Design Considerations of Media Cloud Storage & Inter-Cloud Architecture

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***Abstract*—The rapid increase in digital content, specially multimedia, calls now for standardization of Media Cloud and Inter-Cloud computing, for better provisioning of services. Inter-Cloud computing faces some key challenges in terms of handling multimedia, which are discussed in this paper along with our research status towards their solutions. We also present Inter-Cloud basic architecture and Media Cloud storage design considerations. Some key findings on storage heterogeneity are also part of this paper.**

***Index Terms*—Inter-cloud computing; media cloud; cloud federation; cloud storage.**

I. Introduction

Digital media has convincingly surpassed traditional media, as a result of which this trend makes big and possibly long-term changes to the contents being exchanged over the Internet. The global Internet video traffic had surpassed global peer-to-peer (P2P) traffic in 2010 [1]. Excluding the amount of video exchanged through P2P file sharing, at the time being, Internet video is 40 percent of consumer Internet traffic. By 2012, it was over 50 percent and will reach 62 percent by the end of 2015. If all forms of video are counted, the number will be approximately 90 percent by 2015 [1]. To meet the great opportunities and challenges coming along with media revolution, sophisticated technology and better facilities with more powerful capabilities have become the most urgent demands.

Since different types of digital media contents can be produced and disseminated across different networks, so a standard mechanism is required to allow interoperability between clouds and transcoding of media contents [2]. Purpose of media cloud is to address this problem and to allow users constitute a cloud and manage media content transparently, even if it is located outside the user's domain. For service discovery and creating more services, communication between two or more clouds becomes necessary. This is called Inter-cloud computing. But with Inter-cloud computing, handling media contents will be an issue. Handling multimedia does not only mean transcoding of different media contents into interoperable form, but also to be able to communicate multimedia according to the quality and type of content the user wants.

This paper discusses about the architecture of Inter-Cloud computing and Media Cloud, along with the key challenges faced in Inter-cloud computing and Media Cloud. We also discuss some of the solutions and our already done work.

II. Inter-Cloud and Media Cloud Communication

Communication of two or more clouds with each other is known as Inter-cloud computing. When there are many clouds existing with multimedia content, clouds should be able to communicate with each other, creating inter-cloud computing scenario. This is also important to meet the increasing demands as diverse type of requirements can be made by the user, which may not be offered by one single cloud. To meet the requirement, one cloud has to request another cloud or multiple clouds. Other than this, cloud should be able to discover services available elsewhere. This inter-cloud computing will create a 'Cloud of Clouds' (CoC), being able to communicate the data that is not stored by its datacenters directly. For this, cloud interoperability must be in a standardized way. Standardized way of service level agreement (SLA) must be made part of it. Inter-cloud Protocol, with the support of 1-to-1, 1-to-many, and many-to-many cloud to cloud communication and messaging must exist. Some of the basics on inter-cloud are presented in [3]. To start with, first the entities are to be defined.

A. Inter-Cloud Communication Entities

Inter-Cloud communication involves four entities, which are explained below.

1). Cloud service provider

Cloud Service Provider provides cloud services to the Cloud Service Customer, Cloud Service Partner, and other Cloud Service Providers. Provider may be operating from within the data center, outside, or both. Cloud Service Provider has the roles of: cloud service administrator, cloud service manager, business manager, and security & risk manager.

The sub-roles of cloud service provider include: inter-cloud provider, deployment manager, and customer support & care representative.

2). Cloud service customer

Cloud Service Customer in that entity which uses cloud services and has a business relationship with the Cloud Service Provider. The roles of Cloud Service Customer are: cloud service user, customer cloud service administrator, customer business manager, and customer cloud service integrator.

3). Cloud service partner

Cloud service partner is kind of a third party which provides auxiliary roles, which are beyond the scope of cloud service provider and cloud service customer. Cloud service partner has the roles of Cloud Developer, Auditor, and Cloud Broker.

In a broad sense, Cloud Developer develops services for other entities, like Cloud Service Customer and Cloud Service Provider. Among the roles, Cloud Developer performs the tasks of designing, developing, testing, and maintaining the cloud service. Among the sub-roles, Cloud Developer performs as Service Integrator and Service Component Developer.

Cloud Auditor performs the audit of the provision and use of cloud services. Since service provider and service customer are separate entities, so the service quality, usage behavior, and conformance to SLA, all this has to be audited by the third party having the role of Auditor.

Cloud Broker offers business and relationship services to Cloud Service Customers to evaluate and select Cloud Service Providers, according to their needs. Negotiating between provider and customer is among the main roles of Cloud Broker, other than interoperability operations.

4). Cloud service carrier

Cloud carrier is an intermediary that provides connectivity and transport of cloud services, from cloud providers to cloud customers. With the role of Cloud network provider it provides network connectivity and related services. It may operate within the date center, outside of it, or both. It provides network connectivity, provides other network related services, and manages the services.

B. Inter-cloud TopologyElements

Inter-cloud computing involves three basic entities, which are explained in this part of the article.

1) Inter-cloud Exchanges

Inter-cloud Exchanges are those entities which are capable of introducing attributes of cloud environment for inter-cloud computing.

2) Inter-cloud Root

Inter-cloud Root contains services like, Naming Authority, Directory Services, Trust Authority, etc. it is physically not a single entity, but a DNS-like global replicating and hierarchical system. It may also act as broker.

3) Inter-cloud Gateway

It is a router that implements Inter-cloud protocols and allows Inter-cloud interoperability. It provides mechanism for supporting the entire profile of Inter-cloud protocols and standards.

C. Inter-cloud scenarios

Communication between cloud service customer and cloud service provider(s) can take place in two ways: (a). with broker and (b). without broker. The main purpose of the broker is assisting the customer to find the best provider and the service, according to customer's needs, with respect to specified SLA and providing with a uniform interface to manage and observe the deployed services. Shown in figure 1, Cloud Broker includes application programming interfaces (APIs) and a standard abstract API, which is used to manage cloud resources from different cloud providers. Cloud Broker holds another abstract API for the negotiation of cloud service facilities with the customer.

This access of services can be direct, between cloud service customer and cloud service provider(s). In that case, the interoperability and transcoding related things are handled by the customer itself. Figure 1 shows the architecture of broker and both of the communication scenarios in detail.

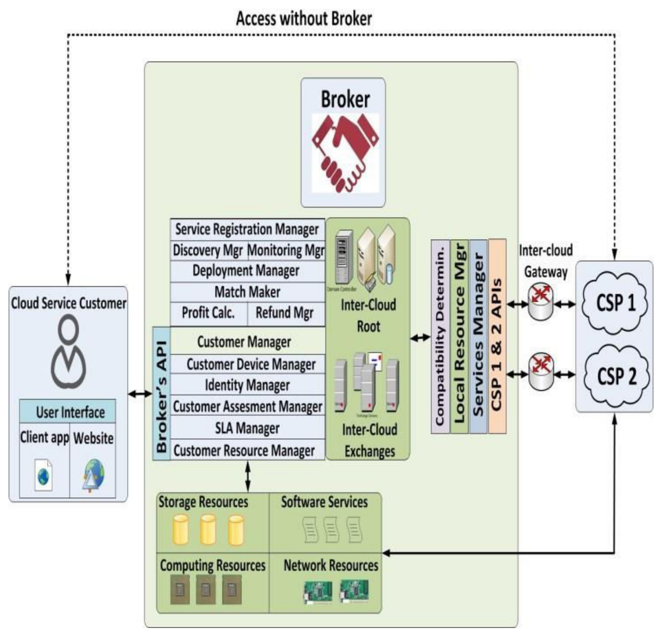

Figure 1: Inter-cloud broker architecture and communication scenarios.

D. Inter-cloud computing protocols

For different types of communications, different Inter-cloud protocols are used [4] [5]. According to their type and extent of use, they are discussed here.

1) Basic communication

"Extensible Messaging and Presence Protocol (XMPP) for basic communication, transport, and using Semantic Web techniques such as Resource Description Framework (RDF) to specify resources." [4]. XMPP is an eXtensible Markup Language (XML) based communications protocol, for message-oriented middleware. XMPP is for near real-time instant messaging (IM), presence information, and contact list maintenance. As it is 'extensible', it has also been used for VoIP signaling, gaming, videos, file transfer, publish-subscribe systems, and Internet of Things applications, such as the smart grid and social networking services. RDF is a 'metadata' data model, which is used as a general method for conceptual description or modeling of information, implemented in web resources using various syntax notations and data serialization formats.

2) Services framework

On top of the base XMPP, one of its extensions, XEP-0244, provides a services framework for M2M communications, named IO Data. XEP-0244 is designed for sending messages from one computer to another, providing a transport for remote service invocation. It also overcomes the problems with SOAP and REST.

3) Authentication and encryption

Transport Layer Security (TLS) is used for communication security over the Internet. Simple Authentication and Security Layer (SASL) is used for authentication purpose. Streams are first secured with TLS, before completing the authentication through SASL. SASL authenticates a stream by means of an XMPP-specific profile of the protocol. SASL adds authentication support in a generalized way to connection-based protocols. Security Assertion Markup Language (SAML) provides authentication services for cloud federation scenario, but it is still not fully supported in XMPP-specific profiles.

4) Identity and access management

SAML is particularly used for authentication and authorization between identity provider and service provider. A significance SAML has in this regard is web browser single sign-on (SSO) mechanism. SSO provides access control of multiple independent but related software systems. Its counter action is single sign-off, which disallows access to multiple services with one action at once, hence saving time and effort. eXtensible Access Control Markup Language (XACML) is also used for access control. It evaluates access requests according to the rules already defined in policies. XACML is more useful in inter-cloud scenarios, where it provides common terminology and interoperability between access control implementations by multiple service providers or vendors.

5) Exchange service directory

RDF is used for resource allocation, such as, storage and processing, in inter-cloud environment, while SPARQL Protocol and RDF Query Language (SPARQL) is a query/matching service for RDF. SPARQL can retrieve and manipulate data in RDF format. When a request is made, it invokes a SPARQL query over an XMPP connection to the Inter-cloud Root, to apply the constraints and preferences to the computing semantics catalog, where it is determined whether the service description on another cloud are according to the requirements of the first cloud.

6) Media related communication

H.264/MPEG4 (Motion Picture Experts Group) or also known as Advanced Video Coding (AVC), is one the most commonly used coding scheme for high quality video recording, compression, and distribution. Because of its Block Motion Compensation (BMC) feature, it is also the most widely used encoding scheme by Internet streaming video services, like, YouTube, Vimeo, iTunes, etc. and also in web-based softwares, like, Adobe Flash Player and Microsoft Silverlight. H.264 supports both lossy and loss-less compressions, so it is suited for Internet streaming services, in which, streaming quality can be dynamically decided based on the condition of the network or user's link. For the delivery of streamed media, Real Time Streaming Protocol (RTSP) is used. RTSP is responsible for establishing and maintaining sessions between two endpoints, while streaming of content is performed by Real-time Transport Protocol (RTP) along with Real Time Control Protocol (RTCP), which is responsible for providing statistics and control information to RTP flows.

III. Inter-Cloud Computing Challenges

This section presents the key challenges faced by Inter-Cloud computing.

1) Heterogeneous media contents and media transcoding

Very diverse types of services are available in the media cloud arena, making transcoding and content presentation an area of concern. Services like, Video on Demand (VoD), IPTV, Voice over IP (VoIP), Time Shifted Television (TSTV), Pause Live Television (PLTV), Remote Storage Digital Video Recorder (RSDVR), Network Personal Video Recorder (nPVR), and the increasing social media content requires a lot of effort in this regard.

2) Heterogeneous QoS requirements and QoS provisioning mechanisms

Depending upon the access network, condition of core network, the requesting device, user's needs, and type of service, heterogeneous QoS requirements can be made. Dynamic QoS provisioning schemes needs to be implemented in this regard. We have worked on it in detail in our study presented in [6].

3) Data/media sanitization

When a client requests for storage space from the cloud, it does not mean that 'any' type of data can now be stored. Data has to be filtered. Some of the cloud storage service providers do not allow some specific type of data to be stored, like pornographic material. One of such services is Microsoft SkyDrive.

4) Security and trust model

Outsourced data poses new security risks in terms of correctness and privacy of the data in cloud [8]. When we talk about media cloud, not only data service will be requested by the user, but also, storage service would also be requested. Storing contents, which may have some sensitive or private information, poses risks to the customers. Some of the details are presented in our work in [7] and [9].

5) Heterogeneous Internet Protocols

IPv4 address space has exhausted. Migration towards IPv6 has formally been expedited. Both of these versions of IP are not directly interoperable. Since this complete migration is going to take some time, may be a decade [10], so both the versions of IP are made to interoperate though some means. Tunneling is the viable solution in hand, but it has its own overhead. We have worked extensively on this and presented our findings in [10].

6) Heterogeneous media storage technologies

Storage is an important part. Multimedia content requires a lot of space. Efficiency in storage and searching is an important aspect media cloud should have. Different storage technologies available are Network Attached Storage (NAS), Direct

Attached Storage (DAS), Fiber Channel (FC), Fiber Channel over IP (FCIP), Internet Fiber Channel Protocol (iFCP), Content Addressed Storage (CAS) or Fixed Content Storage (FCS), and Internet Small Computer Systems Interface (iSCSI). Communication between clouds creates inefficiency when different storage technologies are provided by the service providers. The difference in storage space efficiency of some of the noteworthy cloud storage services is presented in section IV.

IV. Current Research Status

Storage of multimedia content plays a very vital role in this regard. Storage technology has to be standardized to ensure efficiency of coding-decoding and storage space. In a study we conducted on media cloud storage, it was evaluated that different cloud storage services use different storage schemes which affect the size of stored data, its presentation, and quality. This study was done extensively on various parameters, but only few of most relevant results are presented in this section. Six noteworthy cloud storage services, namely, Dropbox, GoogleDrive, Amazon CloudDrive, SugarSync, Microsoft SkyDrive, and Box were selected for this part of study. Results were gathered in Korea as well as in Pakistan, on same machine and type of access network. A lot depends upon the network condition, user's trend of usage on weekdays and weekends, and the current load on storage server, when the results are being gathered. So, to ensure the reliability of results, we gathered multiple samples during different times of the day, on weekdays as well as weekends. In both the countries, this process of gathering results was stretched to around six weekends and up to six weeks, in which different weekdays were chosen to conduct the study, on different times of the days. Accumulated results were then averaged, presented in figure 2 and 3. We used bulk data and HD multimedia content to let cloud service use its maximum resources. Otherwise, QoE and QoS could not be analyzed. Figure 2(a) presents upload delay for a 20MB file for each cloud service. Fig. 2(b) shows jitter for video playback. Figure 3 shows difference in stored data size for Bulk-data. It shows how much a particular service is using efficient encoding scheme (by decreasing the actual size) to store data. Fig. 3(a) shows stored data size efficiency for 50MB data, while 3(b) shows on 100MB data set. For even larger sized data, this will affect the performance more. Amazon CloudDrive does not provide file download, while GoogleDrive does not allow folder download. So their evaluation on respective parameters could not be done.

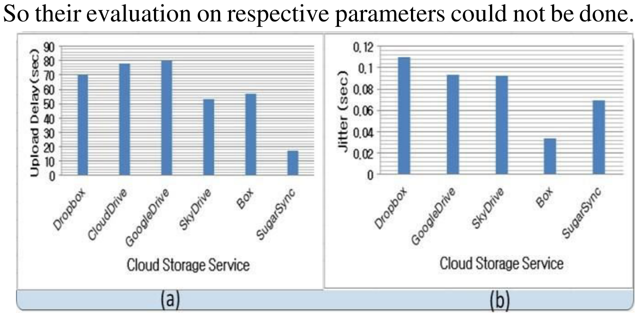

Figure 2: (a). Upload Delay, (b). Jitter of cloud storage services.

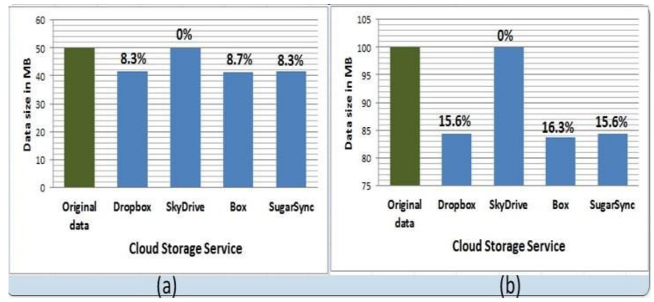

Figure 3: Storage size efficiency on (a) 50MB and (b) 100MB data sets.

V. Conclusion and Future Work

This study focuses on the importance of standardization of Inter-cloud and Media Cloud. We have discussed the architecture of Inter-Cloud computing and storage related design considerations for Media Cloud. Some of the most prominent issues and their solutions are also presented here and we have discussed the current status of our research as well. Currently, we are working on Media Cloud storage and its standardization. Some of the initial results are presented here, which will be extended in future.

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