Design of a Delay-Bounded Media Relay Mechanism for P2P Conferencing Services on Hierarchical Overlay Networks

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***Abstract*—P2P-SIP multimedia conference is operating that users share their resource of conference to each other in the network. It can solve the problem, such as centralized loading, single point error and expensive infrastructure. Peer-to-Peer networks have the problem that peer has difference between physical location and virtual location in overlay network. The key of establishing P2P-SIP multimedia conference is to build application multicast efficiently with physical network information. Thus, this paper proposed a delay-bounded media relay mechanism for P2P conferencing services on hierarchical overlay networks. Based on the application-layer multicast structure and the Hierarchical overlay network architecture, the media relay mechanism can improve the transportation efficiency of conferencing stream exchange.**

***Keywords*—multimedia conference, peer to peer, session initiation protocol, application layer conference, hierarchical network, path recovery**

I. INTRODUCTION

There are many problems like expensive infrastructure, weak scalability and single point error in traditional centralized multimedia conferencing structure. The above-mentioned issues will make service provider spent a lot of cost when user's demand more and more.

In the recent, there are many researches focusing on Peer-to-Peer environment. User sharing resource of conference each other in distributed environment can reduce cost of infrastructure. But user's virtual location in Peer-to-Peer overlay network is differ from user's physical location, it makes network produce redundant route when conference working. Conference system can't build fit multimedia application layer multicast tree when system is short of physical network information in distributed environment.

II. RELATED WORK

In order to the research of multimedia conference is pay attention, IETF established many Working Group to research and formulate standard. It also formulates many RFC documents such as the RFC 4353[1], RFC 4579[2], and RFC 5850[3].

P2P-SIP is combining with Peer-to-Peer distributed structure and traditional centralized SIP Client-Server structure. It use overlay network to provide the service that full-distributed resource register and message transmit to SIP. It has some advantage like decentralize, low cost, high toleration and high scalability to improve SIP system's problem. P2P-SIP is use SIP-over-P2P structure. It uses Peer-to-Peer protocol to provide register and locate to SIP protocol. The IETF make [4] as a standard draft and actively develop the relevant standard protocol.

Because the current network environment is not support IP layer multicast function universally, application layer multicast became the main way that support conference to relay the streaming. The current studies about build fit application layer multicast tree are not many.

III. P2PSIP CONFERENCE SYSTEM

A. Hierarchical overlay network

P2P-SIP conference system is made up by peer which joins overlay network. Each peer will build relationship each other, and manage routing information by overlay network routing algorithms. Peer provides storage to reserve data, which it should keep. The previous study [4] bring up idea that use IP prefix to divided into many local overlay network, and this idea can make peer which in same physical region constitute a cluster and reduce redundant route. Local overlay network transmit message to other local overlay via common overlay, which are show in **Figure 1**. Peer can share resource according peer's capacity to other peer when it became P2P Focus or P2P Mixer. P2P Focus makes session initiation and manages resource of conference. P2P Mixer is using to mix voice data and video data, and transmitting the streaming which it mixed.

Measuring bandwidth frequently will make P2P network has heavy loading, and it will make conference set up time increase. We refer landmark predictive mechanism [6] to predict delay. In this paper, each peer has unconsidered delay with other peer in the same local overlay network. Super node belong each local overlay network will measure RTT periodicity by all landmark and get landmark vectors like **Figure 2**.

Figure 3 is two different local overlay network measure RTT to get landmark vectors by three Landmarks.

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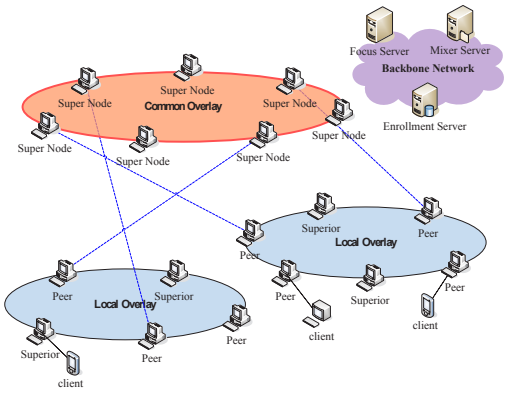

Figure 1 Hierarchical overlay network architecture.

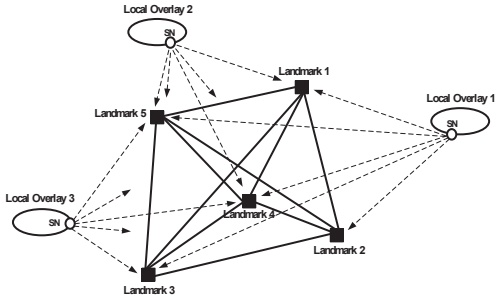

Figure 2 Super node measure RTT by landmark.

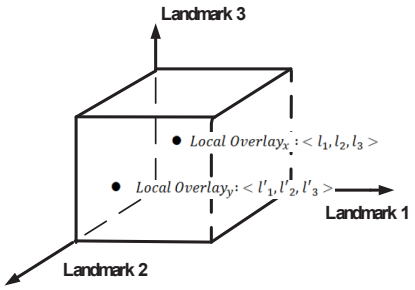

Figure 3 Landmark vectors Schematic diagram.

B. *Priority Weight*

1). Delay Latency

We use landmark and [7] to bring up the formula can predictive delay between two local overlay networks. Two different regions overlay network use x and y to show, and d_i^x is the delay between local overlay network x and Landmark i. n is the number of Landmark. We can use this formula to find delay between local overlay network x and local overlay network y.

$$d(x,y) = \sqrt{\sum_{i=1}^{n} (d_i^x - d_i^y)^2}$$

We use $d(x,y)$ to calculate Priority Weight, so we have to standardize $d(x,y)$. The standardize formula is as follows:

$$d_n(x,y) = \frac{300ms}{d(x,y)} \begin{cases} > 1, \text{the value greater express the delay lowe} \\ \leq 1, \text{this way can't use} \end{cases}$$

ITU defined that one way delay should not over 150ms in VoIP multimedia. The delay that we measure is two way delay, so we use double one way delay to standardize our value.

2). Peer Out-degree

In this paper, each peer will measure or predict the available bandwidth. But we not discuss the way that predicts available bandwidth. Taking into account the standardized Priority Weight, the formula is as follows:

$$c_i = [\frac{\text{available bandwidth}}{\text{the bandwidth which one streaming need}}]$$

$$= \begin{cases} > 1, \text{the value greater express the number of connect more} \\ \leq 1, \text{Unable to establish a connection} \end{cases}$$

In this paper, we use the bandwidth which one streaming need to be our standard. The number of conference member in the value greater express the number of connect more the local overlay which peer belongs is described by i. c_i is the number of connection which peer can support.

Local overlay network is use to be our calculating unit. C_j is total number of connection which belong one local overlay. J represents the j-th local overlay network. n is the number of local overlay network in conference.

$$C_j = \sum_{i=1}^{n} c_i$$

3). Stability Prediction

Peer stability is the important issue in application layer multicast, because the churn will happen when stability is too low. Peer frequent joining and leave lead to system crash is churn. In general way, the stability peers are disposed on top layer of Live streaming multicast tree to reduce effect of churn. Child peer will lose their data when father peer leave.

It is very important issue that fined the balance between delay and bandwidth when build the application layer multicast tree. In this paper, we use

Priority Weight to solve this problem. The formula about Priority Weight of connection is as follow:

$$PW = \alpha \times d(\mathrm{x},\mathrm{y}) + (1-\alpha) \times \mathrm{C_y}, 0 \le \alpha \le 1$$

$d(x,y)$ is the latency between two peer. C_y is the peer's available bandwidth in application layer multicast tree. α is parameter of system, and it can keep balance between delay and bandwidth.

Peer who is the conferencing member know it is meeting in the multimedia conferencing applications, so the multimedia conferencing application's probability of churn is more than live Streaming application's probability of churn. We only handle the peer, which its stability is lower than threshold. System will make low stability peer became leaf node to reduce impact of churn.

C. *ALM Tree Policy*

Our environment is hierarchical overlay network, so we design the peer selection mechanism by characteristics of the environment.

The Global View applications layer multicast tree is built by the unit of local overlay network, Global View is mean observe applications layer multicast tree on the common overlay network side. Each peer of applications layer multicast tree express a local overlay network in Global View. There are many conference members in each local overlay network, so we have to establish streaming transmit policy with Local View.

We hope peer in the Local View can provide great Out-degree to peer in the Global View; it can reduce the depth of tree and delay. The mechanism working is as follow Figure 4. Assuming that each node's available bandwidth can support two streaming connection. Caller will search Focus and Mixer in No.1 overlay network which number of conference member is the maximum, it means No.1 overlay network became the source of this application layer multicast tree. Assuming that the Mixer's Out-degree is four, so it can support four child peers in maximum. We use local overlay network be the unit and build the tree follow the PW, the number of depth is three and the structure is like show the lower left in Figure 4. Because of multimedia conferences churn rate is lower than live streaming churn rate; we can decrease the Stability Threshold. The peer can deploy in anywhere in the tree if the peer's stability is higher than the threshold. Follow the lower right in the picture; we can make the peer whose stability is higher than threshold became child peer of Mixer to reduce the depth of tree and delay with Global View.

IV. OPERATION OF THE SYSTEM

When a user is a proposer to establish a conference, it's flow follow:

(1) The first step is set up the Conference Profile of conference, the Conference Profile include number of member, conference member's SIPURI and some mechanism.

(2) Caller will check the location of all members by SIPURI, and find the Focus on overlay network whose member is the most by service search mechanism. If there are many overlay networks' number of member is largest, we will randomly select one overlay network to be the location of Focus.

(3) Conference proposer submits the Invite message of SIP to Focus to establish the conference. The invite messages include INVITE-Contained List and are transmitted by SDP.

(4) Focus will search the conference member follow the INVITE-Contained List in each local overlay. The search message will relay by Super Node to other overlay network, and get the IP of conference member. In this step, Focus gets the information of landmark vectors of each overlay network when it is searching. The detail describe of landmark vector is in section 3.2.1.

(5) Conference member response the information includes available bandwidth and stability in section 3.2.3.

(6) Focus follows the setting of conference that searches the available Mixer in overlay network.

(7) Focus transmits the invite message of SIP to Mixer.

(8) Mixer response 200 ok to Focus when it agree invite, and the respond message include Media Mixing Level information.

(9) Focus transmit Invite message of SIP to member who in the list and transmit Invite message to conference proposer again. Focus will give the information of Mixer to member. In this step, the message includes the result that according section 3.2.

(10) Conference member according information, which it receives to join conference, and find the fit location to join the application, layer multicast tree.

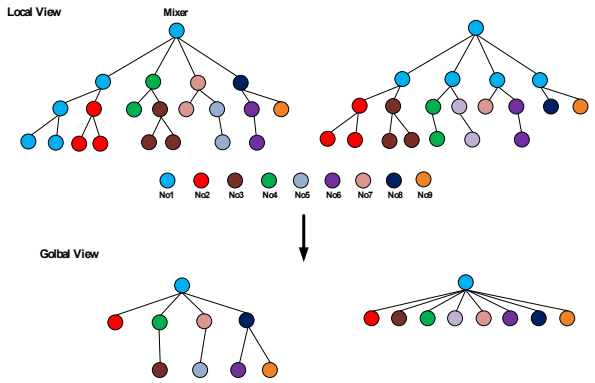

Figure 4 Multicast tree node selection strategies.

V. CONCLUSION

This paper proposed a delay-bounded media relay mechanism for P2P conferencing services on hierarchical overlay networks. Based on the application-layer multicast structure and the Hierarchical overlay network architecture,

the media relay mechanism can improve the transportation efficiency of conferencing stream exchange, such as audio streams and video streams. Moreover, the mixed-media streams would be transmitted to the media relay nodes, and then the media relay nodes would deliver the streams to their local peers. Finally, the case study with the system operations is explained. In the future, the performance evaluation of this mechanism will be analyzed and discussed.

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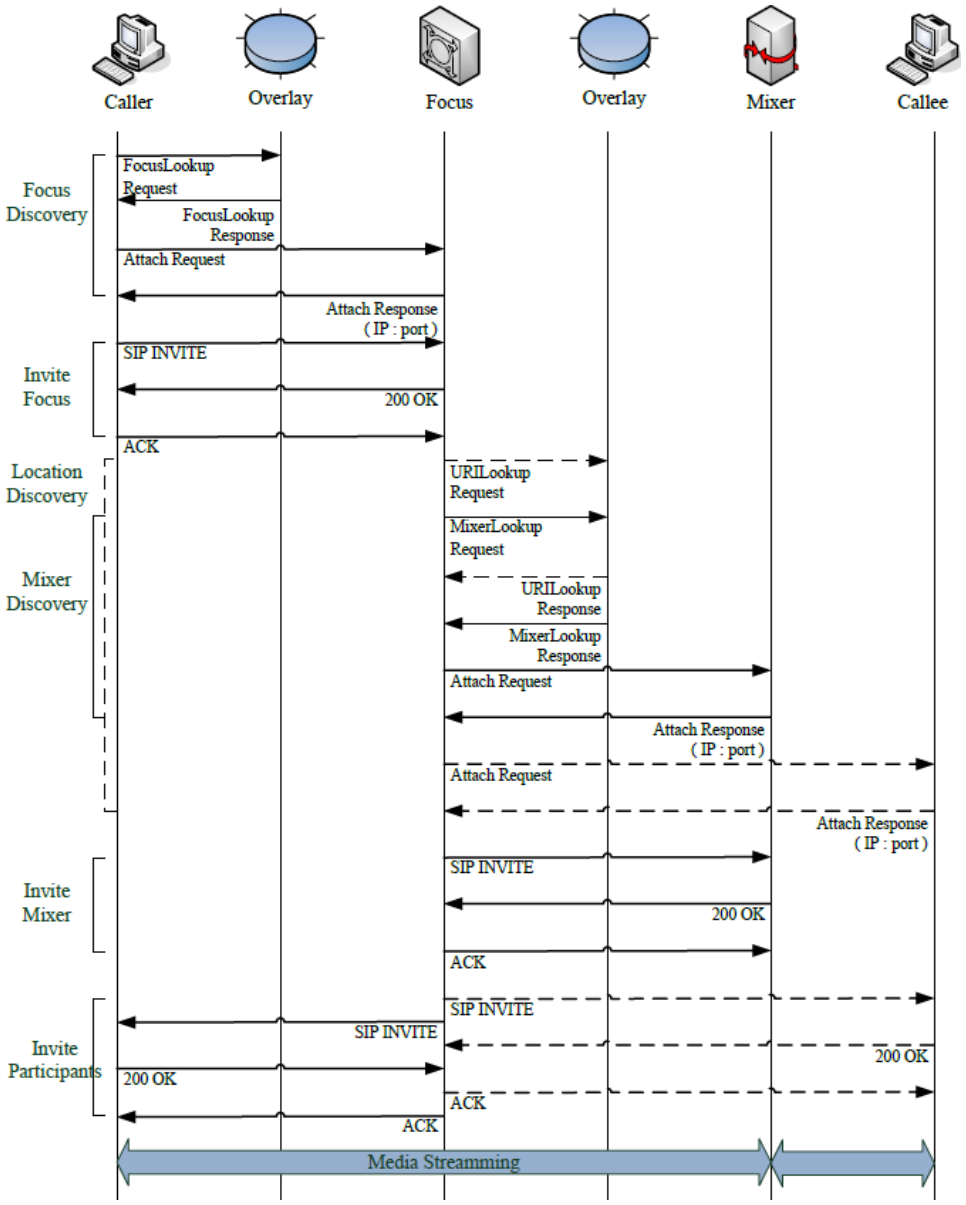

Figure 5 P2PSIP conferencing service creation process.