MEDIA CLOUD: WHEN MEDIA REVOLUTION MEETS RISE OF CLOUD COMPUTING

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Abstract:* Media content has become the major traffic of Internet and will keep on increasing rapidly. Various innovative media applications, services, devices have emerged and people tend to consume more media contents. We are meeting a media revolution. But media processing requires great capacity and capability of computing resources. Meanwhile cloud computing has emerged as a prosperous technology and the cloud computing platform has become a fundamental facility providing various services, great computing power, massive storage and bandwidth with modest cost. The integration of cloud computing and media processing is therefore a natural choice for both of them, and hence comes forth the media cloud. In this paper we make a comprehensive overview on the recent media cloud research work. We first discuss the challenges of the media cloud, and then summarize its architecture, the processing, and its storage and delivery mechanisms. As the result, we propose a new architecture for the media cloud. At the end of this paper, we make suggestions on how to build a media cloud and propose several future research topics as the conclusion.

I. INTRODUCTION

We are witnessing a media revolution. Not only the rich and varied types of media are being used, but also the enormous tide of media utilization is coming. Today's users take the advantage of the rapid growth in Wi-Fi, 3G, 4G, fiber to the home and so on to access and share various resources through Internet at any time, from anywhere in high speed. It has changed and is changing users' pattern of information acquisition and life style. They use social networks, internet radio and television, on-demand video, eBook, online or mobile instant text, voice and video message, and other plenty of newly emerging media. "They are increasingly willing to sample and consume both new and traditional types of content online and on-the-go" [1]. It seems that digital media and the internet have already begun to challenge the conventional media. As a result, this trend makes explosive and possibly long- term changes to the contents being exchanged over the internet. In "Cisco Visual Networking Index – Forecast and Methodology, 2010–2015" [2], it states that global Internet video traffic, for the first time, surpassed global peer-to-peer (P2P) traffic in 2010. Not including the amount of video exchanged through P2P file sharing, nowadays Internet video is 40 percent of consumer Internet traffic. By 2012, it will be over 50 percent and will reach 62 percent by the end of 2015. If counting in all forms of video, the number will be approximately 90 percent by 2015[2].To meet the great opportunities and challenges coming along with media revolution, the new technology and fundamental facilities with more powerful capability have become the most urgent demands. Simultaneously the adjustments of commercial model and industry strategy are automatically necessary to adapt to these changes. Fortunately, here comes the cloud computing just in time. Cloud computing has emerged and advanced rapidly in the very recent years as a promising technology. Generally it can be seen as the integration of Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and Hardware as a Service (HaaS) [3-5]. Cloud computing platform usually provides a shared pool of highly scalable, manageable and schedulable virtual/physical servers, storage, computing power, network bandwidth and so on with modest price. It has the greatest potential to provide a long term package solution for the media revolution if deliberately designed, deployed and integrated with the advanced technologies on media storing, processing and transmission, along with the rational commercial model and industry strategy.

II. LITERATURE SURVEY

While trying to seize the great opportunities from media cloud, we are also confronting great challenges come along with the opportunities. Different research proposals address the fundamental problems and challenges from different points of view, and focus on different directions. But overall, the following could summarize the fundamental challenges:

A. Seamless integrating existing systems to the media cloud.
As a newly emerged technology, media cloud is competing with the existing media technologies and systems. The better way is to integrate and evolve smoothly instead of smashing and rebuilding. To do so, various heterogeneities need to be dealt with [6]:

- The heterogeneity of media types.
- The heterogeneity of services/clients.
- The heterogeneity of networks and devices.
- The heterogeneity of QoS requirements.
- The heterogeneity of Applications.
- Others heterogeneities.

B. The power of media cloud.
Media storage, processing, delivery, media applications, and related user behavior patterns have their own specific characteristics. Many of these characteristics could be used

to tap the potential of cloud computing, which is known as having great capacity, scalability and is waiting to be discovered. In fact, most of the previous work focused on this.

C. Making the media cloud highly scalable to adapt to new services and applications

Besides the heterogeneities that have already existed and will emerge, the media cloud needs to be able to deal with the dramatically increasing video contents: in every second, 1 million minutes of video content will cross the network in. Therefore, to be a successful media cloud platform, its architecture must be designed carefully to adapt to the continuously increasing amount of media content, and need to be adaptable for the new applications and services. Migration of a large-scale system with poor scalability to a new architecture in the future must be avoided because this will end up with unbearable cost hence not an option.

D. Finding innovative and suitable applications for media cloud

The applications around media cloud involve in various types of media services, including TV, movies, music, games, and other information and multimedia services. The most important goal of an application is to provide excellent user experience to consumers.

III. ARCHITECHTURE OF MEDIA CLOUD

Originated from different backgrounds, researchers have proposed architecture blueprints for the media cloud from different points of view provides a comprehensive industrial overview on the media cloud. In this article, Steve Poehlein and et al. point out that media cloud is the solution to suffice the dramatically increasing trends of media content and media consumption. They indicate the key elements that the media cloud should have, including IPTV, three and N-screen delivery, time and place shifting, value-added services, personalized channel, and video analytics. And the media cloud should also support the following services: storage and infrastructure management, cluster and grid management, workflow automation, state-of-the–art capabilities in a multitenant cloud environment. Media cloud architecture consisting of five components is proposed:

- Cloud administrative services.
- Ingest services which accept media input from a wide range of sources.
- Streaming services.
- Video services which manage and deliver videos across media channels to various clients.
- Storage subsystems for content cache and movement, storage, and asset management.

To reduce delay and jitter of media streaming, hence providing better QoS of multimedia services, [6] proposes a media-edge cloud (MEC) architecture. In this architecture, an MEC is a cloudlet which locates at the edge of the cloud. Within an MEC, it uses P2P technology for distributed media data storage and computation. It's composed of storage, central processing unit (CPU), and graphics processing unit (GPU) clusters. The MEC stores, processes, and transmits media data at the edge, thus achieving a shorter delay. In turn the media cloud is composed of MECs, which can be managed in a centralized or peer-to-peer (P2P) manner as showed in Fig.2. In both models, MEC distributedly holds all the content data. But with the P2P based MEC architecture, all users' media data are stored in MECs and the associated users, whereas each node uses P2P to exchange content heads and then get the content locations. Opposite to this, the central-controlled MEC architecture has a central master to maintain all the information of the associated users and content locations.

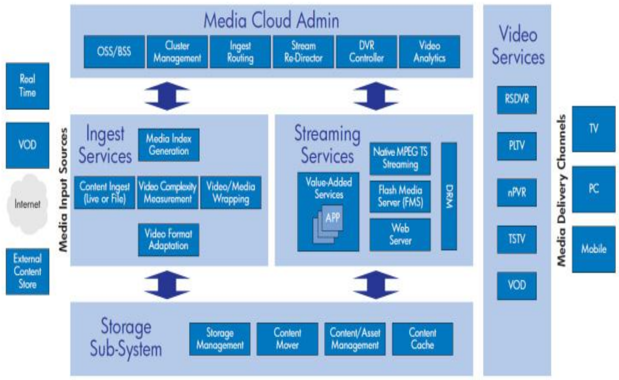

Fig 1. Functional components architecture of media cloud in [1].

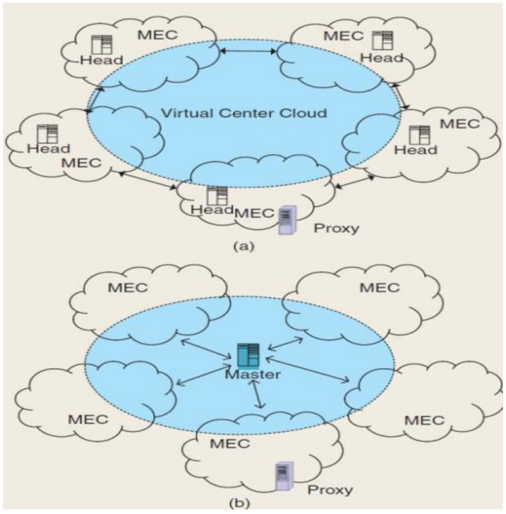

Fig 2. Architecture of (a) P2P-based MEC computing and (b) central- controlled MEC computing [6].

This architecture has three major features: 1) MECs at the edge of media cloud to reduce delay; 2) P2P technology is used both intra and inter (in P2P mode) MECs to provide scalability; 3) proxy residing at the edge of an MEC or in the gateway is used to perform multimedia and caching to compensate for mobile devices since they have limited computational power and battery life. It is not unique that proxy is adopted to seamlessly integrate media cloud with the outside world, hence provides a solution for some of the heterogeneity problems.

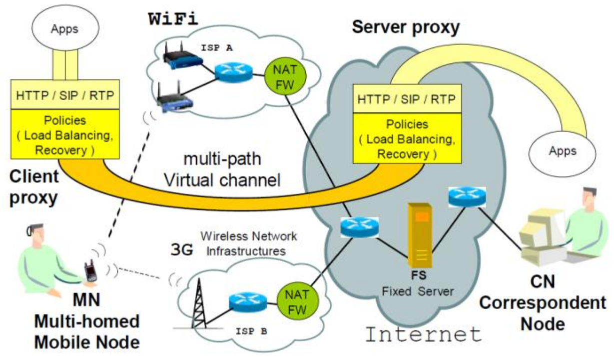

Fig 3. Client Proxy and Server Proxy in [15].

Besides sharing large amount of media with families and friends through proxy or gateway, in [16, 17] the proxy makes the content in the home cloud being able to be indexed under authorization so that the public cloud can build the search database and do the content classification. And then the media cloud provides discovery service, so that family members, friends and other users can search and find the interesting media content and access them through the proxy.

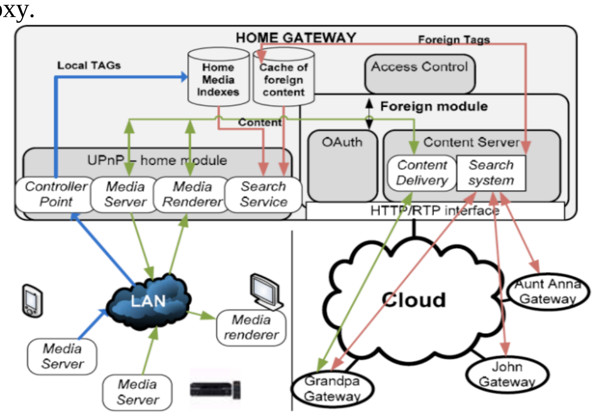

Figure 4. Home cloud proxy in [16].

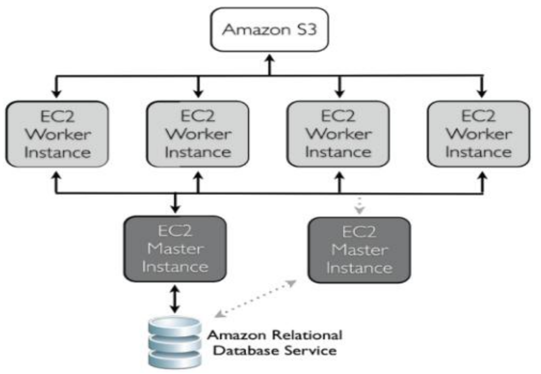

Fig 5. Split and merge architecture within public cloud in [24]

In the work of [20], it addressed points out that the fundamental question of media cloud is to configure the cloud utility to meet the highly dynamic demands of such applications at a modest cost. Based on this perception, it takes VoD as an example throughout the paper. It proposes queuing network based model, and does theoretical analysis to characterize the behaviors of users. It then finds the capacity that the media cloud should have. It does extensive evaluation for the proposed model and algorithm, and concludes that combination of cloud and P2P paradigm can achieve ultimate scalability with minimum operational costs. This paper extends the analysis results from client-server and p2p to cloud platform and has proposed the algorithms for VM provisioning and storage rental. However, the strong connections to the cloud computing and how to utilize the power of cloud computing are not fully addressed. Other work related to media cloud architecture including but not limited to: [21] proposes the concept of stream-oriented cloud and stream-oriented object, and introduces the stream-oriented cloud with a high-level description; [22] provides a high-level perspectives about mobile multimedia broadcast over cloud computing and proposes several principles on what is needed to build such a platform; and [23] describes an ongoing developing system and the preliminary work for personal rich media information management, searching and sharing.

IV. CLOUD MEDIA PROCESSING

As introduced in section I and section II, the media content over the internet tends to explosively increase in the next few years. As a solution, media cloud will be the main source and provider of media content in the near future. To deal with various heterogeneities, hence reducing the complexity and cost of the system, media cloud should transform the text, pictures, audio, video and other multimedia types into several few standard types, and then deliver the transformed media contents to the consumers in uniform formats. When building a media cloud, designers need to be more careful to design the architecture and consider the scalability. At the beginning of building the content database for the media cloud, all the media content need to be processed. But after that, only incremental processing is needed for the newly incoming media. So massive computing power is required at the initiation but might not be so urgent after building the initial cloud media database.

1) Choosing scalable coding for media format

The scalability of the media format must be considered deliberately. Since changing the format of the media stored in the cloud media requires tremendous computation resources and time. So always try to avoid this and choose the scalable format of the media at the very beginning.

2) Hybrid cloud computing and P2P

Things are different for the bandwidth usage: at the beginning of the system deployment, the bandwidth usage might not be too much; but it might be dramatically increasing after a while. In this case, the scalability of the resource rescheduling and allocation, especially for the bandwidth, must be considered carefully even before building the system. According the previous studies, the hybrid media cloud using cloud computing and P2P has more potentials. It builds more generalized, cross-internet cloud computing environment where the peers can be seen as its elastic nodes and the extension of the media cloud. The P2P technology not only can be used to deliver the media content, but also can be used to process the media content, such as transcoding, and some further processing like media character extraction for media recognition usage.

3) Improving media cloud by specializing the process unit
Like a PC, the media cloud has its own storage units, Process units, graphic process units, transmission units, and so on. In some general purpose cloud platforms, a node can be used as arbitrary type. But in media cloud, different units have very different characteristics: The storage unit stores the media content distributedly hence reduce the latency for different users located at different physical locations. The process unit uses computing power, and does data processing, hence the process unit must be close to corresponding data storage so that it can reduce the latency, energy consumption and bandwidth/coast of the transmission. Different architectures require different numbers of these units. Different units have different requirements on computation power, memory, storage, and network bandwidth. To specialize the nodes for different usage, we can greatly improve the performance while reducing the power consumption and waste of the resources, hence improving the performance and reducing the cost.

4) Using hierachial cache or pushing the frequently accessed media content to the edge of the media cloud.
To improve the overall performance of the media cloud,
And to reduce the latency and improve user experience, it is best to use hierarchical cache, or push the frequently accessed media content to the edge. If possible, distributed cache servers or datacenters should be deployed at the different location of the Internet to reduce the access latency.

5) Building a profitable media cloud? Consider more!
To make media cloud profitable, one needs to consider not only technologies and research issues, but also the business model and industry strategy. During the study of recent research works on media cloud, we find that there might be increasing disconnection between research on media cloud and business models and industrial deployment. There are many media cloud system already deployed in practice. For example, although many details of Google TV[72], Apple TV[73], Hulu [12], YouTube[74], Netflix[75], last.FM[13] , and PPLive [62], are not revealed, we can conjecture that they are evolving and migrating to media cloud. But the related research work seems to lag behind the development in industry. This could be at least partially explained by the following statements: “The challenge now is to get ahead of that change and to meet the consumption requirements of the future.” [1], and “In the coming content-driven world, smart companies are moving their media to the cloud.”[1]. so this time the industry companies seem to be faster than our researchers. However, there are still many stimulating and challenging research topics in this area to be investigated. Besides the topics and directions we discussed previously, we will list some other potentially promising directions: Home media cloud, using P2P and proxy to access and share with the world. 3D reconstruction, including the 3D construction of picture and 3D video reconstruction, which will definitely require tremendous computing resources and is very suitable for media cloud. But the result will ome content based multimedia search engine uses digital fingerprint (hash value of the content) to do matching. The work in [32] uses photo to find locations. There is a lot more to do along these directions, such as using photo or video to search related photos, videos, products, and people.

6) Protocol and standard
There are many media cloud platforms as we described above. It is better if there are standards or specifications to define the essential functions, interfaces, components, and protocols, so that the third-party developers and the end users (including companies and individuals), can easily develop the compatible modules and applications for the media cloud, and also can easily migrate their media data, applications and services to different platforms.

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