Research on Resource Sharing and Application Coordinating for Multiple IMS-based Clients on Mobile Device

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Abstract. With the rapid evolution of next generation network IP Multimedia Subsystem (IMS) is maturing. The coexistence of emerging IMS-based clients leads to local resource contention, response conflict, power consumption and potential message storm from periodical signaling. In this paper, we conclude these issues as resource sharing and application coordinating. To solve these issues, we propose IMS-DUCP to conduct centralized signaling control locally. A priority scheduling mechanism is designed for resource sharing and the match mechanism between service characteristics and client capability for application coordinating. An agent registering process is presented to decrease interactions with IMS-core. Evaluations demonstrate that signaling processes controlled by IMS-DUCP work effectively and performances are acceptable.

Introduction

With the growing demands of various communications from customers, service clients on mobile devices are becoming abundant. Moreover, the categories of services are not limited to traditional text, picture, audio or video. Hence, multiple clients for distinct services are coexisting on devices, e.g., colorful OTT APPs on mobile phones. With the rapid evolution of next generation network, IP Multimedia Subsystem (IMS), which is the core of service management and control [1], is maturing, and it is reasonable to predict that, like OTT APPs, the coexistence of IMS-based clients for various services is to occur. Although the Rich Communication Suite (RCS) ecosystem [2,3] contains most kinds of multimedia services, and harmoniously coordinates its different sub-clients internally, the emerging innovative services beyond RCS ecosystem cause coexistence still. In this paper, we focus on solving following two issues brought by multi-clients coexistence.

1) Local resources sharing. As for local exclusive resources, most devices own certain mechanisms to coordinate resource contention. For instance, a typical one is that the occupied audio speaker is reallocated to the newcomer client or shared by multi-clients. Sometimes these instinct mechanisms cannot handle contentions according on customer’s purpose and obtain poor user experience.

2) Message storm and application coordinating. Massive interactions (e.g., periodical register message) between clients and IMS-core consume much power and impose heavy loads on bearing and internal IMS networks. Meanwhile, multiple application clients need coordination to determine the response client to handle the arriving request in good order.

To our best knowledge, relevant methods of resource sharing and application coordinating for multiple IMS-based clients remain blank. Therefore, we propose the IMS device user cooperative proxy (IMS-DUCP) to solve above issues. IMS-DUCP achieves centralized signaling control between multiple clients and IMS-core. We design a resource sharing mechanism based on priority scheduling which is customer-configurable and an application coordinating mechanism through match between service characteristics and clients capabilities.

As for resource sharing, patent [4] presents a multimedia resource management method via priority arbitration. However, the private protocol doesn’t comply with the existing standards, e.g., session initiation protocol. To message storm, the border access controller (BAC), e.g., session border
controller (SBC), executes secure filter and overload control for optimization before messages entering IMS-core [5,6]. Nevertheless, messages still flow into networks between clients and IMS border. Initial Filter Criteria (iFC) conducts service control based on specific criteria, e.g., service subscription and white-black lists [7,8]. But it is convenient to configure criteria on customer’s purpose and cannot controls clients on customer side. But for multi-clients, some works studies the coexistence of RCS and VoLTE [9-12], for which two general solutions are sharing the same IMS protocol stack and using transparent B2BUA/Proxy. However, the two solutions cannot solve resource sharing and application coordinating issues. IMS-DUCP resembles the B2BUA/Proxy in position on device, and just operates on signaling from independent clients.

The rest of this paper is organized as follows. Section 2 presents the framework and modules of IMS-DUCP. In section 3, we introduce the detailed processes of resource sharing and application coordinating. Performance evaluations of IMS-DUCP are demonstrated in section 4. Section 5 summarizes this paper.

Framework of IMS-DUCP

General Framework

The IMS-DUCP position on a device is as depicted in Fig. 1. Multiple IMS-based clients, represented with Client_1~Client_n, coexist on a device. The dotted arrow lines between clients and IMSCore denote the traditional independent signaling interaction. After the centralized signaling control of IMS-DUCP, all actual signaling messages would pass through IMS-DUCP, as shown with the solid arrow lines.

Components of IMS-DUCP

Functional components of IMS-DUCP and their relations are shown within the dashed box in Fig. 2. Five modules are respectively responsible for Message Filtering, Application Coordinating, Resource Sharing, Information Extracting, Data Storage, and detailed functions are introduced in the following.

Message Filtering: Signaling interaction with local clients and external IMS-core, initial parse and handling of signaling messages [13] according to SIP criteria, e.g., session and dialog, message delivery to other relevant modules.

Application Coordinating: Building map between client capacity and service characteristic, coordinating the response client for the service request through match between the parse of request message and client capability, conducting agent register for clients.

Resource Sharing: Generating resource occupation priority of each client, allocating multimedia resource to client according to priority scheduling mechanism.

Information Extracting: Further parse of signaling message, extracting control information, e.g., request method, response state, transaction, service characteristic, multimedia resource.

Data Storage: Storing required data for each module.
Resource Sharing and Application Coordinating

Message Filtering
This process verifies the integrity and validity of signaling message, maintains current SIP session, transaction, and dialog, delivers message to other modules after initial parse. IMS-DUCP owns the third-party control ability to improve control efficiency. The process is introduced as following steps.

1. Verify whether the received message conforms to relevant SIP criteria. If not, terminates; else, goto step (2).
2. Extract SIP session, transaction, and dialog information and query whether relevant information exists. If not, goto step (3); else, modify the message with centralized control parameters according to the information, update relevant information and goto step (4).
3. Generate new SIP session, transaction, and dialog information for the received message. Modify the message with centralized control parameters according to the information, goto step (4).
4. Parse the request message head. If it is from client, deliver it to resource sharing module, else if from IMS-core, deliver it to application coordinating module. Goto step (5).
5. After handled by relevant modules, the message is delivered to target destination. Terminate.

Application Coordinating
One key function of application coordinating is agent registering for multiple clients. IMS-DUCP registers to IMS-core independently and maintains the register state and acts as a registrar server to clients. IMS-DUCP uses OPTION to obtain client capability. Detailed steps are described as follows.

1. Extract service characteristics, e.g., media types, from the signaling message, usually from the request method and SDP message. Goto step (2).
2. Query for the client which is capable for the service according to the map. The preferred client is the one which is set by the customer and registered. Goto step (3).
3. If no satisfying client exists, respond the failure state, terminate; else if the required client is establishing or in a session, goto step (4); else goto step (5).
4. Prompt customer with incoming request. If continuing existing session is chosen, respond the busy state, terminate; else finish the existing session and handle the incoming, goto step (5).
5. If resource sharing is involved, deliver the message to the target module. Terminate.

Resource Sharing
Priority scheduling mechanism is employed to allocate exclusive resources to competing clients. The priorities of occupying certain resources for clients are set default and configured by customer. Detailed steps are presented in the following.

1. Parse the message to determine the new client. Extract service characteristics from the request method and SDP message and obtain the required resources mapping the characteristics, goto (3).
2. Query whether the resources are occupied. If yes, goto step (3); else goto step (5).
3. Compare the priorities of the existing and new clients. If the new is higher than the existing, and the pre-emptible flag is true, goto step (4); else respond the failure state, terminate.
4. Finish the session of the existing client and allocate the resources to the new client. Update the session information and resource occupation state. Goto step (5).
5. Query whether relevant SIP session, transaction, and dialog information exists. If yes, modify the message with centralized control parameters according to the information, update the relevant information, terminate; else goto step (6).
6. Generate new SIP session, transaction, and dialog information for the message. Modify the message with centralized control parameters according to the information, terminate.
Performance Evaluation

We implement functional modules of IMS-DUCP on mobile device to evaluate signaling processes and performance. We choose the device with relatively low capability as the experiment platform, whose major parameters are 4-kernel 1.2GHz CPU, 2GByte RAM, and Android-4.2 operating system. We adopt OpenIMSCore as the IMS-core, IMSDroid as the client. We exploit signaling processes provided by PJSIP to realize centralized signaling control in IMS-DUCP, which is set as the outbound proxy of clients. Signaling processes and messages between clients and IMS-DUCP are collected inside the device, and those between IMS-DUCP and IMS-core are captured by wireshark.

![Sample signaling processes of the agent registering by IMS-DUCP.](image)

Figure 3. Sample signaling processes of the agent registering by IMS-DUCP.

![The numbers of periodical register messages in independent way and using IMS-DUCP.](image)

Figure 4. The numbers of periodical register messages in independent way and using IMS-DUCP.
Application Coordinating

(1) Agent Registering Process

We use two coexisting clients to verify the agent registering function of IMS-DUCP for multi-clients, and the signaling processes are depicted in Fig. 3. Client1 triggers IMS-DUCP to register to IMS-core. After successful register, IMS-DUCP effectively challenges and responds to the register from Client2. We use another scenario to evaluate message storm avoiding. We collect the number of messages in registering process from five clients whose register period are 1~5 minutes respectively. In 10 minutes, the numbers of REGISTER sent to IMS-core in two ways, independent and using IMS-DUCP, are shown in Fig. 4. The number is significantly decreased.

(2) Application Coordinating

The scenario is that Client2 is called by Client3 from another device to establish video session. Client2 has video capability so that IMS-DUCP delivers the INVITE message to Client2. The signaling processes are depicted in Fig. 5, and video stream session is established between them. In order to evaluate coordinating capability more practically, we set a relatively complex scenario. In each a period of 5 minutes, 10 INVITE messages respectively arrive at random time (within 5 minutes), and each established session lasts randomly between 2 and 5 minutes. Fig. 6 shows 6 periods of numbers of handled messages. Due that IMS-DUCP coordinates the target response client and terminates some requests in advance, the messages are much fewer using IMS-DUCP that the
independent way. We also evaluate the performance of centralized control of IMS-DUCP. The number of per-second arriving request messages which are consisting of different ratios of INVITE and MESSAGE increases from 1 to 1024. The handling time of total messages are depicted in Fig. 7. Due that the MESSAGE request occupies no exclusive resource and cannot be terminated in advance, the time increases with the ascending MESSAGE ratio. Time spent in handling 1000 messages per second is 10~14 ms, which is much shorter than the tolerance 7.5s [15,16], so that its performance is acceptable.

![Figure 7. The handling time of messages with different ratios of INVITE and MESSAGE in application coordinating by IMS-DUCP.](image1)

![Figure 8. The handling time of messages for ascending and random priorities in resource sharing by IMS-DUCP.](image2)

![Figure 9. Sample signaling processes of the resource sharing by IMS-DUCP.](image3)
Resource Sharing

The scenario is the audio resource contention between Client3 which has higher priority and Client1 which is occupying the resource. Signaling processes in Fig. 8 show that IMS-DUCP allocates the audio occupation from Client1 to Client3 through Hold method. We compare two more practical scenarios, clients whose number increases from 1 to 32 per second contend for resources with respectively ascending and random priorities. Fig. 9 depicts that handling time increases with the ascending number of clients for ascending priorities, due that IMS-DUCP has to allocate resource from the existing to the newcomer all the time. In comparison, for random priorities, handling time doesn’t increase all the way. In practice, clients interact with IMS-DUCP with random priorities are common, the interacting rate of 32 clients per second is enough for most devices and handling time under 7.5 ms is acceptable [15,16].

Summary

Emerging multiple IMS-based clients coexisting on mobile device are likely to bring contention for local exclusive resources and incur conflict for response to the external service request. Moreover, massive periodical signaling messages lead to message storm or power consumption. In this paper, we generalize the above as two issues, resource sharing and application coordinating. We propose IMS-DUCP as a local outbound proxy that conducts centralized signaling control for multi-clients. A priority scheduling mechanism is designed to achieve resource sharing process. The agent registering process by IMS-DUCP is exploited to decrease interactions between clients and IMS-core. The match between service characteristics and client capability is employed to achieve ordered application coordinating. The evaluation of IMS-DUCP on mobile device shows effective signaling processes and acceptable performances.

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