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Design Issues in Federated Cloud Architectures

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Abstract: Cloud computing offers new ways of flexible resource provisioning for business enterprises to manage IT based applications and big data analysis to meet increasing expectations of customers. The central idea to cloud computing is constant availability; elasticity and scalability satisfy client requirements. Cloud Federation is a distributed, heterogeneous and multi-cloud environment that consists of various cloud infrastructures by aggregating resources of different service providers. This paper gives an insight to the formation and interoperability issues of Cloud Federations. It addresses the several issues of related to service monitoring, data management, protection and security in the area of cloud federations.

Keywords: Cloud Federation, Interoperability, Multicloud, Cloud Broker, Load Balancing, Service Level Agreement (SLA).

I. INTRODUCTION

Cloud federation is a system of interconnected cloud service providers based on open standards. It provides decentralized computing governed by agreements in a multi-provider infrastructure. This enables cloud providers and IT companies to dynamically collaborate and share their workload to provide a better quality of Service (QoS), resource utilization, increased reliability and cost efficiency. Many applications have legislative constraints regarding location of data storage. Therefore, cloud federation can also provide legislative compliant services to their customers.

In a Cloud Federation, cloud service providers voluntarily interconnect their infrastructure for resource sharing as shown in Figure 1. The service providers share their resources through federation regulations to gain from economies of scale. On the other hand, in a multi-cloud, several independent clouds are used by a client or a service. There is no voluntary interaction and sharing of different cloud infrastructures. Resource scheduling and provisioning is done by the client himself. Cloud Federation is useful for both the parties i.e. service providers as well as for customers. Customers may profit from improved performance at reduced costs, while providers may offer more sophisticated reliable services [3, 5].

Advantages of Cloud Federation are:

- Access to so widely distributed resources across the Globe
- Multiple clouds not only provide fault tolerance, but resources from different service providers act as an insurance against a provider being stopped because of regulatory or legal reasons as well.
- A cloud client can easily avoid vendor lock-in in a cloud federation. In vendor lock-in, a customer is completely dependent on only one cloud service provider and to move to other cloud, considerable expenditure is incurred and technical expertise is required.
- If the workload on a particular cloud increases beyond the limits, resources from other clouds can be used. Using load balancing, for example, resource limitation can be overcome during spike in demands.
- Even in a case of data centre outage or resource shortage, the workload can be moved to another cloud to provide better Service Level Agreement (SLA) to customers. SLA is an agreement that sets the expected service-level objectives and penalties if services are not delivered as per this agreement.

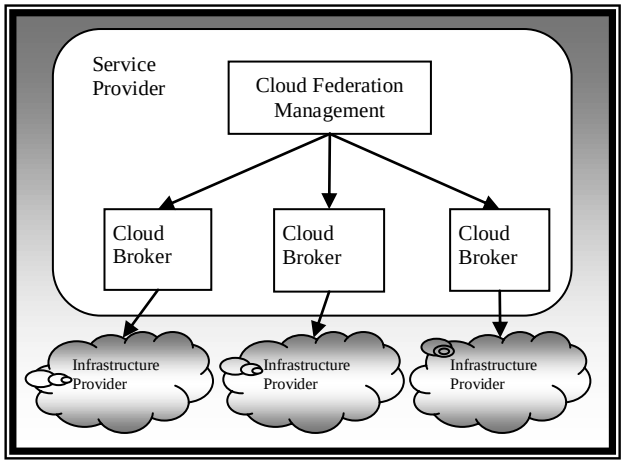

Fig.1. A Cloud Federation

Cloud federation is associated with many portability and interoperability issues. These issues include [1}:

- Manageabiliy: Even though most Cloud solutions handle elasticity, intelligent algorithms are needed for efficient resource utilization.
- Data management: Most data in the Cloud need to be supported by meta-data information and modified standards are needed to guarantee long-term storing

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and interoperable sharing among multiple service providers.

- Privacy and security: Legislative issues of data distribution should be addressed, and security problems during resource sharing among multiple tenants should be eliminated.
- Federation and interoperability: Standard data structures and data representation techniques should be used in place of proprietary ones. New approaches are to be developed to support interoperability to eliminate vendor lock-in.
- Virtualization and adaptability: Optimized resource scheduling algorithms are needed to support cross-platform executions and migrations taking into account spike demands and rapidly changing workloads.
- Programming models: Better control on data distribution is required, and new methodologies are needed to enable better application development and deployment.
- Energy efficiency: Scheduling policies are needed to enable green resource utilization and more efficient resource utilization while reducing power consumption.

II. TYPES OF CLOUD FEDERATION

Cloud Federation has two basic dimensions viz. horizontal federation and vertical federation. While horizontal federation takes place on one level of the Cloud stack, e.g., the application stack, vertical federation spans multiple levels. In this paper we primarily focus on horizontal federation [2].

As we have seen above, that Cloud federation is the federation of cloud service providers for the situation of sudden change in the processing load, in the following paragraphs, we discuss various Federated Cloud Architectures.

- **Cloud Broker Architecture**: Cloud Brokering Architecture allows service delivery capabilities e.g. deployment of virtual resources in the cloud, make scheduling decisions based on various criteria (cost, performance, or energy consumption), to automatically deploy virtual user service in the most suitable cloud, or distribute the service components across multiple clouds. The architecture is shown in Figure 2.

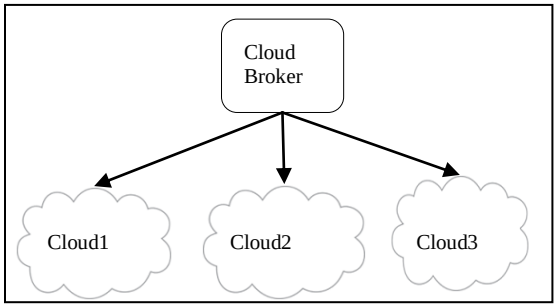

Fig.2. Cloud Broker Architecture

Cloud broker is a consultant and intermediary between buyers and sellers. The broker tracks services, their capabilities, and their interdependencies. Broker also has knowledge of where the services are originated. Objective of the broker is to make it easier, safer and more productive for cloud computing users to integrate, consume, extend and maintain cloud services. In this respect, the broker offers a range of value added services to both cloud service providers and consumers. The broker aims at the creation of a framework that allows cloud service intermediaries to equip platforms with advanced means for continuous quality assurance and optimization of cloud services.

- **Bursting cloud:** This is the simplest form of cloud federation as shown in Figure 3. Bursting cloud is an application deployment model when an application of private cloud bursts into a public cloud when the computing needs spikes to meet peak load. The advantage is that the client pays only for the extra resources utilized. Cloud bursting is recommended only for non-critical, high performance requirement applications.

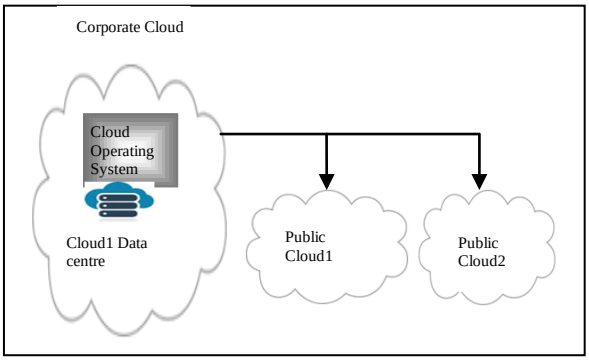

Fig.3. Bursting Cloud Structure

- **Aggregate cloud architecture:** A cloud aggregator bundles and assembles various cloud services into proprietary offerings. It consists of partner clouds to aggregate their resources and provide users with a greater virtual infrastructure as shown in Figure 4. The terms and conditions of the contract among the partner decides the degree of control over the remote resources. Success of a cloud aggregator is dependent on the cloud federation capabilities of the service providers whose services are sold by the aggregators.

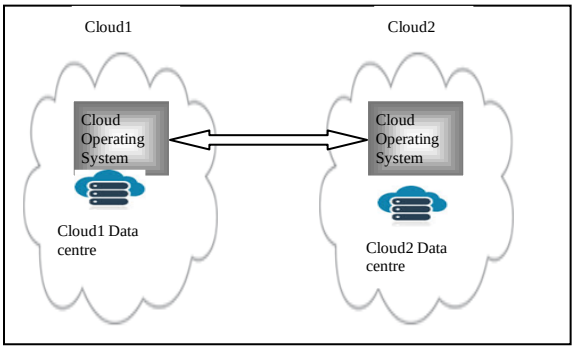

Fig.4. Aggregated Cloud Architecture

- **Multitier Architecture:** This architecture, as shown in Figure 5, follows a hierarchical arrangement where clouds

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are managed by third cloud OS instance, usually belonging to same organization.
Further, a cloud federation may be loosely coupled, tightly coupled or partially coupled. In loosely coupled architecture, the cloud instances are autonomous and have little or no control over the remote resources.

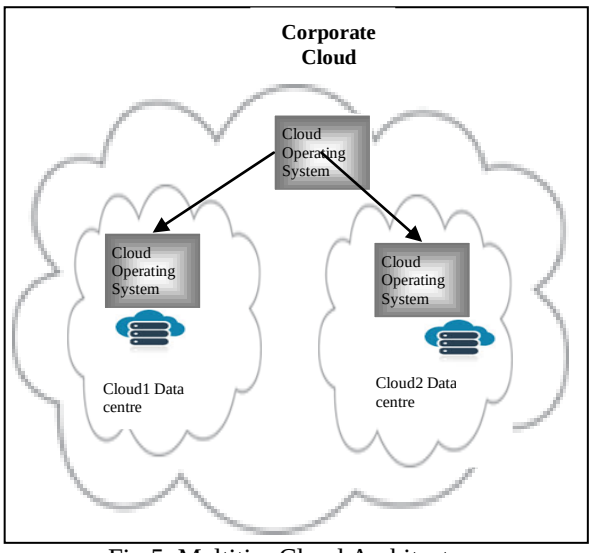

Fig.5. Multitier Cloud Architecture

In tightly coupled federations, the clouds are managed by the same OS possibly because they belong to the same organization. Partially coupled federation consists of the partner clouds governed by some agreement for resource sharing. The service providers may be similar entity or a public service provider. Federation manager provides mechanism managing virtual resources in the remote clouds by performing following functions:

- Authenticating the users of remote cloud
- Access control for remote resource
- Deployment of virtual resources
- Dynamic management of resources
- Termination of virtual resources

A federation manager may be of various types. Design of a federation manager depends on the cloud federation type and the level of interoperability. It is implemented as part of cloud operating system and support architectures at the infrastructure level.

III. CHALLENGES IN FEDERATED CLOUDS

The cloud service providers and brokers are facing challenges in providing and managing federated cloud systems as mentioned below:

A. Interface: Various cloud service providers have different APIs, pricing models and cloud infrastructure. Open cloud computing interface is necessary to be initiated to provide a common application programming interface for multiple cloud environments. The simplest solution is to use a software component that allows the federated system to connect with a given cloud environment. Another solution can be to perform the federation at Infrastructure level and not at application or service level.

B. Networking: Virtual machines in the cloud may be located in different network architectures using different addressing schemes. To interconnect these VMs a virtual network can be formed on the underlying physical network with uniform IP addressing scheme. When services are running on remote clouds, main concern is security of the sensitive strategic information running on remote cloud.

C. Heterogeneity of resource: Each cloud service providers offers different VMs with varying processing memory and storage capacity resulting in unbalanced processing load and system instability [4]. It is likely that the cloud owner will purchase latest models of hardware available at the time of purchase while it is unlikely to retire the older model nodes until their useful life is over. This creates heterogeneity [6].

IV. CONCLUSION

Cloud federation is still an emerging topic and the research community is not aware of the possible impact of cloud federation on the future of clouds. However, cloud federation might have a great influence on the way computing resources and applications will be developed and used. We have presented various cloud federation architecture and also explored the challenges of building a cloud federation like sharing and heterogeneous processing due to variety of resource usage patterns employed, variety of data types stored, and the variety of query processing interfaces presented by those systems.

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