

Design of a Novel Video on Demand System in a CDN and P2P Hierarchical Overlay Network

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ABSTRACT

With the vigorous development of Internet technologies, people can already obtain the high-quality audio and video streams based on the growing network fast speed. Video on Demand (VoD) services is one of the popular Internet applications. However, the traditional centralized VoD architecture has to face a massive number of users. Equipment and network bandwidth may be the system bottlenecks, and the service blocking will be suffered. Therefore, this paper proposes a novel Video on Demand system in a CDN and P2P hierarchical overlay network. In the system, the VoD service provider just only sets up a few infrastructure. The users can share their resource for exchanging video data cooperatively. Finally, the system load of centralized servers will be reduced.

KEYWORDS

peer to peer; content delivery network; video on demand; overlay network; video stream

1 INTRODUCTION

IPTV is currently one of the popular Internet applications. Depending on the type of service, IPTV can be divided into two forms of Push-Based Live TV and Pull-Based Video on Demand (VoD).

Compared to Live TV, the latency requirement of VoD network is lower. Some VoD providers [1] use a P2P architecture to provide streaming service in order to balance the infrastructure cost and service revenue. P2P VoD allows users to not only access to services, but also provide service to others. This

way will be able to spread the load on the users, thereby reducing construction costs and increase service scale. However, the system reliability would be reduced due to the P2P churn. Each peer may leave and join the P2P network anytime.

Therefore, we proposed a combination of hierarchical P2P CDN network infrastructure. This service architecture could reduce network latency and cost by hierarchical P2P mechanism, and use CDN service to improve the issues of P2P churn.

2 RELATED WORKS

2.1 P2P System and DHT

Peer-to-Peer systems are a decentralized information-sharing system that does not exist a specific centralized server, but a location and file sharing resources are achieved by exchanging messages with peers. To compare with a centralized Client/Server mode, P2P can provide greater scalability and service scale.

For early P2P systems (such as: Napster [2]), they uses the directory server (Tracker) to help users to carry out the locators of node resources. But Tracker still faces the issue with traditional centralized architecture. Therefore, the system is coming into a pure P2P architecture [3]. User nodes link together form a logical network with mesh topology that is an overlay network.

In the overlay network, the user nodes by flooding way to the neighbor node broadcasts

or searches for information. In this way, the TTL (Time to Live) has to be set to prevent broadcast storms. Thus, due to the TTL limitation, several resource cannot be found in a large scale network.

Therefore, the distributed hash table (DHT) [4][5] was proposed to organize the user nodes. It generates a unique identification ID by Hash way for each node, so that each node is maintained on an identification ID and IP correspondence table. The nodes communicate with each other through this table to a step by step to locate resources or nodes.

2.2 P2P VoD System

P2P VoD system is to use the P2P mechanisms to achieve VoD streaming services [6]. A typical P2P VoD system provides a video list with a GUI (Graphic User Interface) or non-GUI portal. After the user selects a video, he will join the P2P video overlay network. One video group would share and exchange video data by each other. In the same time, users may watch videos and join multiple P2P video groups. The portal would inform this video Tracker location to user nodes. The video Tracker would manage the current state of the peers in the same video group, especially Seeders. The seeders can share the full video resource in the P2P group.

2.3 Content Delivery Network

Content distribution network is a network architecture to improve the traditional Client/Server model. CDN provides several local content cache server to users according users location and distribution. Users can access the content services from the near cache servers. CDN can adapt to the increase and decrease of system scale. The efficiency of content delivery would be improved. However, in a traditional centralize server, it would be the bottleneck in the network. Moreover, the issues of single point failure would be incurred.

Therefore you must purchase a higher level of server equipment or create a server cluster to provide services. However, if the user scale continue to grow up. In addition to equipment costs but also have to spend more on increasing network bandwidth. So CDN take a decentralized approach to solve this problem.

The CDN service provider would build several servers with cache function around the network edge. These servers are called edge server. According the provider strategies, these edge servers use pull-based or push-based ways from origin server to obtain services. Finally, a special CDN DNS (Domain Name System) would guide the users to access services to the appropriate edge server.

In addition to load balancing mode, CDN also take location-aware technology to determine where the users come from. According to the CDN DNS, users can access the service from the nearest edge service. The service latency would be reduced. In this way, the efficiency of network and system would be improved. Moreover, the CDN services not only provide content services for files and Web pages but also meet the real-time requirements (limited delay) for video services.

3 SYSTEM ARCHITECTURE

The system adopts P2P system as a way to share video resources. In order to improve the P2P network and the actual network delay caused by differences in the use of geographic distance similar Peer-aware technology to partition, and then through the DHT algorithm Chord [4] to form a hierarchical structure.

In addition, the system can be combined on the P2P network to spread the load and can quickly provide services with CDN. In order to improve the Seeder load, latency and resource allocation and other issues of the traditional P2P VoD systems, the overall system architecture shown

in Fig. 1. The CDN is divided into two levels of hierarchical overlay network. The hierarchical network can be divided into two sub-levels, which are stacked area network with a common network. The functions of each layer will be explained below.

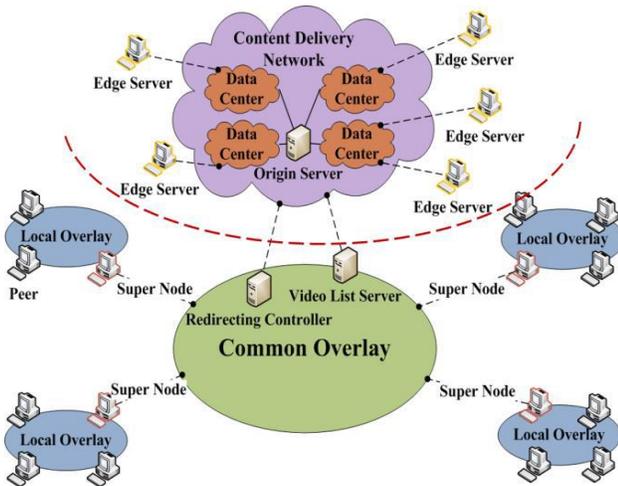


Fig. 1 The system architecture.

3.1 Hierarchical Overlay Network - Local Overlay Network

The local overlay networks are organized by geography and network status of the user who made similar, so there may be a number of different local overlay network. Users can obtain the video by using P2P resource search mechanism and CDN services.

- Peer: Peer is a user role in the system. It is also a major part to construct a local overlay network. In addition to initiating search to access resources, it also need to store information and maintain routing in local overlay network. Moreover, it has to store and cache the watched video for other peers.
- Super Node: In the local overlay network, the super node links and bridges with common overlay network with the relatively high stability of the other peers [7]. When the target resource cannot be obtained at the local overlay network, the super node will help redirect the P2P

search messages to the common overlay network. In the system, the super node would join a local overlay network and the common overlay network simultaneously.

3.2 Hierarchical Overlay Network - Common Overlay Network

The main function of this level in the local overlay network is to do further search for resources not available. The common network can not only help super nodes to search for other local overlay network but also can send a request to the CDN.

- Super Node: Super node is the main components of a common overlay network. Therefore, information must be stored in common overlay network and maintenance of the route. In addition to this, the super node also need to accept peer's commission by its local overlay network and deal with the P2P resource search across different overlay networks. Therefore, extra search mechanism and space to store "video name" is necessary to help peers to locate streaming resources. The "video name" means that the video has been played in this local overlay network. The super node not only helps peers to deal with resource search across overlay networks but also need to search the video list in this layer. The video list identifies the videos and resource states provided in the system. According to the video list, peers aware which video can be access and how to access.
- Video List Server: The node joins in common overlay network from CDN. It's not only one in system. It provides the update of video list for super node and its local overlay network.
- Redirecting Controller: The redirecting controller provided by CDN is the interface in the common overlay network. It's not only one in system. When the requested resource is not available in the

p2p local overlay network and common overlay network, the super node would redirect to request to CDN via the redirecting controller. Therefore, according the CDN DNS mechanism, the redirecting controller would guide the peers the access the video from the nearest edge server.

3.3 CDN layer

The main function of this layer is to store the original multimedia resources and provide access interface that allows users to obtain service from the nearest or lowest latency data center host.

- **Origin Server:** The server stores the original video, and all video segments are stored here. Its resources provide access only CDN devices inside, it does not provide services to end users.
- **Edge Server:** CDN mainly provide server user services. According to user requirements, Edge Server to crawl to Origin Server film resources available to the user, and at the same time staging resources. When other users require the same resources, Edge Server will be able to provide faster service. The same country or region of Edge Server cluster of data centers will be presented in a way.
- **Video List Server:** Timing acquisition to Origin Server is currently available streaming Segments and Hash access to resources ID, and then packed into the movie and the movie name list file registered to a common network stack.
- **Redirecting Controller:** According to peer's geographic information and network status, the redirecting controller is to provide suitable data centers and edge server location. The redirecting controller provides users with fast service and must maintain an area corresponding to the table with edge server. In addition, when a new user is added, the redirecting controller

also helps users to find the right local overlay network. It also play the act of bootstrap node.

4 SYSTEM MECHANISM

The system architecture is combined with CDN and P2P video streaming system. Therefore, this section will introduce how to access CDN resources through the P2P system.

4.1 Local Overlay Network for Joining

The newly added user to get information to calculate its own Special-ID through the IP localization function. And send it to redirecting controller. Redirecting controller to guide the use of the newly added user to join the appropriate local overlay network as well as the user allocated for the appropriate edge server.

4.2 Released Video Information

Video list of this system adopt using the P2P mechanism provides the user rather than portal way. Thus in addition to the list of video server can avoid to denial of Service (DoS). And it can also reduce service provider's system load.

4.3 Searching streaming resources

This system uses a hierarchical P2P architecture to organize peer similar position to facilitate low-latency streaming service. But also according to the conditions and status of different search. It may make remote nodes or CDN to provide service.

In fact, advanced search is a super node on a common overlay network to carry out cross search behavior: To initialize the local overlay network search and CDN connection. And let peer can play through the remaining length to be used to determine how flexible way to gain access streaming clips.

5 SIMULATION AND ANALYSIS

This paper uses OverSim to simulate the proposed mechanism and analyze the performance of system. OverSim is a P2P simulation framework based on the development of OMNet++. OverSim provides several P2P mechanisms such as Chord, Pastry and other P2P module. Users can also write custom modules based on C++ programming language.

Figure 2 shows the traditional Chord ring and our proposed CDN P2P hierarchical overlay network. The traditional Chord is based on a DHT mechanism, and it is a default module in OverSim. The right part of Fig. 2 shows our proposed system. The module was written by C++ language and extended from the native DHT mechanism.

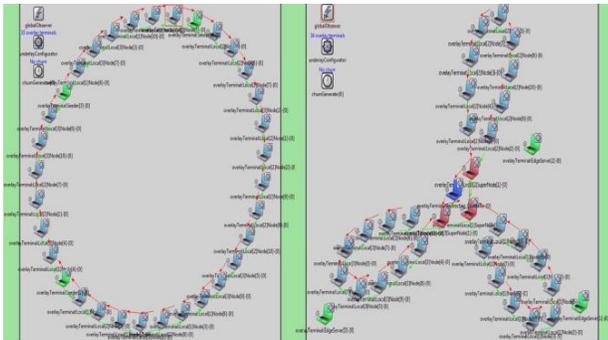


Fig. 2 The OverSim simulation environment.

5.1 Simulation Environment

After the simulation warm-up phase (P2P initialization), we only observed the system stable situation. In the simulation environment, P2P network already exists on the part of the stream segments (70%). There are 10 videos in the system. Each video length is about 15 minutes and each stream segment length is 10 seconds. The peer will leave the P2P system after 10 minutes of the end time of watching the video. Moreover, after 20 minutes of the leaving time, the peer will rejoin the system and watch the next video.

To model the different node distance, the proximal end of the one-way transmission delay between nodes is set to 5ms to 30ms randomly, such near node and far node.

5.2 Resource Search Time

Users in the simulation were divided into 10 different local overlay networks. The node amount in the local overlay network is increasing with 100 nodes for each step. The edge server and the media server can provide only 300 stream segments transmission at same time. Finally, Figure 3 shows the average resource search time of our scheme (J-t_CDN_P2P) and the traditional P2P system (ChordDht). In the result, our scheme is not better than the traditional P2P system. The reason is that our scheme would search the resource in the P2P network first. If the resource is not available in the P2P network, the peer would access the resource from CDN. The total search time includes the P2P search time and CDN access time.

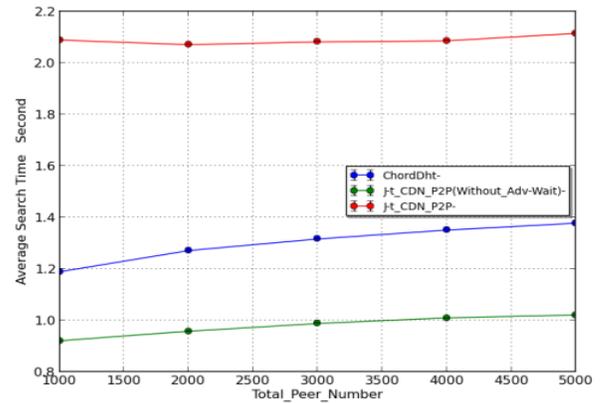


Fig. 3 The comparison of average searching time.

The threshold of P2P search time T_{limit} is enabled. After the expiration of T_{limit} , the P2P search would be given up. The resource would be access from near edge server in CDN directly. This means that even if the hierarchical overlay network does not exist in the target resources. We must wait until the end of the search time to obtain the resources from

CDN. In Fig. 3, our improved scheme (J-t_CDN_P2P(Without_Adv-Wait)) is shown. The average search time of our improved scheme is better than the traditional P2P system.

6 CONCLUSIONS

This paper proposed a combination of hierarchical P2P CDN network infrastructure. This service architecture could reduce network latency and cost by hierarchical P2P mechanism, and use CDN service to improve the issues of P2P churn. The simulation results show that the total search time includes the P2P search time and CDN access time in our scheme. The limitation of P2P search time is necessary to improve the waiting problem due to the resource is not available in the P2P system. The final simulation results demonstrates that the average search time of our improved scheme is better than the traditional P2P system. In the future, the additional content delivery and streaming path optimization in the CDN P2P hierarchical overlay networks will be studied.

ACKNOWLEDGEMENT

We would like to thank the Ministry of Science and Technology (MOST) in Taiwan. This research was supported in part by the MOST under the grant number 102-2221-E-150-001 and 103-2221-E-150-020.

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