing channels for cloud storage and utilization. Thus, it is also referred to as edge computing[8].

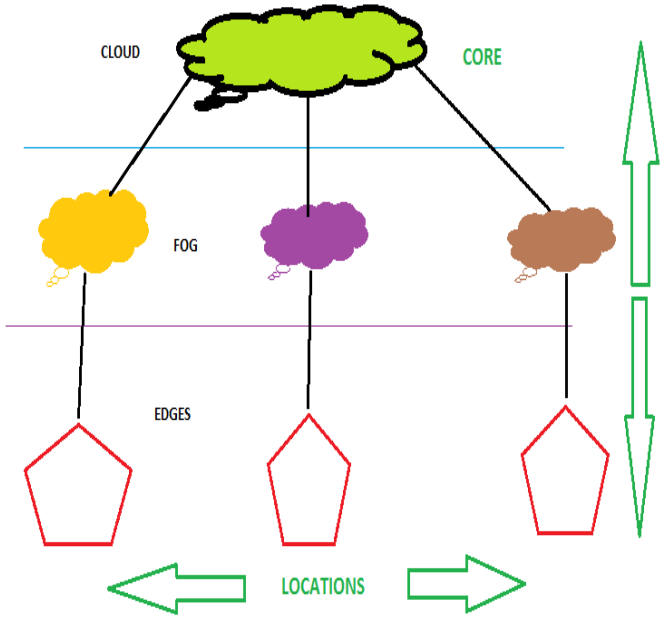

Figure 5: Fog Computing Model

Fog computing was developed to address applications and services that do not fit cloud paradigm. Fog computing keeps data secure where IOT needs it. Fog Computing is a solution to cloud's limitation. Some of the fog computing applications are locking a door using sensors, changing equipment settings, applying the brakes on a train, zooming a video camera, opening a valve in response to a pressure reading, creating a bar chart, or sending an alert to a technician to make a preventive repair.

6. THE CLOUD CONTINUUM PARIDGM

Currently cloud comprises of Datacenters, Things, computing, storage and network hardware. The network interconnects all such elements with datacenters and Internet-connected smart devices (things) [9]. This large collection leads to a rich ICT programmable layer, raising the opportunity for creating a seamless and pervasive collection of clouds.

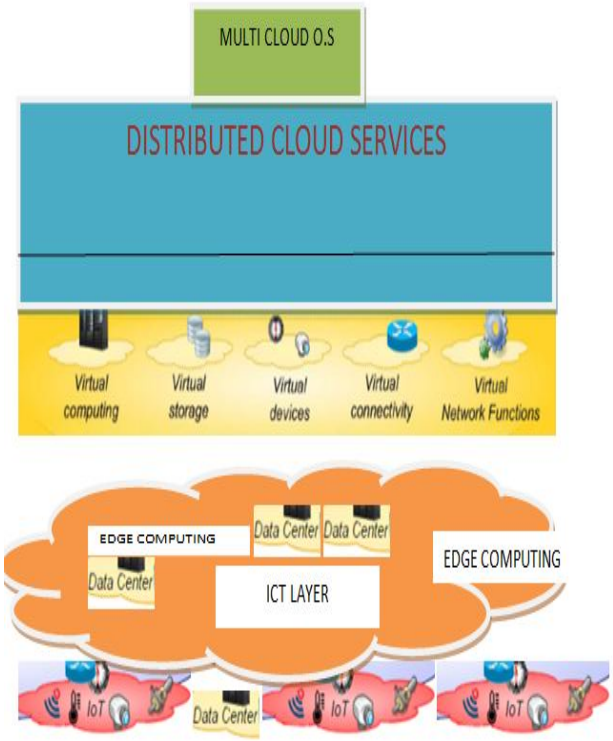

Figure 6: A Framework for a Cloud Continuum

For a Cloud Continuum to thrive networks should be able to manage heterogeneous ICT infrastructures and to build cloud services on top. We need to develop a multi cloud operating system that will be capable of integrating and aggregating spatially separated datacenters, provides access to resources available across multiple clouds, looks after the security of the Continuum and provides necessary API's for deploying & running applications. The Cloud Continuum should be able to hide the difficulty and multiplicity of the available infrastructure.

The Services that a Cloud Continuum is expected to offer are as follows:-

A. Distributed Cloud, Fog Computing, and Locality aware Computing & Storage.
B. Dynamic on demand WAN with carrier grade service guarantee.
C. Hardware Acceleration for processing intensive tasks.

6.1. Cloud Continuum Criteria:

Seven criteria are critical for the Cloud Continuum:

a) Elasticity
b) Op Ex over Capital
c) Speed to Market
d) Compliance
e) Flexibility
f) Performance
g) Control and Security

6.1.1. Elasticity: Elasticity refers to the way in which the cloud can be expanded on demand to cater the needs of the Clients. It is desirable to have a highly elastic Cloud Continuum.

6.1.2. Op Ex over Capital: It refers to the operational expenditure of the capital that the Clients have invested. Usually this criterion should be less for the continuum to be successful.

6.1.3. Speed to Market: It refers to the agility and ability of the continuum to adapt to the current trends of the market. This feature also should be high for the continuum to be a success.

6.1.4. Compliance: It refers to the adherence of the Continuum to the standards present currently. A Compliant Continuum is expected by the Clients.

6.1.5. Flexibility: It refers to the degree of pliability. This criterion is desired to be on the higher side.

6.1.6. Performance: It is expected to be high.

6.1.7. Control and Security: Control and Security of the Cloud Continuum should be very abstract and high. The end user expects the Continuum to be highly secure and trustworthy.

6.2. Application Deployment over a Cloud Continuum

The idea of cloud continuum provides great flexibility in the manner applications are deployed and run concerning to current practice. But issues like interoperability, portability of software, migration of data between various clouds and transfer of services in between heterogeneous clouds surround the developer. In spite of the availability of standard common interfaces like OCCI and CIMI, there are currently many different open and proprietary APIs for Cloud Management, based on different abstractions, semantics and communication protocols [10]. Hence there is a need for a common interface for Cloud Continuum. A typical service deployment on a Cloud Continuum is depicted in Figure 7.

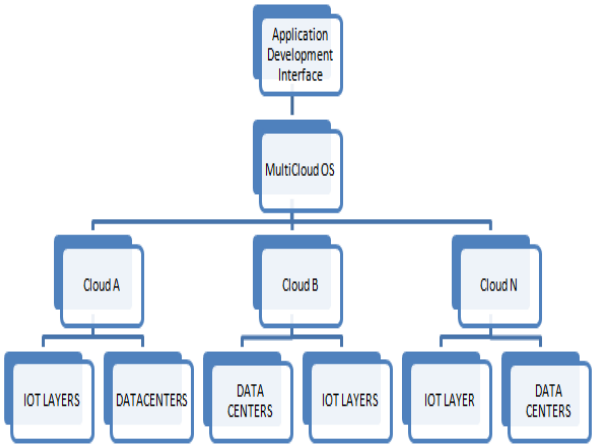

Figure7: Application Deployment over a Cloud Continuum

7. CONCLUSION

We've looked at the evolution of a cloud continuum. There are interests and concerns in the continuum. From a technology point of view, there are interesting technical problems to solve. We outlined the layout of a framework that requires a multi cloud operating system, 5G network to provide connectivity and hardware accelerators. This paper discussed how applications can be deployed over the continuum. This Continuum provides a lot of opportunities for researchers to develop mechanisms that provide common functional abstractions of heterogeneous infrastructures (data centers, ICT fabrics, IoT), to guarantee scalability and availability, and to expose different service models.

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