Conferencing Service Interworking in Peer-to-Peer and IMS Networks

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Received April 9, 2012; revised July 14, 2012; accepted August 15, 2012;
published September 26, 2012

Abstract

The growth of Internet technologies and the widespread use of mobile devices have been paving the way for the increasing use of conferencing services. Two types of systems have been designed to provide conferencing services: 1) a conferencing system using session control over a peer-to-peer (P2P) network and 2) an IP Multimedia Subsystem (IMS) conferencing system. The IMS conferencing system was developed to adapt to a server-based centralized system, whereas the benefits of the P2P operational model in providing such conference services are widely acknowledged. However, each system provides conferencing services only to its own users. Therefore, in this paper, we propose an interworking model to support multimedia conferencing service between the P2P environment and IMS networks. We also introduce protocol architecture and some service scenarios. To verify this system model and the design architecture, we perform an actual implementation and show experienced test results.

Keywords: Peer-to-Peer, IMS, interworking, conferencing service, P2PSIP

A preliminary version of this paper appeared in ICOIN 2011, January 26-28, Kuala Lumpur, Malaysia. This version includes a new conference service scenario, a real implementation, and testing results on our interworking model. This research was supported by the Ministry of Knowledge Economy (MKE), Korea, under the “Convergence Information Technology Research Center” (Convergence-ITRC) support program (NIPA-2012-H0401-12-1004) supervised by the National IT Industry Promotion Agency.
http://dx.doi.org/10.3837/tiis.2012.09.009

1. Introduction

To meet the increasing demand of conferencing services, many studies and the practical developments using not only the P2P paradigm, but also IMS [1] systems. The Internet Engineering Task Force (IETF) has been striving to propose a Resource Location and Discovery (RELOAD) usage for Distributed Conference Control (DisCo) [1], using RELOAD [1] as the P2P-based signaling protocol. Moreover, the 3rd Generation Partnership Project (3GPP) and the 3rd Generation Partnership Project 2 (3GPP2) have standardized IMS, which has brought many opportunities for studying and making contributions toward providing IMS-based such services [1][5]. However, each conference system only provides its own users with conferencing services. In this paper, we assume a scenario (see Section 2 in detail) and some interworking use cases that facilitate communication across the different systems.The basic conferencing service for the IMS which is specified in 3GPP TS24.147 [1], allows a user to create, manage, terminate, join, and leave conferences. The framework for conferences is specified in RFC 4353 [1]. To provide conferencing services, two main components are needed.

- Media Resource Function Controller (MRFC)/ Conferencing Application Server (AS): The MRFC entity controls the functions of low-level conference focus, such as conference policy and focus. In turn, the MRFC in turn is controlled by the AS. The AS is assigned the functions of top-level focus, such as conference policy and notification server.
- Media Resource Function Processor (MRFP): The main function of the MRFP is to receive a set of media streams and combine them, redistributing the result to each participant. The MRFP is controlled by the MRFC/AS.

P2P overlay conference is based on DisCo [1], which is described in a tightly coupled model with Session Initiation Protocol (SIP) [1]. A P2P overlay provides self-organizing, scalable signaling, which allows RELOAD peers and plain SIP user agents to participate in a managed P2P conference. The proposed conferencing scheme in DisCo supports mechanisms to build an optimized interconnecting graph between participants and their responsible conference controllers. Conference members are enabled to select the controllers based on proximity awareness to reduce delay or jitter [7]. DisCo extends the conference control mechanisms to provide a consistent and reliable conferencing environment. Controlling peers maintain a consistent view of the entire conference state. The multiparty system can be restructured based on call delegation operations, which balances the load at the focus peers. It also provides secure mechanisms that allow users to join or even control a distributed conference. A straightforward solution for P2P conference service is to use a DisCo service infrastructure, given the requirements of P2P conference session management. For the purpose of interworking management, we use a special gateway (see Section 3 in detail). We also have a mechanism to prevent overload on this gateway by taking advantage of the REFER method. The rest of this paper is organized as follows: In Section 2, we introduce a interworking scenarios using conference service over a P2P network. The network model, protocol architecture and three interworking scenarios between P2P overlay and IMS networks are presented in Section 3. Section 4 shows the performance evaluation with each scenarios and our implementation will be noted in Section 5. Section 6 summarizes our conclusions.

2. Conferencing Service Interworking Scenario

This section discusses a conferencing service to demonstrate how it can be applied to a P2P overlay and IMS networks. P2P conferencing devices, including cameras, send multimedia data in the form of audio and/or video content to a group of participants who are equipped with monitors, personal computers, and smart phones and who desire to monitor the content and discuss in conference.

Fig. 1 illustrates the situation in which a user may stay at his office near a display-capable device or personal computer. In addition, camera devices are distributed to each area in the office for different purposes, such as to provide security at the front door, windows, living room, and other rooms.

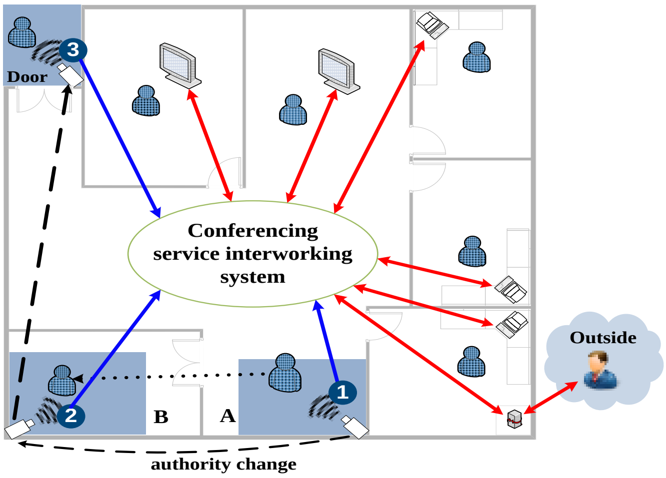


Fig. 1. Example of conferencing service interworking in P2P networks

- Step 1: P2P participants from different areas are conducting a conference, but are near a displaydisplay-capable device or computer.
- Step 2: A boss or a manager is on his business trip, and is able to join the P2P conference to talk and/or see what is going on in his office.
- Step 3: After joining successfully, he can monitor an employee in area A by the captured image which is sent from the camera and displayed at his device. When that employee moves to area B, the camera in area A recognizes that the employee is out of its scope and relinquishes its role as the source of content. The camera placed in area B is then authorized to be the source of content and begins to send video images to the participants.
- Step 4: During this time, a front-door camera captures a visitor and informs the system of an event. It then obtains the authority to send the content related to the event to participants. After finalizing the event, the sending role is entirely left back to the camera in area B.

The following methods are required to support the service described above.

- Methods for session initiation and management: A session-control method is required for multimedia communication between the display devices near participants and the camera devices. A content source (i.e., a camera device authorized to send multimedia content) should first identify the display device nearest to the participant who is interested in the content, and then initiate the session(s) to deliver the content. In addition, sessions are managed whenever both participant and the target node (i.e., the child in the scenario) move from space to space.

- Methods for one-to-many multimedia communication: In our illustration, a source sends multimedia content to multiple devices near members of the conference. Various factors need to be considered when a source sends its multimedia data to multiple recipients, such as encoding schemes for heterogeneous devices and multisession management embedded in each device. These factors make the development of P2P devices highly difficult.
- Decision methods to select a content source (authorized source): In our example, the multimedia source is not dedicated to any specific device and can change depending on the event. Once a source is authorized to send data, the others should go into inactive mode. To ensure adherence to this method, a function is required that will select a source once an event occurs. The appropriate source of content can be selected based on a predefined priority of events that might occur in the office. For example, a device related to high-priority events sends predefined control packets to a second one with a lower priority, to obtain immediate authorization for the role of sender.

3. Interworking Architecture

3.1 Network Model

On the P2P side, an architecture based on a centralized and dedicated conference server is inefficient because there are few member nodes. For this reason, we decide to use the DisCo system architecture for P2P conference networks. In this architecture, RELOAD is used as the conference protocol for the P2P overlay network.

The IMS system provides conferencing services with the CSCFs (Call Session Control Functions) [8], the MRFC-AS and MRFP. To interconnect both networks, recent studies proposed the Proxy Peer and Relay Agent [1]. These entities play a significant role in interworking between P2P overlays and IMS systems. The Proxy Peer maintains message signaling between the P2P overlay and IMS network, which has a similar role to the I-CSCF (Interrogating-Call Session Control Function) in IMS, and needs to be registered with the public domain name system (DNS) to obtain a unique identification for the overlay. The Relay Agent is responsible for transferring media streams to other domains, which are supposed to be used in conjunction with standard tools for network address translation (NAT) traversal (i.e., Session Traversal Utilities for NAT (STUN) [1], Traversal Using Relays around NAT (TURN) [1] and Interactive Connectivity Establishment (ICE) [12]).

In contrast, the Gateway AS [13] has interfaces to both networks: one works as the ordinary peer in the P2PSIP (Peer-to-Peer Session Initiation Protocol) network and the other is used for the SIP AS in the IMS. To operate in the P2PSIP and IMS networks, the Gateway AS needs to register itself with the P2PSIP network, but only registering the host name part (for example, ims-domain.com). IMS users who want to use the interconnection ability to the P2PSIP network have to set up the appropriate Initial Filter Criteria (iFC) in their user profile, which is stored in the HSS (Home Subscriber Server). Meanwhile, the appropriate iFC for P2PSIP interconnection contains the address for the Gateway AS. Sessions can be established between P2PSIP and IMS via the Gateway AS, as soon as the registration procedures on both sides have been performed.

The Proxy Peer and Gateway AS are the main components for interworking between the P2P overlay and IMS network. They both maintain the signaling level interconnection. However, the registration procedures for the Gateway AS are more convenient than the ones for the Proxy Peer. Therefore, we propose a P2P-IMS gateway component that includes both the Gateway AS and Relay Agent functions. We take advantage of the Gateway AS to be used as a signaling controller and of the Relay Agent as a gateway media controller. The P2P-IMS gateway plays an important role in interworking conferencing between P2P networks and IMS networks, as shown in Fig. 2.

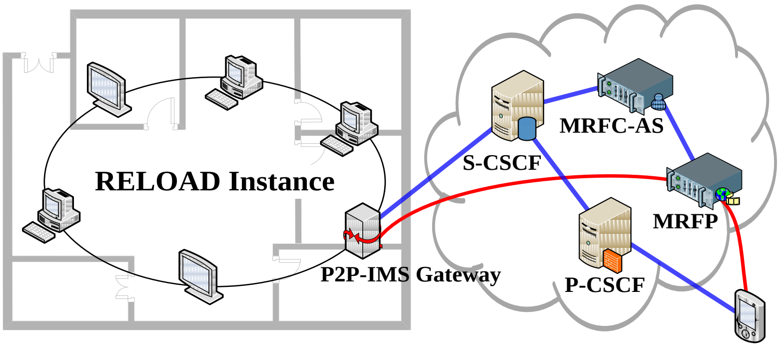


Fig. 2. Network model of the conference system

3.2 Protocol Architecture

Fig. 3 illustrates the interaction between each component in our system model. For conferencing service interworking, the SIP signaling messages are firstly exchanged between a P2P peer and an IMS user via a P2P-IMS gateway and CSCFs. We separated video and audio into two different streams. The video stream is controlled by FCP (Floor Control Protocol) that, second, takes over to control the right to send video in the conference service – and determines, depending on the priority of the predefine event, which camera or device will be the source of content for sending video data. For example in Section 2, participants are talking in conference and the video source of the content keeps changing causes by events, but audio data are still being transmitted. The focus peer and MRFP with mixer functions will take control over mixing audio data in the P2P conference network and in the IMS conference network, respectively. Finally, the RTP (Real-time Transport Protocol) packets, which include audio and video data, are sent.

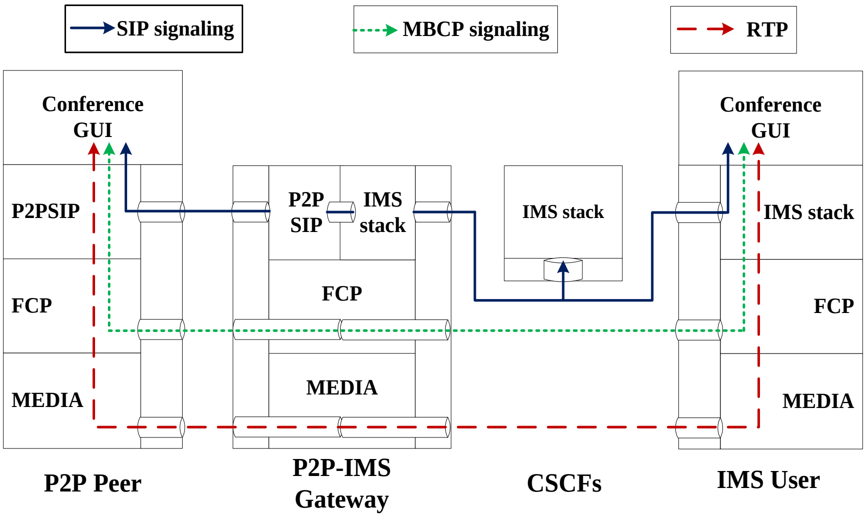


Fig. 3. Protocol architecture for interworking of the conference system

3.3 Interworking between P2P Overlay and IMS Networks

The proposed model is used to identify three interworking scenarios that might occur among users from two different environments. The three primary scenarios include: 1) the IMS user has a desire to invite a user in the P2P overlay, 2) the P2P peer invokes the IMS user, and 3) the existing focus peer serving the P2P conference works with the IMS clients. For each scenario, we describe the signaling message flow in detail as follows.

- An IMS UA (User Agent) invites a P2P peer to join the IMS conferencing service

Fig. 4 illustrates a scenario in which an IMS-aware UA wants to INVITE a P2P-aware peer in the overlay to join the IMS conference. Assume that both the IMS UA and P2P peer have completed registration within their own systems. The IMS UA registers with the IMS system and the P2P peer registers with the P2P overlay network.

From Step 1 to Step 2, the IMS UA initiates the IMS conference by sending an INVITE request with its request URI (Uniform Resource Identifier) set to conference factory IMS MRFC-AS URI. After negotiations with the IMS system are completed [1], the MRFC creates a focus for the newly created conference, assigns the IMS UA a conference URI in the Contact header of the response “200 OK” message, and sends this message to the IMS UA as a final response to the INVITE request. In Step 3, the IMS conference is established, and the RTP data begin flowing between the IMS UA (from here, we can call the IMS UA an IMS conference participant) and MRFP.

In Step 4, the IMS participant invites a peer in the overlay network to a conference using the REFER procedure. The IMS participant sends a REFER message with Refer-to containing the conference URI as learned during the IMS conference establishment. Additionally, the "method" URI parameter indicates that the P2P peer is requested to send an INVITE request to this conference URI. The CSCFs performs an analysis of the destination address, calculates and determines the best P2P-IMS gateway, and forwards the REFER message to the gateway.

In Steps 5 and 6, the P2P-IMS gateway (the middle entity, which knew both the P2P overlay and IMS system) looks up a P2P peer IP address in the overlay network, then forwards the REFER message to the network in Step 7. In Step 8, the P2P peer accepts the REFER request by sending a “202 Accept” response. In Step 9, a NOTIFY message is sent to IMS UA to inform that the REFER request is being processed. In Step 10, a “200 OK” message acknowledges the NOTIFY message. The P2P peer is made aware of the conference factory URI by the REFER request. Then, in Steps 11 and 12, the P2P peer enters the IMS conference. A NOTIFY message is sent to the IMS participant, indicating that the P2P participant has successfully joined the conference in Steps 13 and 14. In Step 15, the conference is now in progress, and the MRFP is merging and distributing the media stream to all conference participants.

We have two procedures for the P2P peer to join the IMS conference system: 1) the IMS conference participant knows the P2P peer URI and uses a REFER message to invite the P2P peer to join the conference; or 2) the P2P peer in the overlay network knows the IMS Conference URI and wants to join the conference. The procedure we discussed above is Case 1. In Case 2, instead of the conference factory URI being learned from the REFER message, it may be learned by email, a Web site, or in other ways; then, the P2P peer sends an INVITE message to the IMS conference factory via the P2P-IMS gateway.

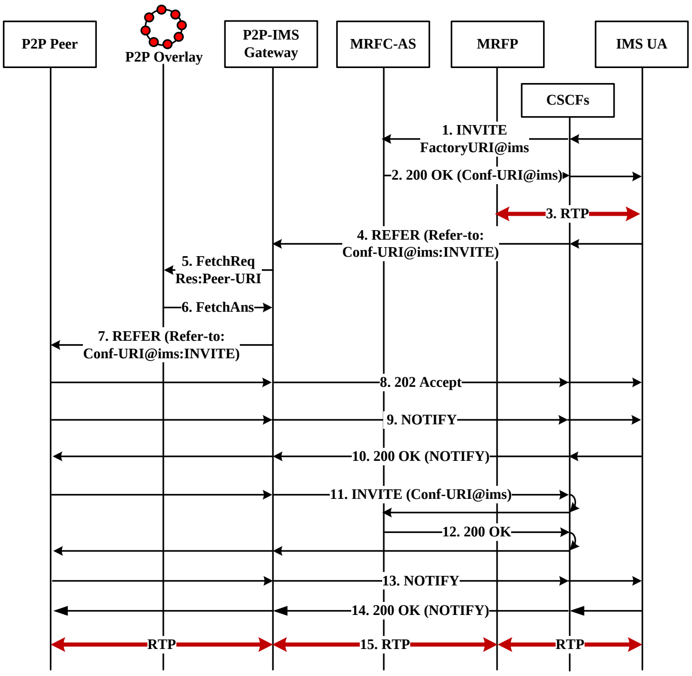


Fig. 4. Service scenario flow I

- A P2P peer invites an IMS UA to a P2P conferencing service

Fig. 5 illustrates a scenario in which a P2P peer wants to INVITE an IMS UA in the IMS network to join a conference.

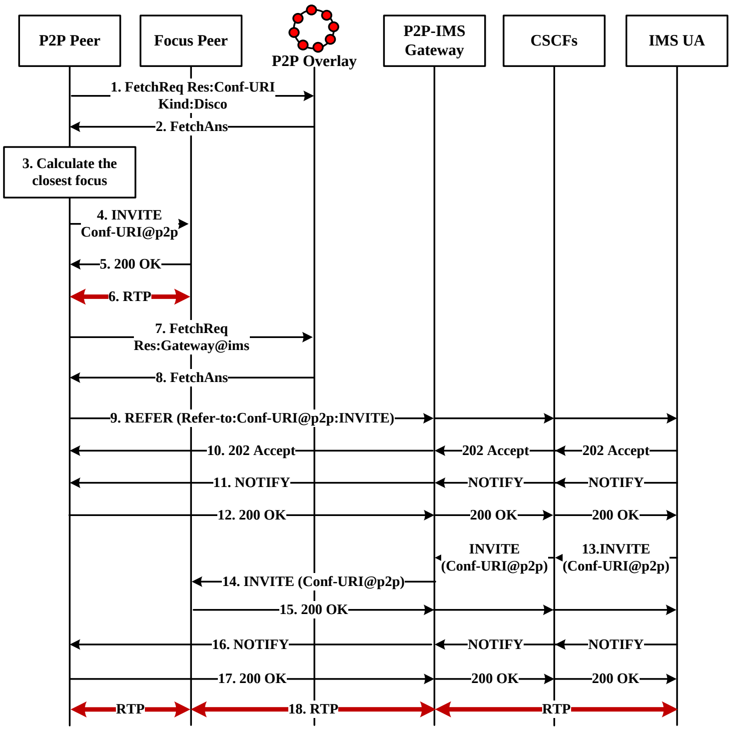


Fig. 5. Service scenario flow II.

In Steps 1 and 2, the joining peer in the overlay network intending to join an existing conference retrieves the list of focus peers, which is stored in special peers in the overlay network. In Step 3, once the joining peer has received the Fetch results, it calculates which of the focus peers is the nearest to itself, then establishes a connection by sending an INVITE message to the focus peer in Steps 4 and 5. The conference is established in Step 6. To invite the IMS UA to join the conference, the P2P participant looks up the URI of the P2P-IMS gateway from the overlay (Steps 7 and 8), then sends a REFER message to the IMS UA (Step 9). In Steps 10 to 12, the "202 Accept", "NOTIFY" and "200 OK" messages are exchanged between P2P peer and IMS UA. In Steps 13 to 17, the IMS UA enters the P2P conference. In Step 18, the conference is now in progress, and the focus peer is merging and distributing the media stream to all conference participants.

- Interworking between the P2P focus and MRFC-AS

Assume that we have an existing P2P conference with a focus peer, some P2P participants, and three established IMS participants (A, B, C) (Step 1).

Fig. 6 illustrates a scenario in which an IMS UA (D) wants to join the existing P2P conference. In Step 2, the IMS UA (D) joins the P2P overlay conference system by using service scenario flow II as previously described. The focus peer has reached its threshold for serving a new IMS participant (D) as a focus peer and has to transfer the call (Step 3). At first, the focus peer temporarily accepts the call of IMS UA (D) and fetches the latest conference information (not shown in **Fig. 6**). Then, the focus peer determines whether to transfer the call to an adequate focus peer or an MRFC-AS. This decision is based on the number of IMS participants.

In this case, four IMS participants are in the conference; therefore, the best choice is to transfer the request of the newcomer to the MRFC-AS by sending a SIP Redirect request (Step 4).

The Redirect request must contain the P2P conference URI from the overlay network as a payload in the request body and conference factory URI in the IMS network in the Redirect-to header field. In Step 5, the IMS UA (D) initiates a conference in the IMS network and then sends a SIP REFER request to the MRFC-AS, and the Refer-to header field is the P2P conference URI (step 6).

The MRFC-AS sends an INVITE message to establish a session between the focus and the MRFC-AS (Step 7). After that, the MRFC-AS sends IMS UA (D) a NOTIFY message to notice the state of establishing the session between focus peer and MRFC-AS (Step 8). The conference state then will be updated through a synchronization process (Step 9). The focus sequentially sends the reINVITE [hold] to IMS UAs (A, B and C) to stop receiving media streams from them (if present), and sends them REFER messages to INVITE the MRFC-AS to join the IMS conference (Steps 10 and 11). To rejoin the conference, each IMS participant retrieving a REFER message establishes a session with the MRFC-AS (Step 12). Each IMS participant then sends a NOTIFY to the focus (Step 13). The focus tears down the old session with each IMS participant by sending a BYE message (Step 14).

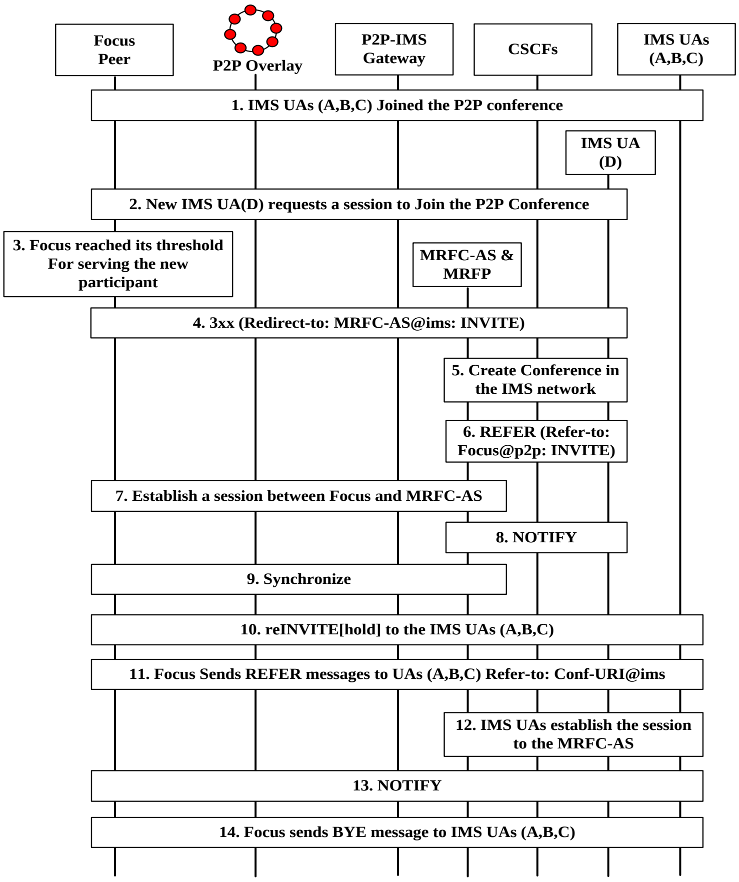


Fig. 6. Service scenario flow III

4. Performance Evaluation

This section derives the analytical expression for the session setup delay. We evaluate that value in two aforementioned scenarios: 1) from user in P2P overlay to IMS network, and 2) from IMS user to P2P user. (Fig. 4 and Fig. 5). Table 1 shows system parameters. The following parameters and equations were defined by [14] to compute session setup delay time. $T_{wl\_X,Y}$ (resp. $T_{w\_X,Y}$) is the one-way transmission delay of a message of size s between X and Y with a wireless (resp. wired) link.

Table 1. System Parameters

Parameters	Values
Wired link bandwidth ($\mathbf{B_w}$)	100 Mbps
Wireless link bandwidth ($\mathbf{B_{wl}}$)	11 Mbps
Wired link delay ($\mathbf{L_w}$)	2 ms
Wireless link delay ($\mathbf{L_{wl}}$)	10 ms
Message packet size (**S**)	600 bytes

$$\mathrm{T_{wl\_X,Y}(s) = d_{X,Y}\left(\frac{1+q}{1-q}\right)\left(\frac{s}{B_{wl}} + L_{wl}\right)} \tag{1}$$

$$\mathrm{T_{w\_X,Y}(s) = d_{X,Y}\left(\frac{s}{B_{w}} + L_{w} + \omega_q\right)} \tag{2}$$

The parameter $\mathrm{d_{X,Y}}$ is the average number of hops between node X and Y; q is the probability of a wireless link failure; ω_q ω_q is the average queuing delay (0.5 ms) for each router on the Internet. $\mathrm{B_w}$ (resp. $\mathrm{B_{wl}}$) is the bandwidth of a wired (resp. wireless) link, and $\mathrm{L_w}$ (resp. $\mathrm{L_{wl}}$) is the wired (resp. wired) link delay. In addition, to obtain a total session setup delay time, one must consider the lookup delay. This paper used the Chord algorithm to organize the P2P overlay network. (Chord - $\log_2 N$, where N indicates the number of peers).

According to **Fig. 4**, the duration for an IMS UA to set up a call is from Step 4 (sending a REFER message to gateway) to Step 14 (sending the final 200 OK message to the invitee). This value in **Fig. 5** is from Step 7 to Step 17. From reality, we assume that only $\mathrm{T_{UA\rightarrow PCSCF}}$ and $\mathrm{T_{PCSCF\rightarrow UA}}$ are operated in a wireless environment, and that after finishing the lookup procedure, a P2P-IMS gateway has a hop link with a peer. The involved processes for scenario I are calculated as followings:

$$\mathrm{T_{UA-PCSCF} = \left(\frac{1+q}{1-q}\right)\left(\frac{s}{B_{wl}} + L_{wl}\right)}$$

$$\mathrm{T_{GW-PCSCF} = 2 * \left(\frac{s}{B_{w}} + L_{w} + \omega_q\right)}$$

$$\mathrm{T_{GW-Overlay} = (d_{GW-Overlay} + 1) * \left(\frac{s}{B_{w}} + L_{w} + \omega_q\right)}$$

$$\mathrm{T_{GW-Peer} = \left(\frac{s}{B_{w}} + L_{w} + \omega_q\right)}$$

$$\mathrm{T_{GW-MRFC} = T_{PCSCF-GW} + \left(\frac{s}{B_{w}} + L_{w} + \omega_q\right)}$$

$$\mathrm{T_{REFER} = T_{UA-PCSCF} + T_{PCSCF-GW} + T_{GW-Overlay} + T_{GW-Peer}}$$

$$\mathrm{T_{NOTIFY} = T_{OK-NOTIFY} = T_{GW-Peer} + T_{PCSCF-GW} + T_{UA-PCSCF}}$$

$$\mathrm{T_{INVITE} = T_{OK-INVITE} = T_{GW-Peer} + T_{PCSCF-GW} + T_{GW-MRFC}}$$

$$\mathrm{T_{UA} = T_{REFER} + 2 * (T_{NOTIFY} + T_{OK-NOTIFY}) + T_{INVITE} + T_{OK-INVITE}} \tag{3}$$

Regarding scenario II, we compute the latency for a peer in the same way as previously described. However, Step 14 in **Fig. 5**, the GW has to retrieve the address of the focus target before forwarding the INVITE message from PCSCF. Thus, the INVITE time should be:

$$\mathrm{T'_{INVITE} = T_{UA-PCSCF} + T_{PCSCF-GW} + T_{GW-FocusPeer} + T_{GW-Overlay}}$$

$$\mathrm{T'_{OK-INVITE} = T_{FocusPeer-GW} + T_{GW-PCSCF} + T_{PCSCF-UA}}$$

The total delay for a peer is:

$$T_{UA} = T_{REFER} + 2 * (T_{NOTIFY} + T_{OK-NOTIFY}) + T'_{INVITE} + T'_{OK-INVITE} \tag{4}$$

We considered two factors that have an impact on the conferencing session setup delay, namely q and the P2P overlay network size. A comparison of (3) and (4) shows no considerable difference in the session delay of a P2P peer and the IMS UA. If the inviter is a peer, it has to suffer a period of time to retrieve the address of the gateway and focus peer by the invitee UA. We compare scenarios I and II on this value with different probabilities q. The results are illustrated in **Fig. 7** as follows:

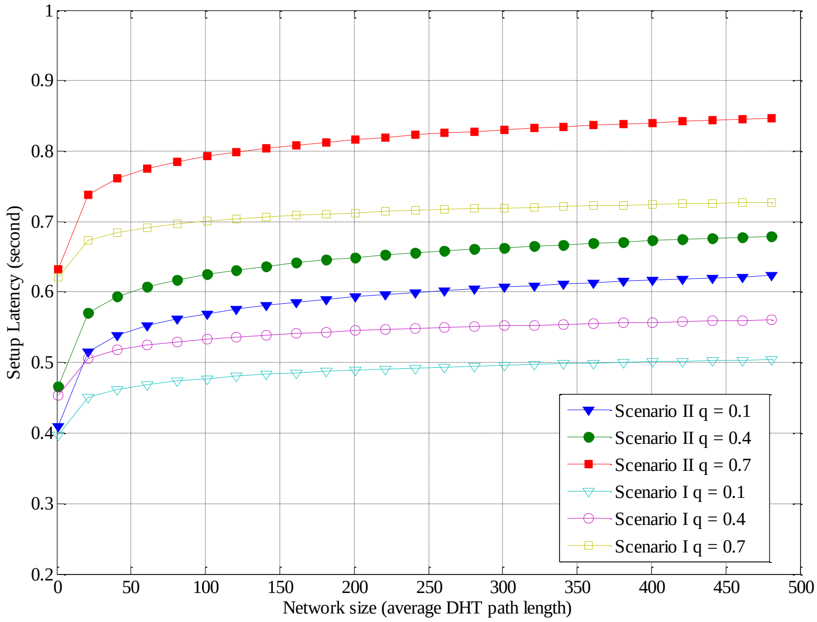


Fig. 7. Comparison of session setup latency in two scenarios I and II

In scenario III (**Fig. 6**), we concentrate on the delay between current IMS user (A,B,C) and the new participant (D). As previously described, D will send the INVITE to join the conference held by a focus peer. After that, D will again be invited to re-join another conference that is later created by MRFC-AS&MRFP with the REFER message. Another INVITE from MRFC-AS to focus peer is sent before D finishes in Step 8. Then A, B, C are informed about this event and receive a REFER message to leave the current conference to join the new one. In the same way, we have:

$$\begin{aligned} T_{D-INVITE} &= T_{D-OK-INVITE} \\ &= T_{D-PCSCF} + T_{PCSCF-GW} + T_{GW-Overlay} + T_{GW-FocusPeer} \end{aligned}$$

$$T_{REDIRECT} = T_{FocusPeer-GW} + T_{GW-PCSCF} + T_{PCSCF-MRFC}$$

$$T_{D-REFER} = T_{MRFC-PCSCF} + T_{PCSCF-D}$$

$$\begin{aligned} T_{INVITE,FocusPeer-MRFC} &= T_{OK-INVITE,FocusPeer-MRFC} \\ &= T_{MRFC-GW} + T_{GW-Overlay} + T_{GW-FocusPeer} \end{aligned}$$

$$\mathrm{T_{D-NOTIFY} = T_{D-OK-NOTIFY} = T_{MRFC-PCSCF} + T_{PCSCF-D}}$$

$$\mathrm{T_D = T_{D-INVITE} + T_{D-OK-INVITE} + T_{REDIRECT} + T_{D-REFER} + T_{D-NOTIFY} + T_{D-OK-NOTIFY} + T_{INVITE,FocusPeer-MRFC} + T_{OK-INVITE,FocusPeer-MRFC}} \quad (5)$$

The duration at A client includes the following equations:

$$\mathrm{T_{A-ReINVITE} = T_{A-OK-ReINVITE} = T_{FocusPeer-GW} + T_{GW-PCSCF} + T_{PCSCF-A}}$$

$$\mathrm{T_{A-REFER} = T_{FocusPeer-GW} + T_{GW-PCSCF} + T_{PCSCF-A}}$$

$$\mathrm{T_{A-INVITE} = T_{A-OK-INVITE} = T_{A-PCSCF} + T_{PCSCF-MRFC}}$$

$$\begin{aligned}\mathrm{T_{A-NOTIFY}} &= \mathrm{T_{A-OK-NOTIFY} = T_{BYE} = T_{OK-BYE}} \\ &= \mathrm{T_{A-PCSCF} + T_{PCSCF-GW} + T_{GW-Overlay} + T_{GW-FocusPeer}}\end{aligned}$$

$$\mathrm{T_A = T_{A-ReINVITE} + T_{A-OK-ReINVITE} + T_{A-REFER} + T_{A-INVITE} + T_{A-OK-INVITE} + T_{A-NOTIFY} + T_{A-OK-NOTIFY} + T_{BYE} + T_{OK-BYE} = 2 * (T_{A-ReINVITE} + T_{A-INVITE} + T_{A-NOTIFY} + T_{BYE}) + T_{A-REFER}} \quad (6)$$

The number of peers does not have much of effect on the delay of existing participants when he moves to new host at the IMS side. The difference between two kinds of users in **Fig. 8** is still stable when that number increases from 100 to 500. In addition, the quality of a network plays an important role in this situation. A, B, and C spend less time (<0.1s) with the good quality wireless environment than in bad environment.

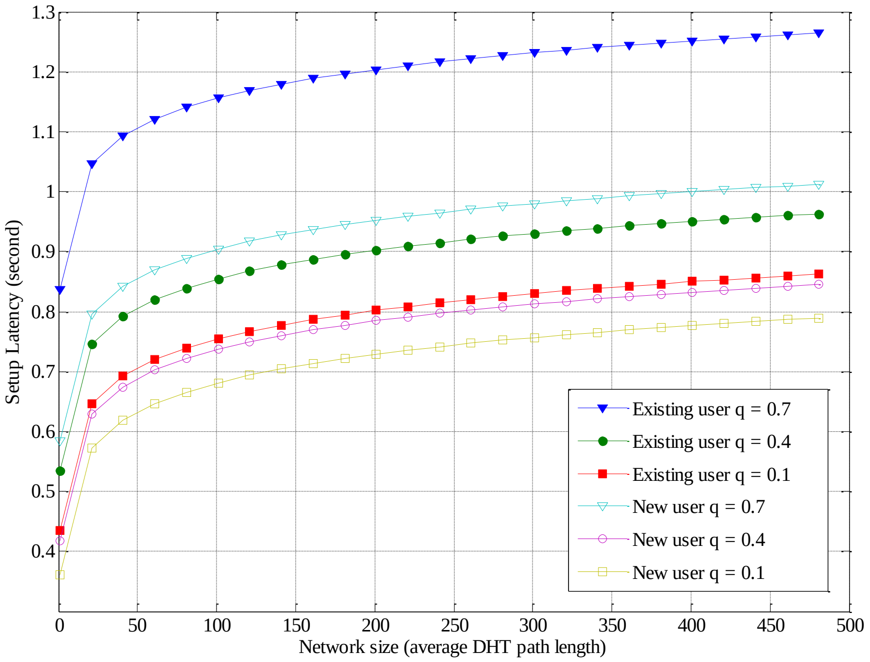


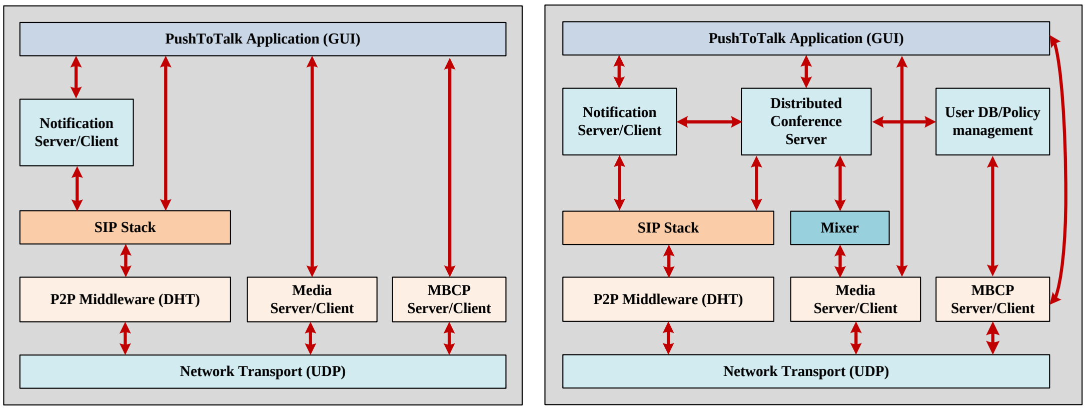
Fig. 8. Delay time for existing and new participants in scenario III

5. Implementation and Testing

5.1 Implementation architecture

The implementation is divided into two parts. One is the P2P peer and focus peer. The other is the P2P-IMS gateway.

P2P peer and focus peer: All P2P peers in a P2P conference can become focus peers for their multiparty, and the decision depends on the capacities of the joining P2P peer (e.g., sufficient processing power (CPU, memory) and quality of the network connectivity). Additionally, a P2P peer intending to become the focus of a conference should not be located behind NAT, and its IP should not belong to a private address range [1]. Fig. **Fig. 9** (a) shows the ordinary P2P peer functional components and **Fig. 9**(b) shows the focus peer functional components. Participants in the conference communicate among themselves through a set of protocols: P2P middleware utilizes the RELOAD protocol as the DHT (Distributed Hash Table) overlay network; a SIP Stack is used as a conference-call-signaling protocol to maintain conference sessions; the Binary Floor Control Protocol (BFCP) [1] deals with the video source assignment; and the focus peer provides conference notification and acts as a notifier [1] that accepts subscriptions and notifies subscribers about the state of the conference changes. A conference media function receives media streams as inputs, and based on directions provided by the focus, passes media streams to the conferencing application (GUI) or to a mixer. The mixer is always under the control of a focus, and it is responsible for combining and generating output streams that will be distributed to recipients. Distributed focus and policy play the roles of focus and conference policy server [1]. The conference object in our system contains data that represent a conference during each of its various stages. It also contains the core information of a conference (i.e., capabilities, membership, call control signaling, media, etc.) [17].



(a) P2P peer **(b) focus peer**

Fig. 9. Functional modules of P2P peer and focus peer

- P2P-IMS gateway: **Fig. 10** represents a P2P-IMS gateway with the inside functional components. This entity owns two considerable features: Gateway AS and Relay Agent, and interfaces to both networks. Similar to the Gateway AS (see Section 3), the gateway must register both the P2P overlay and IMS networks. Therefore, it has the basic functions of a P2P peer and an IMS UA. The P2P-IMS gateway converts and then forwards SIP messages to the corresponding endpoints. It also plays the role of Relay Agent, which is responsible for transferring media streams to other domains.

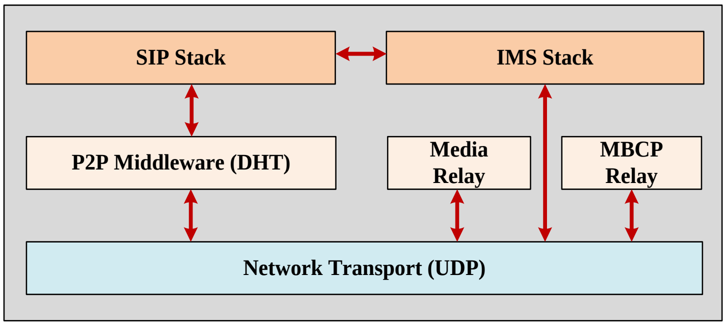


Fig. 10. Function modules of P2P-IMS gateway

5.2 Implementation and Test Results

With the implementation architecture described above, we tested our implementation in an environment as shown in **Fig. 11**. In Computer Number 3 (COM 3), we ran the application server as a P2P-IMS gateway function.

The scenario for our test is a P2P network: We held the conference with one focus peer and two P2P users; this scenario was deployed on COM 4, in Fig. **Fig. 11**.

The sequentially increased the number of IMS users from one to five users joining the P2P conferencing network; then, we captured and showed the number of packets going through the P2P-IMS gateway, in **Fig. 12**. The experience shows that as every additional IMS user takes part in the P2P conferencing via the P2P-IMS gateway, it increases the packet load through the gateway until the moment at which the focus peer in the P2P network reaches its threshold. The focus peer then temporarily accepts the IMS user. Then, call transfer methods are executed to transfer all IMS user sessions controlled by the focus peer in the P2P network to the MRFC-AS server in the IMS conferencing system (the call transfer method was mentioned in Section 3). **Fig. 13** illustrates the reduction in the number of packets going through the P2P-IMS gateway during each call transfer.

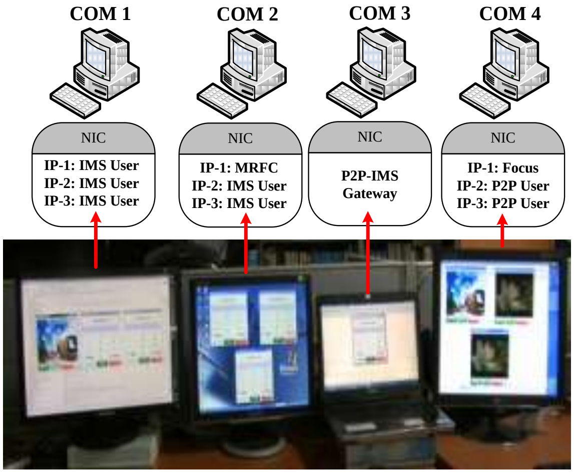


Fig. 11. Implemented results and test environment

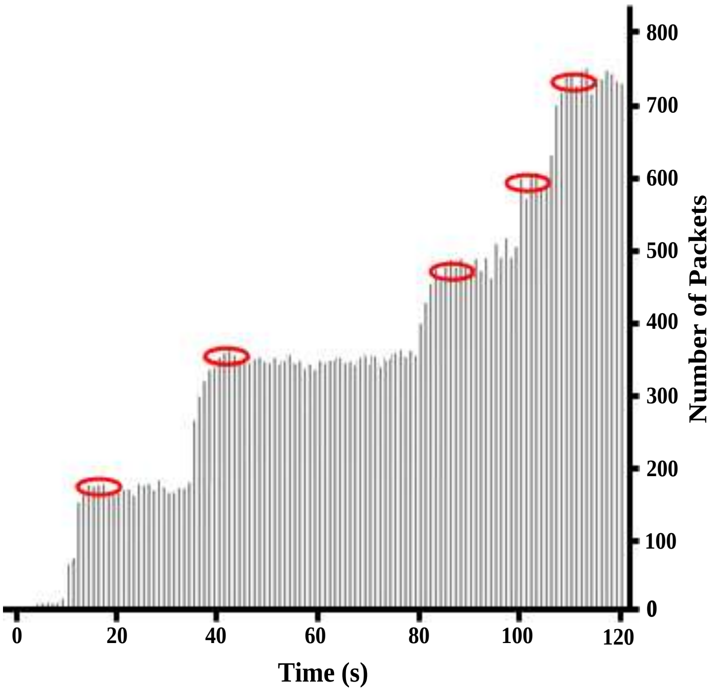


Fig. 12. Number of packets through P2P-IMS gateway as the number of IMS users increases

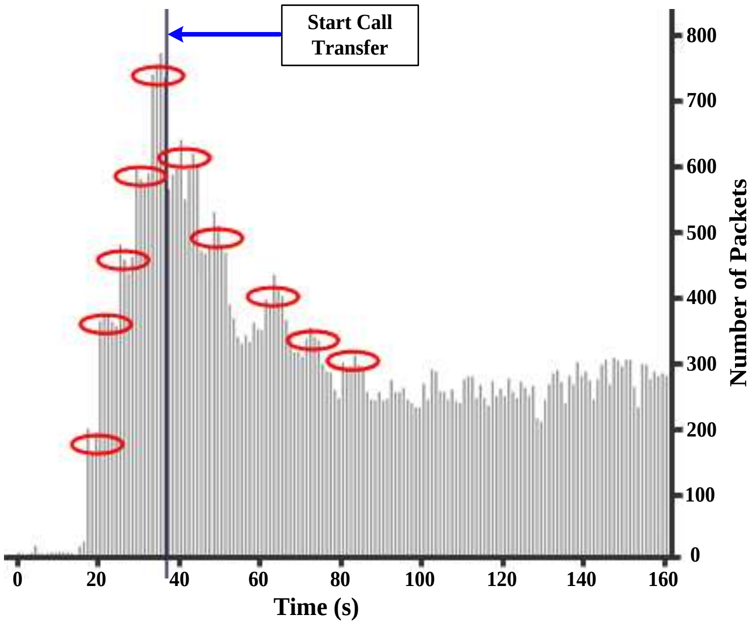


Fig. 13. Number of packets through P2P-IMS gateway before and after starting call transfer

Conclusions

This paper proposed a system model for enabling conferencing service interworking in P2P networks with IMS networks. We introduced three conferencing scenarios and described in detail the implementation functions of each component in the architecture. Our system was verified by using an actual implementation and we analyzed the number of packets going through the gateway both before and after starting the call transfer method.

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