Inter-Operator Cooperation Challenges in SIP-Based Service Architecture of IP Multimedia Subsystem of UMTS

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Abstract

One of the benefits of the evolution of the third generation mobile systems such as UMTS (Universal Mobile Telecommunications System) toward the all-IP network architecture is to provide functionalities to support real-time multimedia services. Simple and efficient multimedia session handling characteristics of the Session Initiation Protocol (SIP), candidates it by 3GPP (Third Generation Partnership Project) for the signalling protocol of IP Multimedia Subsystem (IMS) of UMTS. An important issue in IMS is the fact that service control procedures of the subscribers are performed in the home network. In this paper we review the SIP-based service registration and session establishment procedures in IMS and we study the challenges for providing a SIP-based cooperative mechanism between network operators of different subscribers in IMS in order to prevent extending of service control procedures of roamers to home network and to optimize the session establishment procedure by performing service control procedures of roamers in the visited network.

1 Introduction

Heterogeneous environment of the Next Generation Networks (NGN) and the convergence of fixed and mobile telecommunications in the NGN environment emphasize the need for realization of service architecture capable of providing “any where, any time” multimedia real time services as well as customized and personalized services to users. Some examples of these services are: Push-to-Talk over Cellular (PoC), multimedia conferencing, multimedia messaging, live/ on demand streaming and Presence aware services.

In order to deploy these IP-based multimedia services in NGN, Release 5 of 3GPP introduced IMS [1], as an open IP-based service infrastructure that overlays the UMTS core network. In the IMS infrastructure, multimedia session establishment, maintenance and termination are performed by using SIP [4]. SIP is standardized by IETF (Internet Engineering Task Force) and is selected by 3GPP as signalling protocol of the IP-based UMTS network for establishing multimedia sessions.

Functionalities that are required for supporting multimedia real time services, such as service creation, registration, invocation and execution are incorporated in the service architecture of IMS. Among these entities, IMS contains multiple SIP proxies called Call Session Control Functions (CSCFs) with following roles: P-CSCF (Proxy-CSCF) which is the first contact point in IMS and interacts with GGSN (Gateway GPRS Support Node) i.e. the access point from UMTS to external networks, for policy control and resources allocation, I-CSCF (Interrogating-CSCF) which acts as a SIP Registrar and is responsible for routing sessions to appropriate S-CSCF (Serving-CSCF), and finally S-CSCF which performs session control and service trigger [1].

In this paper, we will first review the session registration and establishment procedures. In this review we present the structure of user profile and service related information saved for each user. User profile is stored in Home Subscriber Server (HSS) and during service registration and session establishment procedures, S-CSCF retrieves the user profile from HSS over CX interface [2] and stores it for further session establishment procedures. Therefore, user profile retrieving is performed during user registration in the network. Afterwards for each session establishment procedure, user profile stored in S-CSCF will be referred. We will review the user registration and session establishment procedures based on 3GPP specifications [1, 2, and 3]. According to these specifications, session control procedures should be extended to home network of subscribers. In continue of our paper regarding to the issues in the service architecture we exploit the challenges that exist for providing network operators cooperation in order to provide session control procedures for roamers in the visited network. Finally we resume and conclude the mentioned challenges.

2 User Profile Structure

The user profile stored in HSS indicates the private identity of the subscriber and the one or more service profile(s) related to this subscriber. As subscribers can register for multiple services, user profile contains one or several service profile(s). In this part we will explain the structure of user profile presented in figure1 [2].

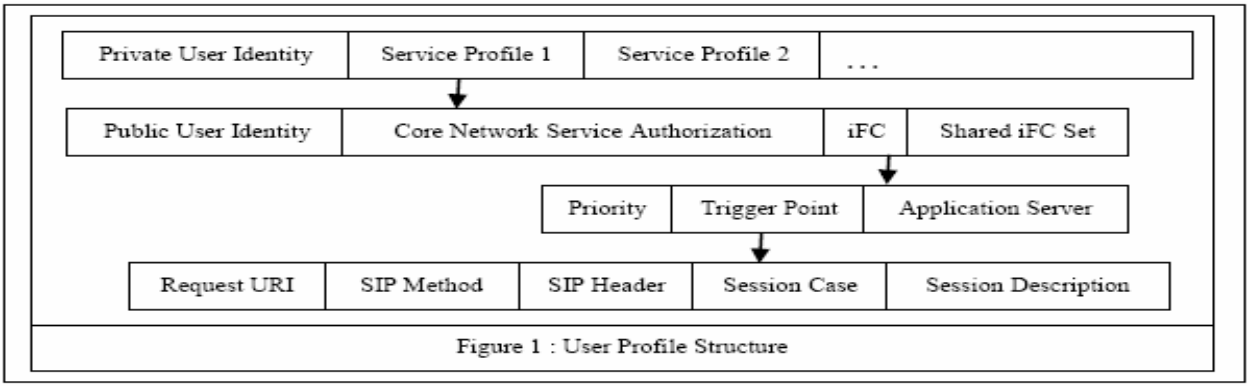

Figure 1 : User Profile Structure

The service profile field in the user profile structure presented in figure 1 contains the following information:

- One or several public user identity (identities) is presented as a SIP URI of the user or as a tel URI. Each public user identity is associated to a service profile. For each public user identity, information about core network service authorization, initial Filter Criteria (iFC) and shared iFC set are registered.
- Core Network Service Authorization mentions the identity of subscribed media. If this field is not present, S-CSCF will not apply any filtering related to the subscribed media.
- iFCs are assessed according to their priorities. Each iFC indicates the SIP URI of the application server and the relevant triggering point(s) containing: the URI of the SIP request, the SIP method indicated in the SIP request, the header fields and their contents, the content of any SDP (Session Description Protocol) field in the body of SIP request and information about the originating or terminating case of session. Triggering points should be checked to verify if service triggering criteria are met for current session and to see if indicated application server should be contacted or not. The service platform [3] in IMS is composed of
  - SIP Application Server (SIP AS): SIP AS is a lightweight application invoked by S-CSCF through a SIP based service mechanism such as SIP Servlet API, JES (Java Enhanced SIP), SIP CPL (Call Progressing Language) scripts or SIP CGI (Common Gateway Interface).
  - Open Service Architecture (OSA) [5]: enables the operators to provide third party service provider access to their UMTS service architecture.
  - Customized Applications for Mobile Network enhanced Logic (CAMEL) [6]: based on IN (Intelligent Network) concepts, allows reusing of existing GSM/UMTS IN services such as prepaid services.

However, from S-CSCF's point of view, each of these service platforms is identical and the S-CSCF will have access to theme through a single interface ISC (IP Multimedia Service Control). If no triggering point is indicated, then triggering to application server will be unconditional.

- Shared iFC Set is the iFC set locally administrated and stored at S-CSCF.

During registration procedure, user profile, containing mentioned information will be retrieved and saved in the related S-CSCF of the user in the home network. In the next part we will present the details of the registration and session establishment procedures.

3 Service Registration & Session Establishment

When a mobile user enters to a network, the registration procedure will be performed. Registration consists of two levels: "GPRS network registration/PDP context activation" and "IMS network registration". GPRS registration and PDP context activation provide user the possibility to obtain IP address and to indicate QoS profile. After registration to IP core network, SIP REGISTER request performs IMS level registration for session and service accomplishment. This procedure, based on [1], is illustrated in figure2.

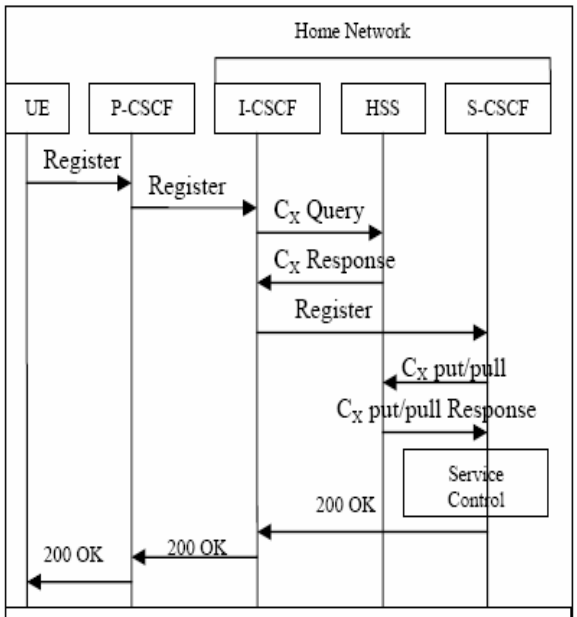

Figure 2 : Service Level Registration

As it is presented in the figure 2, the SIP REGISTER request of the user entering in a network (Home or Visited), will be send to a P-CSCF that it's address is found through GPRS registration or by using DNS or DHCP server. Registration information in this request are: Public User Identity, Private User Identity, Home Network Domain Name and IP address of user entity. P-CSCF by receiving REGISTER request, adds to received information flow it's address and the network identity. Then P-CSCF forwards the request to the I-CSCF of the home network of the user by using the home domain name of the user. I-CSCF refers to HSS through Cx interface to check whether the user had already registered or whether the user is allowed to register in P-CSCF network. Acceptance of registration of the user in a network depends on the user subscription information and the network operator limitations. If the registration is accepted, HSS chooses an S-CSCF for the user and sends the name and capabilities of S-CSCF to the I-CSCF. Afterwards I-CSCF forwards registration request to the S-CSCF. Then, S-CSCF will retrieve the user profile from HSS, and stores in HSS the address of S-CSCF for this user. Afterwards based on the retrieved filter criteria, S-CSCF sends the registration information to the service control platform, and forwards the acceptance of the registration to the user via I-CSCF and P-CSCF.

According to this procedure, for each session establishment procedure, depending on the user profile stored in the S-CSCF of the home network, services will be invoked. If mobile user is roaming in a VPLMN (Visited Public Land Mobile Network), all SIP signalling messages are sent to the S-CSCF located in the HPLMN (Home Public Land Mobile Network). This procedure allows the mobile user to benefit from the homed subscribed services when roaming out of his network but multiple addressing to the home network during session establishment procedure may provoke the exchange of multiple SIP messages and a long delay of session establishment, because service control procedure will be extended to the home network and the visited network is not able to offer same services to the mobile user. The session establishment delay is a critical issue as it is clearly perceived by subscriber and it should not be longer than GSM circuit switch bearer establishment.

In order to clarify these issues in the session establishment procedure, we present following scenarios for session establishment procedure, concerning subsequent cases:

1. The Caller and the Called parties are in the home network
2. The Caller party is in the visited network and calls a user in the home network
3. The Caller and the called parties are both in the visited network
4. The Caller is in the visited network and calls a subscriber of the visited network

In following descriptions of scenarios, based on the 3GPP specification [1], we assume that A and B are subscribers of domain1, and C is subscriber of domain2.

In the first scenario, presented in figure3 A and B have already registered to domain1 according to registration procedure presented in figure2 and therefore their user profiles are stored in the S-CSCF of domain1. A invites B to establish a session, by sending an INVITE request including SDP part to the P-CSCF discovered during registration. SDP contains media characteristics of the session that A needs to share with B. The P-CSCF generates and stores an Authorization Token and forwards the INVITE request to the S-CSCF. The S-CSCF validates the service profile of A, invokes required service logic and determines the home network of B. As B is also a subscriber of domin1, and had already registered, it's user profile is retrieved in S-CSCF during registration. Therefore S-CSCF validates service profile of B and invokes required service logic. Then S-CSCF forwards the INVITE request to B. B answers to the SDP offered from A in INVITE request and returns it's media capabilities in 183 Session in Progress provisional response. S-CSCF forwards this answer of B, to the P-CSCF to authorize the required resources for this session. P-CSCF includes Authorization Token to Session in Progress response and sends it to A. A decides about the offered set of media streams for this session, initiates resource reservation for the offered media and acknowledges session in progress response by PRACK (Provisional Response ACKnowledgment) that will be forwarded towards B. B sends back 200 OK response to A via S-CSCF and P-CSCF. When resource reservation is completed, A sends UPDATE message to B to indicate success of resources reservation. B answers A by 200 OK response and alerts A for success of session establishment by Ringing.

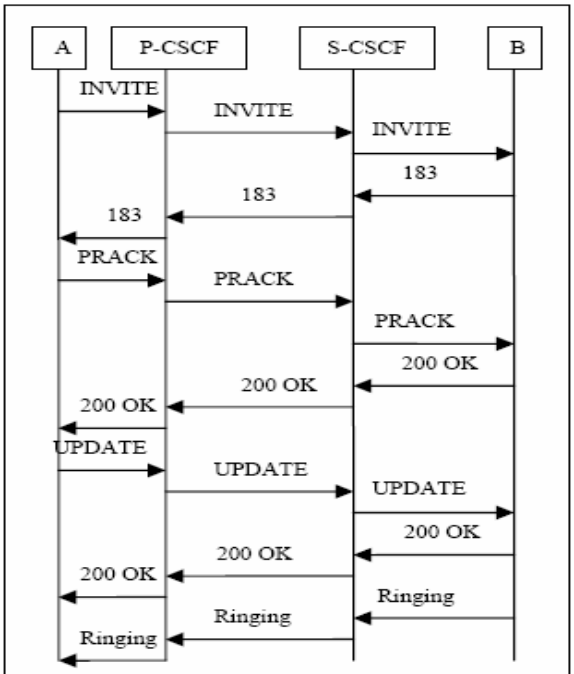

Figure 3 : Scenario 1, Session Establishment

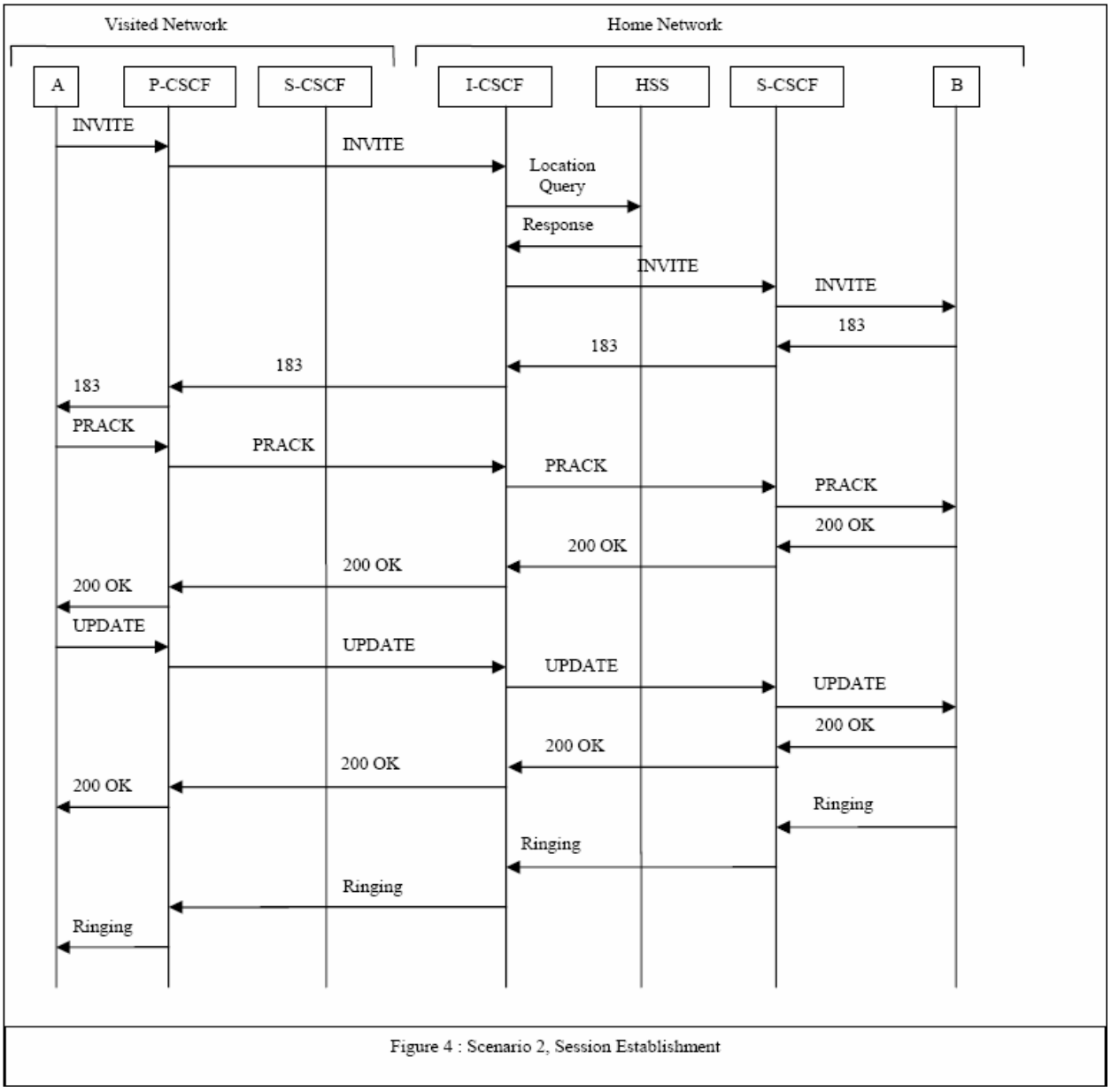

Figure 4 : Scenario 2, Session Establishment

In the second scenario presented in figure4, we suppose that A leaves domain1 and enters to domain2 and invites B for session establishment. In this case, as A enters to domain2, it must first register to this network according to the registration procedure that is previously explained. We recall that the user profile of A will be retrieved and saved in S-CSCF of doamin1 and for each session control procedure S-CSCF of domain1 will be referred. In this scenario, as P-CSCF of domain2 detects that A is a subscriber of domain1, it will forward the INVITE request to I-CSCF of domian1 in order to find correspondent S-CSCF to A. I-CSCF requests HSS and finds S-CSCF associated to B and forwards the request to S-CSCF. S-CSCF invokes service logic appropriate for this session setup and sends the request to B. As in precedent scenario, A and B negotiate about the media streams, reserve necessary resources and finally B alerts A to start media transmission. In third scenario A and B which are subscribers of domain1, are located in domain2. They have already registered in domain2 and A starts to establish a communication with B. This scenario will be the same as second scenario and as user profile of both A and B are saved in S-CSCF of domain1, session establishment procedure will be extended to domain1. In forth scenario also, as user profile of A is saved in S-CSCF of domain1, session establishment procedure between A and C will be performed by the intermediate of S-CSCF of domain1.

In the next section we will present the challenges for providing an inter-operator agreement based on which the service registration procedure will be modified in order to optimize the session establishment procedures.

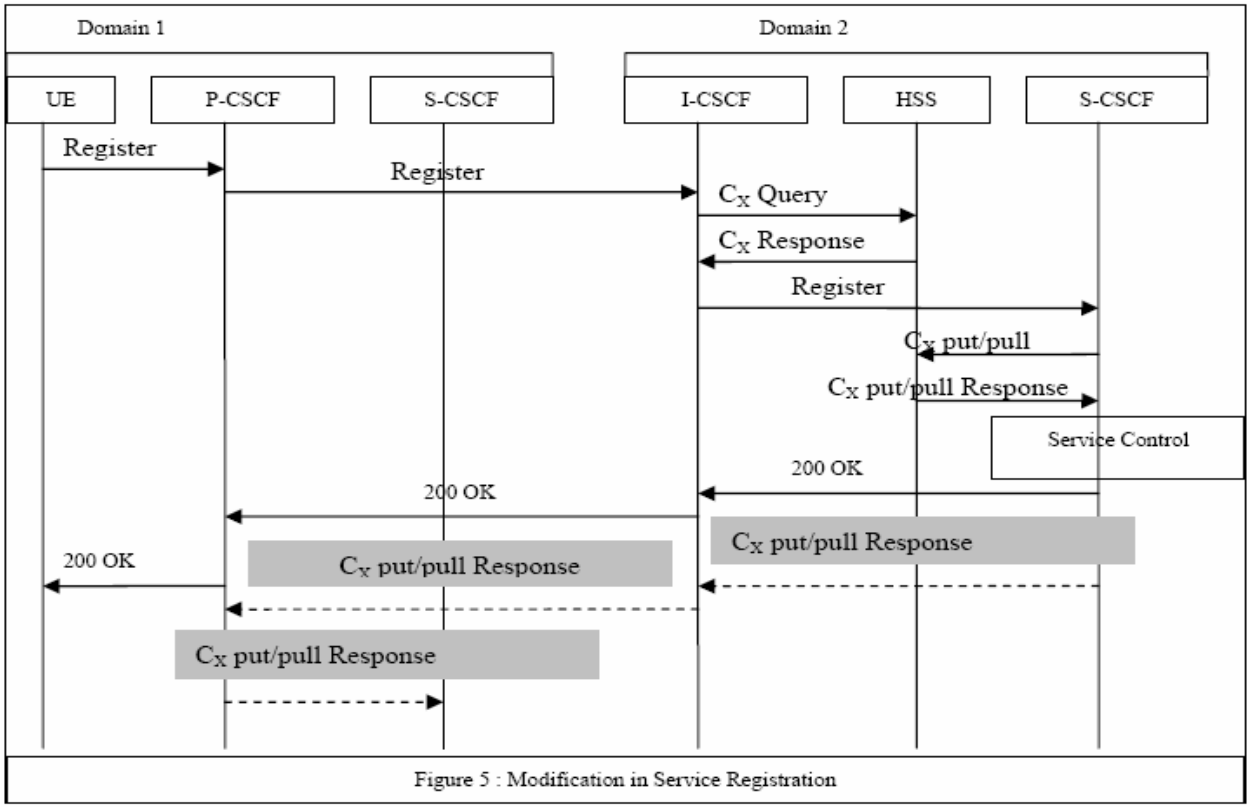

Figure 5 : Modification in Service Registration

4 Session Control Issues

Multiple references to home network for retrieving the user profile of a roamer in a visited network will introduce long delays for session establishment and several SIP requests will be exchanged between two networks. Access to home network will be repeated for each session establishment procedure from roamer in the visited network.

To deal with these issues home and visited network operators can establish an agreement in order to allow service control functions of roamers to be performed in the visited network without requiring to extend the control to the home network. Based on this agreement, the visited network dedicates one or several specific S-CSCF for roamers and once a roamer registers in this visited network, i.e. after interrogating the S-CSCF of home network and retrieving user profile, a copy of this user profile will be send to the S-CSCF dedicated to roamers in visited network and P-CSCF related to the roamer marks in a data base that this user is located in the visited network. By this modification in the registration procedure, when a P-CSCF in the visited network receives an INVITE request from a roamer, it will refer to the data base to verify if the caller and called parties (Request URI and To field in INVITE request) are located in the visited network or not. If both are in visited network, P-CSCF will forward the INVITE request to the S-CSCF of roamers in the visited network without requiring to forward the request to the home network.

If the called party is not located in the visited network, P-CSCF forwards the INVITE request to I-CSCF of the home network of the called party and the session will be established through S-CSCF of the home network. In other words, if the called party is also located in the visited network, as the case of scenario three and four, this modification will prevent the need for accessing to the home network and therefore the session control procedures will be performed in the visited network. Eliminating the intervention of the home network for session establishment procedure is the essential benefit of this modification in service registration and session establishment procedures. But if the called party is placed in other network than visited network, as the case of second scenario, referring to S-CSCF of home network causes the same establishment delay and the same number of exchanged messages as referring to S-CSCF of visited network.

In figure 5 we present the modification in registration procedure for the case when mobile user registers in a visited network. In this figure, once S-CSCF has retrieved user profile over CX interface, it forwards the user profile to the P-CSCF via I-CSCF. These entities do not parse or modify the user profile, but only forward it. P-CSCF associates an S-CSCF to the mobile user in the visited network and forwards the user profile to this S-CSCF. As we explained before, this S-CSCF is selected according to the inter operator agreement. S-CSCF behaves just like when it retrieves a user profile from HSS and therefore save the received user profile. According to this registration procedure, by assigning S-CSCF of visited network to A in

third and forth scenarios, i.e. when user is located in the visited network and wants to establish a session with an other user in the same network, the number of exchanged SIP messages during the session establishment and the corresponding delay will be reduced compared to the case where user had to access the home network for session establishment procedures. In figure 6, we present the session establishment procedure for third scenario. Comparing this scenario with the one illustrated in figure 4 that presents same scenario without modification in the service registration procedure, confirms the benefits of this modification in the registration procedure.

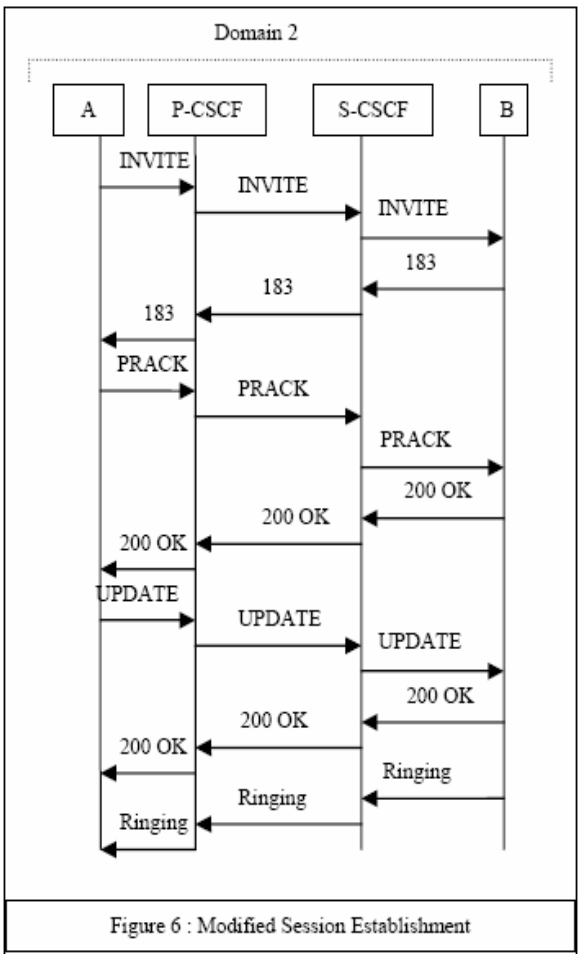

Figure 6 : Modified Session Establishment

The benefits brought by this inter-domain agreement for a user located in a visited network are the followings: eliminating the intervention of the home network for the session establishment procedure and preventing the necessity of multiple refers to the home network of the foreign user that wants to establish a session with users presented in this visited network during session establishment procedure.

Beside these benefits, we encounter following challenges regarding inter-operator cooperation: First challenge is related to specific characteristic of each of the Application Servers (AS) in each domain. If home and visited network are engaged to provide service control functions to subscribers of each other, they should also offer the capability to access the local AS instead of home AS. The design of such platform will be more complex when billing aspects of services are also involved. A typical problem in this case is to decide how to manage prepaid services between two operators.

Other challenge concerns the inter-working between P-CSCFs of the visited network when the caller and the called parties register to two different P-CSCFs in the same visited network. For routing the outgoing call from the P-CSCF of the caller to the dedicated S-CSCF to roamers in visited network, the P-CSCF of caller must be aware of the presence of called party in same visited network, i.e. P-CSCFs must contact each other for sharing the list of roamers in the visited network. Therefore a P-CSCF/P-CSCF interface must be designed in order to provide broadcast of the lists of roamers between P-CSCFs.

5 Conclusion and Discussion

The IMS infrastructure brings in functionalities to offer real-time multimedia services, but according to current state of 3GPP specifications, control procedures of these services are performed in the home network of roamers. In this paper we presented the issues that network operators should deal with, in order to cooperate for optimising the service architecture especially for satisfying roamers that uses delay sensitive services by providing session control procedures in the visited network and preventing the need for extending the session control procedure to the home network. Implementing this cooperation mechanism remains a challenge for operators. However it will be interesting to see how this inter-operator cooperation will impact networks.

References

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