Session Mobility between Heterogeneous Accesses with the Existence of IMS as the Service Control Overlay

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Abstrac-Session Mobility is an advanced feature that provides new capabilities for the clients as well as more benefits for the service operators. In this paper we propose the deployment of a Mobility Server in IMS- IP Multimedia Subsystem to provide Session Mobility between the devices connected to different access technologies. We have modified SIP based session mobility approaches and we have adopted them in IMS. Moreover, advanced features of session mobility like session splitting and combined device discovery and session mobility is sought in this paper.

I- Introduction

IMS- IP Multimedia Subsystem [1], was firstly standardised by 3GPP release 5 in 2002. IMS relies on SIP servers and proxies and creates an independent service control plane over underlaying transport technology.

SIP- Session Initiation Protocol [2] is an IP based protocol to control conversational multimedia sessions and is going to be the dominant telephony over IP signalling protocol.

The clean split that IMS creates between service plane and transport plane reduces considerably the time to market for new services. In fact, the services can be enhanced and developed and then be deployed independently of the underlaying infrastructure. This is why IMS has attracted the endorsement of other network technology operators as well as other standardisation organisms. TISPAN [3] group in ETSI, in the field of NGN project, is reusing the work on IMS done by 3GPP to provide all IMS services to broadband xDSL subscribers and some selected services to PSTN/ISDN customers [4]. In the U.S., cable multiple systems operators (MSOs) are also showing interest in IMS as part of the recent CableLab PacketCable 2.0 initiative [5]. Furthermore, the work for WLAN access to IMS was started in 3GPP Release 6 and is being continued in Release 7 [6]. Therefore IMS as the service control overlay is going to create horizontal service convergence in spite of heterogeneity in underlaying transport technologies. For instance, the services that we are currently used to use are separated by the nature of their networks. We use our fix PSTN telephone line for a certain number of applications. Besides, our xDSL (Cable) line is used for internet applications; and in addition we use our cell phones to benefit other services. However with IMS, all of these services will be available from each of these access technologies and there is no more need to use a special access technology for certain kinds of applications. This is the realisation of *horizontal service convergence*. In such environment, a very attractive feature may be the ability of transferring an active session running on a device to another device connected to another access technology. In another word: *session mobility* between two devices connected to two different access technologies.

Session Mobility is one of the aspects of mobility that brings out many advantages including:

- New Capabilities for the customers;
- Better Utilization of Resources ;
- Higher user satisfaction level ;
- Service Persistence: Services more attractive;
- Leverage frequency and duration of service usage: More benefit for the service operators.

For example, if a user who is visiting a company, gets battery failure alarm, he will be capable of transferring his session to a device authorized for visitors in that company to save battery consumption. Or consider a user at his home with a xDSL wireless modem who is in the same time in the coverage of a 3G and GSM networks. This user is able to transfer some sessions receiving via his 3G cell phone to the other devices connected to other access technologies: For instance, he can transfer the Video session to his PC connected to xDSL modem and his voice call to his GSM cell phone. This possibility, lead to a better resource utilization and lower cost for the costumer.

Now, according to the fact that there is more and more agreement for deployment of IMS over different network technologies (Wifi, Wimax, 3G, xdSL and Cable) this article seeks for the solutions to benefit the IMS control plane architecture to provide session mobility feature among the devices of different access technologies. According to the fact that IMS is using SIP, session mobility approaches based on SIP seems appropriate for our purpose. However we will show that they won't be efficient if we deploy them without modification. Therefore, in this paper, we introduce a Mobility Server in the application plane which is connected to IMS via the IMS Service Control (ISC). ISC is a SIP based interface standardised by IMS to connect the Services to IMS elements.

In the rest of the paper, we introduce the main components of the session mobility. Then we discuss two existing SIP based solutions: Third Party Control and REFER method. Then in sections V, VI and VII we introduce our approach in the existence of IMS.

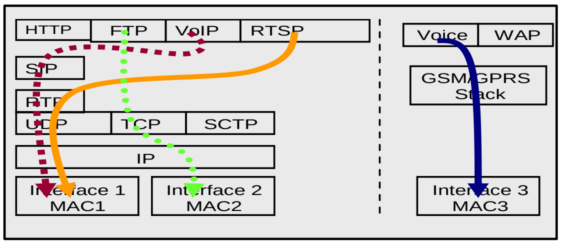

Fig. 1: Different active Sessions on a Device

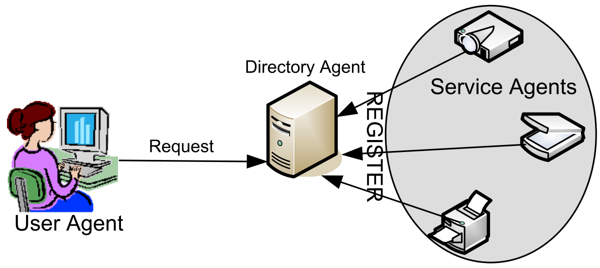

Fig. 2: Service Discovery Architectre

II- Session Mobility Components

Session mobility is the process of transferring an active session to another terminal or another interface. There are four main components involved in a session mobility process:

Triggering Device:

The *Triggering Device* is the device that triggers the session mobility. In the simplest scenario, Triggering Device is one of the two devices that are currently involved in the active session (caller or callee device). However, in advanced model of session mobility, the Triggering Device is not necessarily one of devices involved in the current session. Triggering Device should just have authorization for this session transfer request.

Source Device:

Source Device, is the device involved in the current session and its session will be transferred to another device.

Target Device/Interface:

The Target Device/Interface is the device/interface that receives the media after session transfer.

Corresponding Device:

The corresponding device is the device of other party of the session that remains unchanged after session mobility.

Session mobility needs the following steps to be completed:

1. Device/Session Discovery.
2. Authentication of the devices.
3. Selecting and authorizing the target device for transfer.
4. Informing the Corresponding Device about new party.
5. Negotiating for the new parameters of the session.
6. Session Migration: Media transferring
7. Session Resume (in the case)

As it is mentioned, the first step is Device/Session Discovery. In the Device Discovery process, *Triggering Device* discovers the legitimate devices whose capabilities match with the requirements in the query for Target Device. The discovered devices all have already authenticated by the system, and non-authenticated devices are not allowed to take part in the discovery process.

On the other hand, Session Discovery is required when the *Triggering Device* is not involved in the current session. In this case *Triggering Device* needs to discover different active sessions on the *Source Device* to select the one it desires to transfer.

According to the fact that each session on a terminal uses its proper protocols in each layer of the protocol stack (Fig. 1), all the sessions on a terminal should be described with a *session digest* in a manner that they can be distinguished from other sessions.

Digest of a session is the minimum peaces of information which unify a session.

SDP-Session Description Protocol [7] describes the sessions with identifying the following information: i) five tuple information: Source IP address, Destination IP address, Source port No., Destination Port No. and transport protocol name. ii) Session ID. iii) Connection Protocol (Internet, CS, …). iv) Media Type (Video, Audio,…). v) Format of the media (H261 Video, MPEG Video, etc).

SDP is currently used in SIP-Session Initiation Protocol and RTSP [15]. RTSP is standardised for Streaming Services and is used more and more in such kinds of applications. In this paper for session description we consider the use of SDP.

After Device discovery, when the *Target Device* was chosen, the *Corresponding Device* will be informed about the new device parameters and if required, the session re-negotiation for new parameters will be accomplished. Then finally, the media will be established between *Target Device* and *Corresponding Device*.

In some cases, after a while, the *Source Device* needs to retrieves the session. We call that *session resume* or *session retrieval*. For example consider that a user, transfers a voice session from his cell phone to his fix phone when he arrives to his office. Then after some minutes he decides to leave the office, so he should be capable of retrieving his session on his cell phone.

In session mobility, there are also some advanced interesting features: *session splitting* and *merging*. Session splitting means that, a composed session split over several simple sessions on different devices. For instance, a video phoney including video and voice, may be split over three sessions as follow: Ingress Video, Egress Video and Voice.

In contrast, session merging is needed to merge a sessions that is split over several devices to a single session on a unique device.

Session Mobility solutions are proposed in different layers: In network layer, MIPv6 with some modification will be able to support session mobility [8]. As a matter of fact, MIP makes a MN- Mobile Node- accessible when it changes its IP address by providing a binding between Care of Address (New Address) and Home Address of MN. If MIP creates a binding between two Home IP Addresses of two different devices, it will be able to provide session mobility. MIP solution for session mobility has a lot of limitation. For example with mobile IP, all the active sessions of a device will be transferred together. There are also some solutions in transport layer like TCP-Migrate [9] that supports session mobility for a certain transport protocol (TCP).

However in this paper, we focus on the solutions based on SIP for two main reasons: Firstly, IMS is based on SIP. Secondly, session mobility solutions based on SIP in comparison to the other approaches are much more flexible in supporting advanced features like session splitting and merging. However before discussing the SIP based approaches, we introduce Device Discovery approaches in a separate section. Because Device discovery protocols and approaches are independent of the session mobility signalling protocol.

III- Device Discovery: The First Phase of Session Mobility

Device Discovery required in session mobility, is in the scope of a more general problem called service discovery. A service discovery protocol, may have three main entities [10] (Fig. 2): User Agent, Service Agent and Directory Agent. Services register their service name with a description of their services in Directory Agent. A service description consists of two parts. The first part is service description header containing the semantics of the service. The second part is service description body, which describes the detail of the service including the service access point. Then, the user agent sends a query and request for its desired services (devices). For device discovery, the devices will be seen as the services: the service name is the device type and Service Attributes are device capabilities. Service Discovery protocols are developed by different teams and organism for different network scales [11]:

- PAN scale: Bluetooth SDP.
- LAN/Enterprise Scale: SLP, Jini, Unpn, Salutation.
- Internet Scale Discovery: INS/Twine, Ninja.

In the proposed architecture for Device Discovery proposed in this work, we have chosen SLP- Service Location Protocol [12]; because SLP like SIP is proposed by IETF and is technology independent (unlike Unpn).

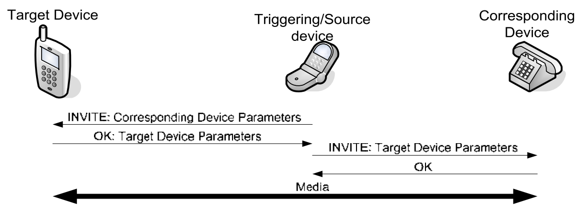

Fig. 3: Third Party Control approach

However, there is no limitation on the use of other protocols.

IV- SIP Based Session Mobility

Two methods for SIP based session mobility exists: Third Party control and REFER method. To simplify the scenarios of our examples, we ignore the Device Discovery Phase and we assume that the *Target Device* is already selected. In addition, we consider that *Triggering* and *Source Device* are the same.

Third Party Control [13]:

The Signalling Flow of this method is depicted in Fig. 3. In this figure, D1 is the *Triggering*/*Source* device and D2 is considered as *Target Device*. In addition the *Corresponding Device* is indicated by CD. To trigger the session mobility, D1 sends an INVITE request to D2 conveying the SDP parameters of the *Corresponding Device*. Then D2 responds with an OK and indicates its preferred SDP parameters to D1. Then D1 use these parameters and sends an INVITE to CD including the SDP parameters of D2. If CD agrees with these parameters, it sends an OK to D1, and then the media will be transferred to the D2. In this method there is no direct session negotiation between CD and D2. In fact, All the SIP messages will be passed through D1; this is why this method is called third party controlled. However, the media may be end-to-end or again being proxied by D1. This method supports easily session splitting [13]. But there are some essential limitations: Firstly, the session transfer will be triggered always by *Triggering Device*. Secondly, even after transfer, the *Triggering Device* should remain active for session re-negotiation during the session; therefore, if for example *Triggering Device* gets a battery failure, or leaves the area, the session will be lost.

REFER METHOD [13]

REFER method is defined by IETF Sipping group in a separate RFC [14] as an extension to the SIP methods defined in RFC 3261 [2].

Fig. 4 shows the session mobility signalling flow by using REFER method: D1 sends REFER to the D2 asking to accept its active session. If D2 accepts, it will send an ACCEPTED to D2. And then it creates an INVITE targeting to CD. This INVITE contains a *Replace header*, explaining the modification of the session parameters. CD informs D2 its acceptance with an OK. Then D2 sends a NOTIFY to D1 to inform it about the success of negotiation.

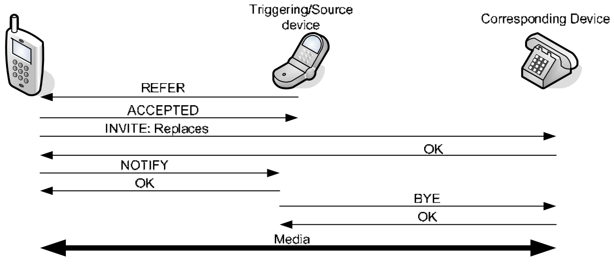

Fig. 4: Session Mobility with REFER Method

Then, in the last phase, D1 sends a BYE to CD and quits the session. In this time, the media will be transferred to D2. This method, cope with the main draw back of the third party control mode. It means that, the *Triggering Device* will be no more in the session signalling. However, with this method the session splitting is more complicated to be implemented [13]. In fact, if Triggering/ Device desire to split its session over D1 and D2, it should send two separate REFER to each device; in consequent, each of these two devices will contact CD separately by sending an INVITE. There is no guaranty that these two INVITEs arrive in the same time, hence there will be the problem of session synchronization.

V- Defining the Mobility Server in IMS

IP Multimedia Subsystem is standardised based on SIP elements. Among the IMS components there are three core IMS control functions: S-CSCF, I-CSCF and P-CSCF. S-CSCF- Serving Call Session Control Function, manages access to subscriber database and use the information stored in that database to invoke features and applications in response to subscriber requests. Interrogating CSCF (I-CSCF), controls the boundary to the network and is responsible for routing requests to the right S-CSCF. The Third Control Function, the Proxy CSCF (P-CSC), acts as an interface to clients, secure the link to the client, and facilitates roaming.
In the application/service layer of the network, an IMS architecture introduces the IMS Service Control (ISC) interface for connecting the S-CSCF to a Service Capability Interaction Manager (SCIM). The SCIM is a special kind of SIP application server which performs feature interaction management, and connects to application servers using the same ISC interface. According to the fact that IMS uses SIP, the SIP based session mobility is easy to be adopted in IMS. However there are two important issues:
First, Third party control method, because of security problem, is not accepted in IMS. In fact, it is not acceptable that a transferred session will be controlled by a terminal (triggering device) which is not involved anymore in the session.
Second, using REFER method for session mobility as what is proposed by IETF, push a huge amount of signalling load in the radio links. Fig. 6-a shows that in REFER method (without modification) a session transfer requires the exchange of 18 signalling messages which all pass through the access network. These issues are our main motivation to develop a Mobility Server which connects to IMS via ISC interface similar to other application services. The mobility server, handle the mobility features that the mobility management mechanism of the network (like mobile IP) can not manage. These features include: Session mobility, personal mobility, service mobility and service adaptation to the user context. Fig. 5 depicts the overall architecture and the situation of the Mobility Server.

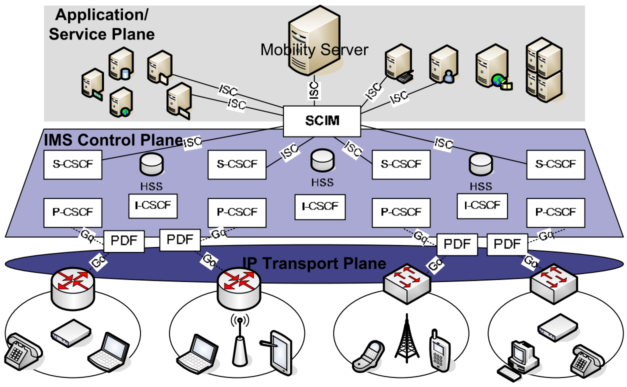

Fig. 5: Mobility Server and IMS Architecture

Numerous advantages may be achieved by deploying such mobility server. As a matter of fact, because it is deployed as a service and is connected to IMS via the same interface as other application servers, it is able to cooperate with other services to provide enhanced features in mobility management. For instance, the collaboration of Location Server and this server can bring out location aware handover. The location information provided by GPS and analysed by the location server can be sent to this mobility server. Then according to the location, movement direction of the user and the session QoS parameters, the best access technology in that proximity will be chosen in handover process.
However, the focus of this paper is only on the Session Mobility feature that this Server can provide by using the service convergence that IMS brings for heterogeneous technologies.

VI- How Mobility Server Provides Session Mobility

As we mentioned before, the two SIP based session mobility approaches proposed by IETF can not be used directly in IMS.
By deploying Mobility server, we propose a combination of these two approaches to benefit the strong points of each approach as well as cope with the drawbacks of them. Figure 6-b, shows the session mobility signalling flow with the existence of a Mobility Server in IMS. Mobility server receives the REFER method from *Triggering Device*. Then it starts an approach like third party control method. By using this hybrid method, the number of SIP messages pass through access network will be decreased to half. In addition there is no more the problem of third party control method that even after session transfer, the session should be controlled by the previous device. In our method, Mobility server receives the REFER from D1 requesting transfer of the session to D2. Then Mobility Server, sends an INVITE with CN parameters to the D2. If D2 accepts, it will send an OK with its parameters. Then Mobility Server provides another INVITE destined to CN conveying D2 parameters. After acceptance of CN, Mobility Server sends BYE to D1 and the session will be established between D1 and CN.

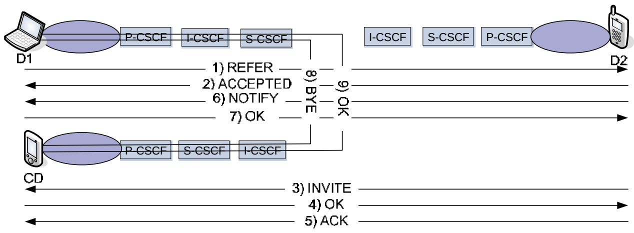

Fig. 6-a: REFER Method without Mobility Server

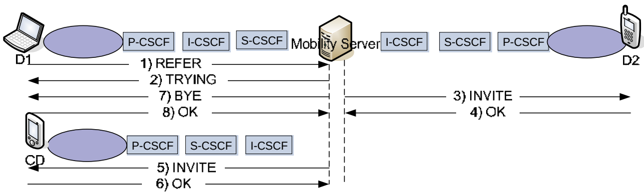

Fig. 6-b: Session Mobility by using Mobility Server In IMS

VII- Advanced Features of Session Mobility in the Introduced Architecture

Advanced features can be considered in this architecture for session mobility:

Device Discovery:

Each domain can deploy local device/service discovery mechanism. Device discovery enhance the session mobility features. With contact to Service Discovery Directory Agent, IMS clients will be able to discover the devices with different capabilities in that proximity. Each subscriber, according to its profile is authorized to use a certain number of devices.

Session Splitting:

As we mentioned before, Session Splitting means decomposing a combinational session and transferring each session component to a separate device.

Fig. 7 shows our session splitting approach: *Triggering Device* sends REFER to Mobility Server. In this REFER, the *Triggering Device*, indicates the desired *Target Devices* for each session component. Mobility Server, according to the received REFER, creates separate INVITEs with the relevant SDP parameters for each of the Target devices. Then each of the target devices receives only the SDP parameters of a part of the original combinational session. Each target device replies with an OK indicating its desired parameters for their relevant session. Then, Triggering Device concatenates all the SDP parameters of each target device in a single INVITE and sends it to the Corresponding Device.

Combination of Device Discovery and Session Mobility Process:

The process of device discovery and session mobility may be combined. In this approach, instead of indicating the exact contact information of the new device, the *Originating Device*, just sends the Mobility Server a description of the capabilities of the *Target Device* that the user desires. Then the Mobility Server sends a query to the Service Discovery Directory Agent (DA).

DA replies back to this request with a list of available devices compatible to the request. The Signalling flow is depicted in Fig. 8.

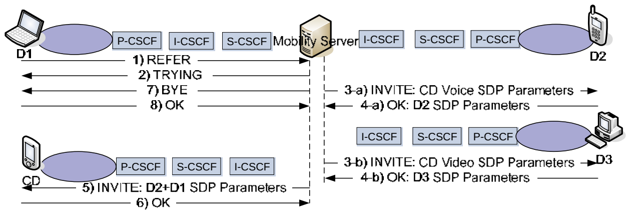

Fig. 7: Session Splitting with Mobility Server in IMS

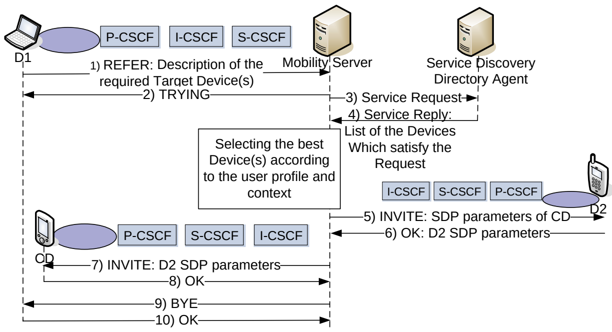

Fig. 8: Combination of Device Discovery and Session Mobility Signalling

Summary

In this paper we benefited the IMS architecture and introduced a Mobility Server over hybrid access technologies. The Mobility Server provides Session Mobility between the devices of different technologies. SIP based session mobility approaches are modified to reduce the required signalling for session transfer. Moreover, the advantage of this Mobility Server is that it uses the same interface as other application services to connect to IMS. Therefore with collaboration of Mobility servers and other servers like Directory Agent Service Discovery, new advanced features like combined Device Discovery and Session Mobility can be provided.

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