

An Insight into Intercloud Topology and Interoperability

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ABSTRACT: The Intercloud is an interconnected global "cloud of clouds" and an extension of the Internet "network of networks" on which it is based. It became popular and has also been used to describe the datacenter of the future. The Intercloud scenario is based on the key concept that each single cloud does not have infinite physical resources or ubiquitous geographic footprint. The Intercloud scenario would address such situations where each cloud would use the computational, storage, or any kind of resource (through semantic resource descriptions, and open federation) of the infrastructures of other clouds. This is analogous to the way the Internet works, in that a service provider to which an endpoint is attached, will access or deliver traffic from/to source/destination addresses outside of its service area by using Internet routing protocols with other service providers with whom it has a pre-arranged exchange or peering relationship. It is also analogous to the way mobile operators implement roaming and inter-carrier interoperability. This paper gives a glance at Intercloud Topology and Intercloud Interoperability.

KEYWORDS: parallel, Distributed, Cloud, virtual computers, Computing, Resources, Service, Multi-Cloud, Inter-Cloud, Topology and Ontology..

1. INTRODUCTION

The cloud is the service being delivered from remote sites. As public and private industry budgets continue to shrink, executives are plotting new strategies to become more efficient and cost effective. Cloud computing has gleaned a lot of attention over the past several years as a means to reduce IT expenditures, improve scalability and reduce administration overhead. As savings amount and efficiencies increase, cloud computing will continue to grow. Most of the enterprises are already operating their applications or infrastructure in a cloud environment. Now a day's most of the personal and general purpose services are also provided to personal cloud user by the cloud service providers. Up to 2015 the top 10 cloud services^[1] are Rack space, Amazon Web Services(AWS), Site Ground, Storm On Demand, Microsoft Azure, Digital Ocean, Liquid web, Net magic Solutions, Ctrls and Servint.

1.1. Definition of cloud Computing

The National Institute of Standards and Technology has defined Cloud computing^[2] as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". (Mell&Grance, 2011, p. 2). There is little consensus on how to define the Cloud and I add yet another definition^{[3][4]} to the already saturated list of definitions for Cloud Computing:

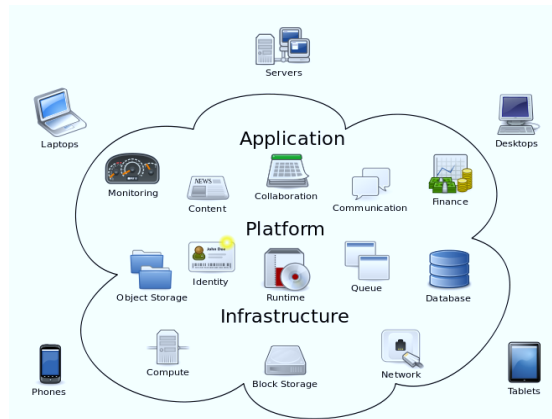


Figure 1: Cloud Computing Layout Diagram

A large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the internet.

Cloud Computing is anything that provides hosted services over the internet^[5]. These services are shared to the end users. The main uses of cloud are data storage, process and management services on the internet rather than having local servers. The service provider has to look up all the issues related to the cloud. The end-user doesn't require any server to maintain, simply requesting the services from the cloud and pay for using it. Fig.1 depicts the cloud computing layout diagram.

II. CLOUD COMPUTING ENVIRONMENT

NIST also defines five key and essential characteristics, three service models and four deployment models are shown in below^[2].

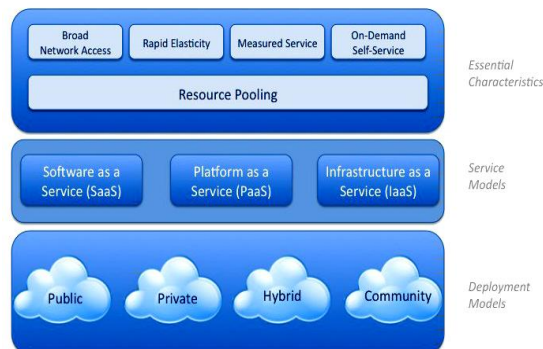


Figure 2: NIST defined Essential characteristics, Service models and Deployment models.

2.2. Characteristics of Cloud

According to National Institute of Standard Technology^[2](NIST, U.S.Department of Commerce), cloud has five essential characteristics as follows.

1. On demand self service

2. Broad network access
3. Resource pooling
4. Rapid elasticity
5. Measured service

NIST categorizes Cloud computing into a Service Model and a Deployment Model.

III. INTRODUCTION TO INTER-CLOUD

3.1. What is Intercloud?

The Intercloud^[6] is an interconnected global "cloud of clouds" and an extension of the Internet "network of networks" on which it is based.^[7] The term was first used in the context of cloud computing in 2007 when Kevin Kelly opined that "eventually we'll have the intercloud, the cloud of clouds". It became popular in late 2008 and has also been used to describe the datacenter of the future.^[8] The Intercloud scenario is based on the key concept that each single cloud does not have infinite physical resources or ubiquitous geographic footprint. If a cloud saturates the computational and storage resources of its infrastructure, or is requested to use resources in a geography where it has no footprint, it would still be able to satisfy such requests for service allocations sent from its clients. The Intercloud scenario would address such situations where each cloud would use the computational, storage, or any kind of resource (through semantic resource descriptions, and open federation) of the infrastructures of other clouds. This is analogous to the way the Internet works, in that a service provider, to which an endpoint is attached, will access or deliver traffic from/to source/destination addresses outside of its service area by using Internet routing protocols with other service providers with whom it has a pre-arranged exchange or peering relationship. It is also analogous to the way mobile operators implement roaming and inter-carrier interoperability. Such forms of cloud exchange, peering, or roaming may introduce new business opportunities among cloud providers if they manage to go beyond the theoretical framework.^[9]

3.2. Intercloud definition

Inter-cloud or 'cloud of clouds' is a term that refers to a theoretical model for cloud computing services based on the idea of combining many different individual clouds into one seamless mass in terms of on-demand operations. The inter-cloud would simply make sure that a cloud could use resources beyond its reach, by taking advantage of pre-existing contracts with other cloud providers. Cisco inter-cloud strategy is shown below.

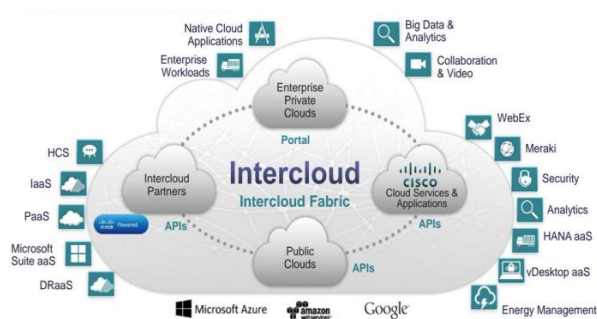


Figure 4: Cisco Inter-cloud Strategy

Essentially, an Inter-Cloud allows for the dynamic coordination and distribution of load among a set of cloud data centers^[13] - see figure 5.

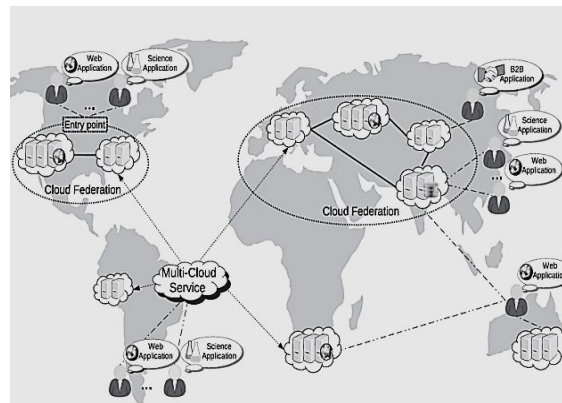


Figure 5. Overviews of Inter-Cloud approaches and use cases.

IV. INTERCLOUD INTEROPERABILITY

Currently, Intercloud computing is an emerging computation paradigm in the area of cloud computing. Although Intercloud Computing shared cloud a service has been increasingly utilized by diverse users, the research on Intercloud computing is still at an early stage. There are many challenges that have not been fully addressed in Intercloud Computing in addition to the new emerging issues introduced by enterprise applications. One of the existence challenges is the Intercloud Interoperability issue.

Intercloud addresses the interoperability between various cloud computing instantiations where each cloud would use computing resources of other clouds. Cloud Computing environments need to be interoperable in order to reduce scaling/producing cost within the development of the components. Cloud costumers should be able to migrate in and out of the cloud and switch between providers based on their needs, without a lock-in which restricts customers from selecting an alternative provider. Furthermore, cloud providers should be able to interoperate among themselves to find an alternative cloud provider to give better services. The present Intercloud network merely connects different cloud systems and each cloud provider has its own way on how cloud applications/customers interact with the cloud. Fieldhouse^[16] summarized the current challenges in Cloud Interoperability as follow:

- Several different Cloud Standards from different parties are available.
- Existing Open Grid Forum (OGF) standards not or only partly ready for the cloud.
- A consistent OGF Cloud Portfolio is needed.
- Strategies for combining different Cloud Standards / APIs are needed.
- Existing implementations of Cloud APIs need to get interoperable.
- Combined Interoperability Verification Suites need to be developed.
- It is essential to discuss on issues related to specifications and implementation.

Currently different organizations, such as IEEE, are working on developing essential standards and appropriate APIs for Intercloud Interoperability. The future Intercloud network will expand the required functions to prepare collaboration among cloud services. Grozev&Buyya summarized their studies and classified 20 major Intercloud developments including both academic and industry projects^[17]. According to their studies, Intercloud is classified as *Volunteer federation* and *Independent* shown in the figure 6.

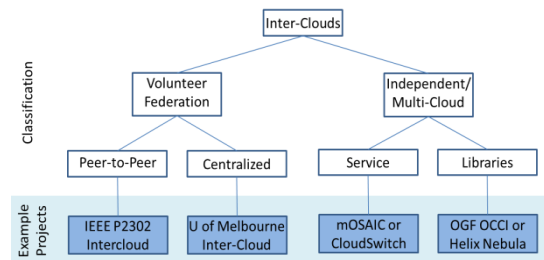


Figure 6. Architectural classification of Intercloud^[17].

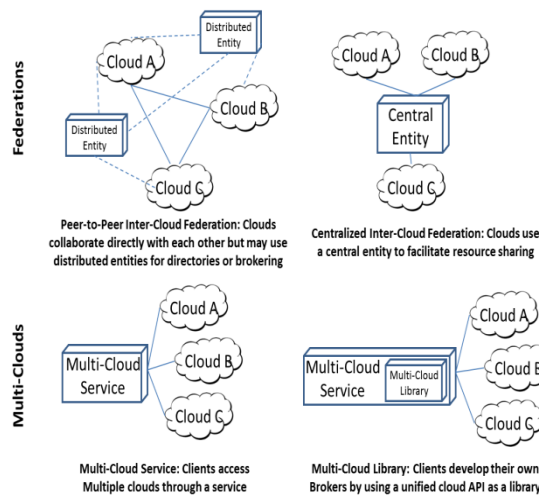


Figure 7: Intercloud developments' architecture.

1. *Volunteer federation*: when there is voluntarily collaboration between cloud providers that is often feasible for governmental clouds or private cloud portfolios and is classified as two architectural categories *Centralised & Peer-to-Peer* as in figure 7.
2. *Independent*: when an application or its broker independently from the cloud providers (both governmentally and private clouds) exploit multiple clouds and is classified in two architectural categories *Services & Libraries* as in figure 7.

V. INTERCLOUD TOPOLOGY

Cloud instances must be able to dialog with each other. One cloud must be able to find one or more other clouds, which for a particular interoperability scenario is ready, willing, and able to accept an interoperability transaction with and furthermore, exchanging whatever subscription or usage related information which might have been needed as a pre-cursor to the transaction. Thus, an Intercloud Protocol for presence and messaging needs to exist which can support the 1-to-1, 1-to-many, and many-to-many Cloud to Cloud use cases. The vision and topology for the Intercloud we will refer to is as follows. At the highest level, the analogy is with the Internet itself: in a world of TCP/IP and the WWW, data is ubiquitous and interoperable in a network of networks known as the "Internet"; in a world of Cloud Computing, content, storage and computing is ubiquitous and interoperable in a network of Clouds known as the "Intercloud"; this is illustrated in Figure 8.

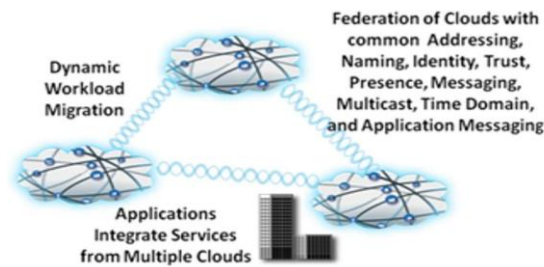


Figure 8. The Intercloud Vision

The reference topology for realizing this vision is modelled after the public Internet infrastructure. Again, using the generally accepted terminology^{[18][19][20][21]}, there are Public Clouds, which are analogous to ISP's and Service Providers offering routed IP in the Internet world. There are Private Clouds which is simply a Cloud which an organization builds to serve itself.

There are Intercloud Exchanges (analogous to Internet Exchanges and Peering Points) where clouds can interoperate, and there is an Intercloud Root, containing services such as Naming Authority, Trust Authority, Directory Services, and other "root" capabilities. It is envisioned that the Intercloud root is of course physically not a single entity, a global replicating and hierarchical system similar to DNS^[23] would be utilized. All elements in the Intercloud topology containsome gateway capability analogous to an Internet Router, implementing Intercloud protocols in order to participate in Intercloud interoperability. We call these Intercloud Gateways. The entire topology is detailed in Figure 9.

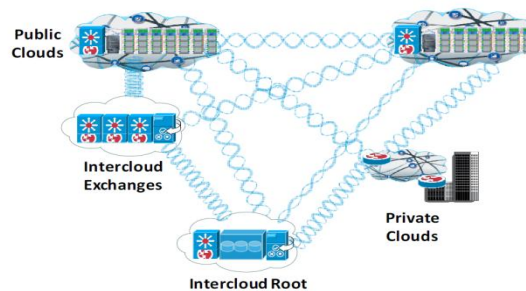


Figure 9: Reference Intercloud Topology

The Intercloud Gateways would provide mechanism for supporting the entire profile of Intercloud protocols and standards. The Intercloud Root and Intercloud Exchanges would facilitate and mediate the initial Intercloud negotiating process among Clouds. Once the initial negotiating process is completed, each of these Cloud instance would collaborate directly with each other via a protocol and transport appropriate for the interoperability action at hand; for example, a reliable protocol might be needed for transaction integrity, or a high speed streaming protocol might be needed optimized for data movement over a particular link.

5.1. Intercloud Root, Exchanges, and Catalog

Various providers will emerge in the enablement of the Intercloud. We first envision a community governed set of Intercloud Root providers who will act as brokers and host the Cloud Computing Resource Catalogs for the Intercloud computing resources. They would be governed in a similar way in which DNS, Top Level Domains^[24] or Certificate Authorities^[25] are, by an organization such as ISOC^[26] or ICANN^[27]. They would also be responsible for mediating the trust based federated security among disparate clouds by acting as Security Trust Service providers using standards such as SASL^[28] and SAML^[29].

5.1.1 Intercloud Root: The Intercloud Root instances will work with Intercloud Exchanges to solve the n2 problem by facilitating as mediators for enabling connectivity among disparate cloud environments. This is a much preferred alternative to each cloud vendor establishing connectivity and collaboration among themselves (point-to-point), which would not scale physically or in a business sense.

5.1.2 Intercloud Exchanges: Intercloud Exchange providers will facilitate the negotiation dialog and collaboration among disparate heterogeneous cloud environments, working in concert with Intercloud Root instances as described previously^[22]. Intercloud Root instances will host the root XMPP servers containing all presence information for Intercloud Root instances, Intercloud Exchange Instances, and Internet visible Intercloud capable Cloud instances. Intercloud Exchanges will host second-tier XMPP servers. Individual Intercloud capable Clouds will communicate with each other, as XMPP clients, via XMPP server environment hosted by Intercloud Roots and Intercloud Exchanges.

5.1.3 Intercloud Catalog: In order for the Intercloud capable Cloud instances to federate or otherwise interoperate resources, a Cloud Computing Resources Catalog system is necessary infrastructure. This catalog is the holistic and abstracted view of the computing resources across disparate cloud environments. Individual clouds will, in turn, will utilize this catalog in order to identify matching cloud resources by applying certain Preferences and Constraints to the resources in the computing resources catalog. The technologies to use for this are based on the Semantic Web which provides for a way to add "meaning and relatedness" to objects on the Web. To accomplish this, one defines a system for normalizing meaning across terminology, or Properties. This normalization is called Ontology.

5.2. Ontology based Cloud Computing Resources Catalog

The Intercloud system not only focuses on the provisioning of computing resources inside a single cloud; it provides a holistic and abstracted view of the computing resources across disparate cloud environments. Participating cloud providers will advertise their resource capabilities within the cloud computing resources catalog hosted by Intercloud Root Providers. Management of the thousands of resources and configurations requires careful control and planning to achieve business objectives and avoid errors. The chief objectives of the planned configuration are to provide cost effective use of computing resources and to meet the business objectives of the enterprise. In order to automate an environment whereby software agents versus traditional human users discover and consume services, intelligent ontology based service registries are needed for dynamically discovering and provisioning computing resources across various computing cloud environments (Amazon, Azure etc.etc.).

Comprehensive semantic descriptions of services are essential to exploit them in their full potential. That is discovering them dynamically, and enabling automated service negotiation, composition and monitoring. These semantic mechanisms currently available in service registries such as UDDI^[30] are based on taxonomies called "tModel"^[31]. tModel fails to provide the means to achieve this, as they do not support semantic discovery of services^{[32][33]}. tModel supports a construct which serves two purposes: it can serve as a namespace for a taxonomy or as a proxy for a technical specification that lives outside the registry. Such a tModel construct has some intrinsic limitations, for example classifications for the Intercloud use case can also be defined for individual operations or their argument types. However, this requires searching mechanisms for services that are distinct from those for their argument types. Likewise, tModel's reference to an external technical specification, as applied in UDDI also implies that a different mechanism is required for reasoning over service interfaces.

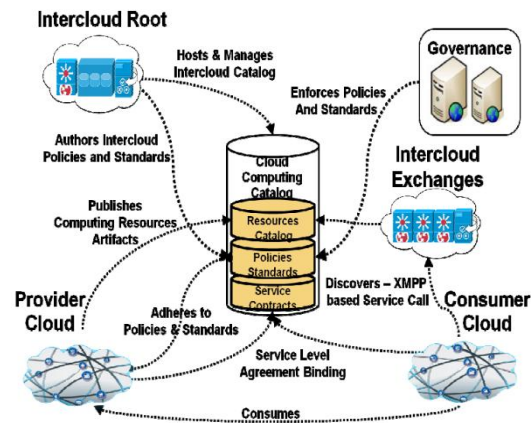


Figure 10. Cloud Computing Catalog

Although the terms “taxonomy” and “ontology” are sometimes used interchangeably, there is a critical difference. Taxonomy indicates only class/subclass relationship whereas Ontology describes a domain completely. The essential mechanisms that ontology languages provide include their formal specification (which allows them to be queried) and their ability to define properties of classes. Through these properties, very accurate descriptions of services can be defined and services can be related to other services or resources. We are proposing a new and improved service directory on the lines of UDDI but based on RDF/OWL^[34] ontology framework instead of current tModel based taxonomy framework. This catalog captures the computing resources across all clouds in terms of “Capabilities”, “Structural Relationships” and Policies (Preferences and Constraints).

VII. CONCLUSION

As of June 2015, The Intercloud has yet to show real world demonstration of federation and interoperability, and challenges remain regarding security and trust, governance and legal issues, QoS, monitoring, arbitration, and billing. The Intercloud is the only solution to the clouds to provide the unlimited services with no barriers by giving flexibility to the users. Here I give a glance on Intercloud issues and are still under research and development led by the major companies like CISCO pumped with billions of funds.

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BIOGRAPHY



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