Mobility-Aware P/I-CSCF : a solution for achieving seamless handover in IMS

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***Abstract*—This paper is focusing on IMS session continuity of a Mobile Node (MN) roaming from different access technologies. Comparison between different mobility solutions used in NGNs are addressed. Vertical mobility using End-User context information and SIP signaling are foreseen to efficiently comply to 3GPP standards and to provide enhanced end-user satisfaction. The usage of SIP mobility within our solution does not introduce any change in the signaling functionalities nor the architecture. Only slight modifications are required in the P-(or I-)CSCF in order to enable media switching. This paper also introduces a new algorithm in the MN to handle incoming media from different network interfaces. A proof-of-concept involving wlan to 3G mobility validates our analysis and provide interesting results.**

***Keywords*-IMS; NGN; Mobility; Multi-homing; LTE;**

I. Introduction

Mobile devices proliferate thanks to the advances in embedded technologies. Mobile users consume more sophisticated 'live' services on their embedded systems through a wide range of wireless technologies. Nevertheless, mobile communication still suffers from a lack of transparency and personalization when users are consumming media in most daily scenarios. For instance, a consummer might be on call when he reaches his office. Wireless communication whereas as 3G is suffering from bad signal strengh indoor while technology such as WLAN is providing good network conditions for indoor communication with a mobile phone. Communication devices are equipped with several networks interfaces such as LAN, WLAN, 3G/HSDPA/LTE, WiMAX. Services should then consider this network diversity to extend coverage area and increase user satisfaction. Mobility is the ability of a Mobile Node (MN) to change its location without restarting its applications and without disrupting any ongoing communications while keeping the agreed Quality of Service (QoS)/Quality of Experience (QoE). Next Generation Networks (NGN) such as IP Multimedia Subsystem (IMS) [1] aims to unify service interfaces through a common IP-based core network hidding access technology characteristics. Located in control plane, it ensures the delivery of multimedia services with a specified QoS through different access networks. Each Radio Access Network (RAN) usually has its own IP subnet. A MN has as many IP addresses as access network interfaces attached to RANs. With the standardization of NGN, micro, macro and global mobility appeares. Micro mobility also called intra-system handover within the same network domain refers to a handover within the same RAN. Macro mobility is defined as the migration between these RANs subnets also called inter-system handover within the same network domain. Global mobility refers to inter-system handover through different network domains. Seamless handover often requires soft handover. Devices equiped with two or three network interfaces can usually work simultaneously for a short period during handover allowing soft vertical mobility. This configuration implies multihoming. End-user might have preferences such as security concerns, communication price range, battery consumption, required QoE which all might affect the network selection and usage. Nevertheless, IMS specification does not include any concept of user preferences (e.g. network preference) or satisfaction (e.g. QoE). Furthermore, vertical handover in IMS is still under study as session continuity is not yet supported in standards. IMS is based on Session Initiation Protocol (SIP) which acts at session and above layers. The standardised 3GPP LTE mobility solutions are defined at IP layer raising SIP session issues. As devices have the opportunity to play multimedia content over heterogeneous networks accesses and as NGN is foreseen to provide the best QoS for end-user, this paper is focusing on macro mobility in NGN networks. Section 2 introduces the existing mobility solution in the telecommunication area and give a comparison among them. Section 3 depicts our solution working on macro and global mobilities. Section 4 depicts the proof-of-concept and presents the results of this solution. Finally a conclusion and future work ends this paper.

II. Existing Mobility Solutions

A. Classification

Many different mobility solutions based on different signaling protocols raised up. One classification is based on the OSI network layer on which these protocols are acting. We extended the survey [2] with tranport and application layer solutions. Actually pure link layer mobility in cellular networks does not allow an extensive mobility solution as mobility management requires higher layer for the signaling between different equipments, handover decision computation, location management and routing functionalities.

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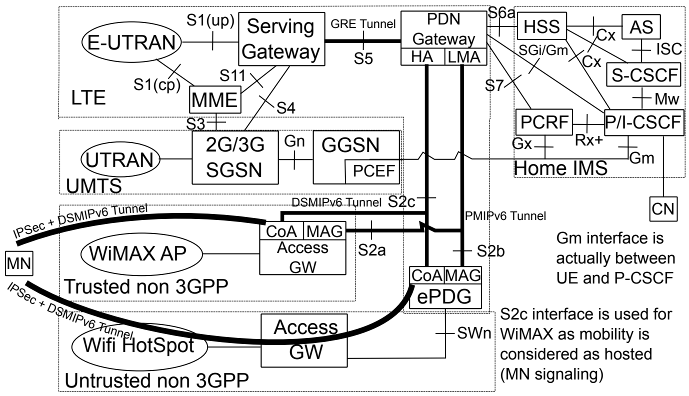

Figure 1: LTE Interworking Architecture with Anchor Points

Thanks to Mobile IP (MIP), network layer mobility enforces vertical handover by redirecting traffic of the MN to its current IP address. MIP is an IETF standard that introduces the concepts of home address , Home Agent (HA) and Care-of Address (CoA). The home address is the permanent address of an end-user device. The CoA is a temporary address assigned to a device that leaves its home network. The HA is a router in the home network aware of CoAs. It relays all packets addressed to the home address towards the newly-acquired CoA. MIP's extension HMIP, HAWAII, CIP, MIP-RR, IDMP and DMA, TeleMIP are defined and analysed in this survey [2]. Based on MIPv6 and NEMO technologies, DSMIPv6 [3] enables mobility for dual-stack MNs supporting IPv4 and IPv6. The HA has also to be dual stack. 3GPP adopted DSMIPv6 and Proxy MIPv6 (PMIPv6) to handle host-based mobility and network-based mobility functionalities in its LTE architecture [4]. As network controlled mobility, PMIP avoids any UE actions in the mobility management. The proxy mobility agent in the network ensures the mobility management on the behalf of the MN. The standards defines two core functional elements Local Mobility Anchor (LMA) and the Mobile Access Gateway (MAG). When MN changes its network attachment, the new MAG (nMAG) should detect the attachment and reactively initiate the necessary procedures to authenticate and authorize the MN. PMIP lowers the probability for a signaling message to be dropped as it does not travel on the air interface. Nevertheless, handover interruption tends to be higher even more for slow access technology as PMIP is a reactive solution. A proactive solution predicting the MN's movement thanks to a Proxy Information Center (PIS) is presented in [5] and reduces the handover interruption. J. Kim et al in [6] propose soft handover for PMIPv6 through a bicasting system. This solution reduces again media disruption as bicasting allows to optimize the packet switching on the MN side. Nevertheless, no MN algrorithm is given in order to know how application should play packets from each interface. Besides, extra and non standardized signaling between previous-MAG and new-MAG is required.

Figure 1 represents the LTE architecture [4] and its

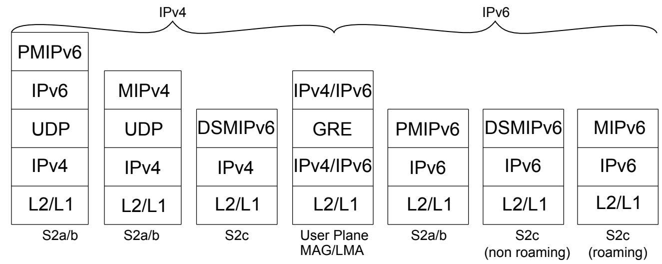

Figure 2: Protocols Stack for S2a, S2b and S2c

interconnecting interfaces. S2c reference point in P-GW defines host-based mobility and S2a/S2b define network-based mobility. Evolved Packet Data Gateway (ePDG) is similar to a VPN concentrator enabling (de-)encapsulation of packets for IPSec and PMIPv6 tunnels. This figure describes the mobility anchor points. The HA for MIPv6/v4 and DSMIPv6 protocols and LMA for PMIP protocol are located in P-GW. CoA and MAG functionalities are located in either Access GateWay or ePDG whether the non 3GPP access is trusted or not. In the host-based mobility mode, IPsec tunnel is established between the MN and its corresponding CoA and then a DSMIPv6 is established over this IPSec tunnel. In the network-based mobility mode, no tunnel is required between MN and its MAG. Nevertheless, a PMIP tunnel is created between MAG and LMA. Figure 2 describes the protocol stack of mobility protocols used in LTE.

Transport layer mobility is an alternative at network layer mobility. SCTP and its mobile extension in IMS is studied in [7] and discussed in following section.

Application layer solutions are mainly focused on SIP protocol. A comparison from 2002 in [8] between SIP and MIP explains that MIP mobility gives smaller disruption for handoff than SIP mobility. Indeed MIP triggers mobility to HA whereas SIP re-invite message travels all the way to the Correspondent Node (CN). SIP B2BUA hiding MN mobility from CN and RTP translator multicasting RTP packets during handover is presented in [9]. These two elements optimizes handoff delay and reduces packets loss. In [10], SIP B2BUAs and RTP media gateway are embedded in base stations or access points in order to duplicate and re-route the RTP traffic as soon as new interface is up. A "joint" header is introduced in SIP Re-Invite request in order to retrieve the media session and start duplicating RTP packets on both interfaces. The re-Invite is then sent to the CN to proceed the IP address changement. This solution implements extra signaling on the client side by sending two re-Invite message (one for B2BUA and one for CN) and needs special parsing for "joint" header. This solution is not applicable in NGN networks.

Cross-Layer solutions are the most common used in live system as low layers information improves the overall handover mechanism. Interesting work [11] extends SIP-NEMO with IEEE 802.21 MIH standard using multihoming functionalities. MIH main functions focuses on the initiation and preparation of cross-layer handover. MIH Functions in the MN facilitate handover process exchanging data (link quality, link ID, offered QoS, target point of attachement) with the MIHF in Point of Service (PoS). The latter communicates with Media-Independent Information Service (MIIS) server hosted in core network. The MIIS server collects information related to the access networks close to the MN. The PoS computes handover decision and requests MN to proceed a handover. A cross layer solution with SIP and MIH functionalities is presented in [12] and shows the interest of using interface handler and mobility manager inside the MN. Nevertheless, this solution requires MIH support in IMS.

B. *Discussion and analysis*

Latest release of LTE uses MIP, DSMIP or PMIP as mobility protocols to maintain communication during a handover. Nevertheless xMIP hides location update from SIP layer and then from application layer. MIP functions hides the mobility from the CN. The element Home Address assigns a permanent IP address to the MN when it wanders from its home network through HA to a foreign network through a CoA. With MIP, users can seamlessly move without having neither to reconnect nor to reconfigure at every point of attachment. However, it is based on an asymmetric routing, which can add unpredictable delay to the traffic. Delay added might thus be an important issue in real-time communications. Furthermore, MIP handles mobility on IP level bypassing any SIP session update or SDP re-negotiation according to the new link capacity. In a context of user centricity networks, real-time information is very sensitive information in order to bring advanced and profiled services to the end-user. One advantage of host-based mobility is that the MN has the best perspective of what alternative links it can wander to. User profile management [13] helps to collect this context information and the corresponding QoS/QoE information on each interface.

In this paper, we focus on mobility between 3GPP and non 3GPP access networks. LTE standard needs an IP Mobility Selection (IPMS) mechanism in order to choose the type of the handover. This handover selection within 3GPP networks is done during the attach procedure over the source access network. On handover between non 3GPP accesses, the selection depends on whether the UE and the network are capable to handle network-based mobility. Our solution avoids this mechanism as the same signaling works for macro and global handover.

The mSCTP solution in IMS proposed in [7] requires several modifications and adaptations to comply to the standards. First, modification in HSS is needed to handle the different IP primary/secondary addresses. Second, the REGISTER sip messages is extended with 2 new optional headers ”add-location”, ”set-primary” and a new ”SWITCH” method is created to handle handover signaling and only understood by an extra component in the IMS architecture : the mSCTP-based proxy. As SCTP stack is not yet supported as a transport protocol in IMS, this proxy converts all mSCTP messages towards SIP messages. Some extra signaling like a redirect message ”305 use proxy” in order to reroute the traffic to the m-SCTP based proxy and a REFER sip request to establish a session from this proxy to the AS are needed. Besides, the handover mechanism is launched on the old interface which is not efficient in case of abrupt disconnection of this access attachment. Some integration and design issues still need to be overcome.

The Dynamic Address Reconfiguration (DAR) function defined in mSCTP can also be implemented directly at the client side through a User Profile (UP) management. [13] expresses the interest of using UP gaining in user satisfaction for IPTV services over different terminals and access networks. User context information is gathered in the SIP extended XML body and let the IMS core aware about the UE environment. SIP with an XML body using a Re-Invite handles the basic function of DAR and allows the mobility management in the core network to accept or not the mobility request according to the collected UE information and the service which is consummed.

IP Multimedia Subsystem (IMS) on top of a LTE [4] architecture is part of NGN and both are standardized by 3GPP. Vertical handover in IMS is still under study whereas session continuity is addressed in 3GPP with [14]. This technical report introduces the Multi-Media Session Continuity (MMSC) Application Server (AS) acting as a SIP B2BUA and handling the mobility management at a SIP layer. The operator is controling the session mobility within its home network and keep a life trace about where the MN is located. Nevertheless, no media re-routing are discussed in this specification. In this paper, we propose a full solution. One of the major issue of mobility in general is the complexity of the signaling and the cost of extra resources. [15] gives a comparison of different mobility schemes during the registration process. IMS SIP registration time lasts up to five longer than MIPv6 as HSS database and Serving-CSCF (S-CSCF) are involved in the process. Nevertheless, registration time is not considered as an important parameter in our solution as dual-homing allows registration execution while consuming the media on the previous interface. Recent concept of Session Mobility [16] through different devices brings complex session handoff using REFER and NOTIFY methods and ”replaces” header in SIP invite. It has not yet been mapped to IMS standard. As an intermediate solution, we propose a 'simple' session mobility.

Table I summarizes the existing mobility solution for NGNs. It gathers description of the protocols used in LTE standard, of mSCTP including the DAR functionality and two SIP-based solutions. It first gives nature of the mobility solution (i.e. operating layer, mobility scope, mobility management type and handover control). It indicates then

Table I: Summary of Mobility Solution

Protocol criteria	*(DS)MIP*	*PMIP* [17]	*mSCTP* [7]	*SIP* [12]	*B-SIP* [10]	*MA-PCSCF*
Operating Layer	Network	Network	Transport	Application	Application	Application
Mobility Scope	Global	Local	Local/Global	Local/Global	Local/Global	Local/Global
Mobility Managing	Host-based	Network-based	Host-based	Host-based	Host-based	Host-based
Handover Control	Hard	Hard, soft [6]	Soft	Soft	Soft	Soft
Required Infrastr.	HA	LMA, MAG	mSCTP proxy	MIH-based	B2BUA in BS	MA-P/I-CSCF
MN Modification	Yes	No	Yes	Yes	Yes	Yes
Tunneling over WL	Required	No	No	No	No	No
Handover Latency	Bad	Bad, good [5]	Good	Bad	Good	Good
Complexe to deploy	No	No	Yes	Yes	Yes	No
Scalability	No	No	No	Yes	No	Yes
Overhead	No	No	Yes	No	No	No
IMS/NGN oriented	No	No	No	Yes	Yes	Yes
QoE management	No	No	No	No	No	Yes

the required elements for mobility solution and the requirements on the MN side (MN Modification and Tunneling over Wireless). The complexity of the signaling and the number of the element involved in the mobility management encompasses the "complex to deploy", "scalability" and "overhead" criterias. Finally, no existing solution is fully IMS/NGN oriented and QoE enabled as session continuity is not addressed for MIP, mSCTP solutions and none of the existing solution considers QoE.

III. Mobility Aware (MA) P/I-CSCF : a solution for achieving seamless handovers in IMS-based environments, based on End-User's context.

For the reasons explained in section II, the proposed mobility solution is facing session continuity issues in IMS networks using MMSC-AS [14] and by controlling the media flow of a multihomed MN. Our SIP-based solution merges intra-system (within HPLMN) and inter-system (between HPLMN and VPLMN) handovers. IMS is defined to control media session over a wide range of access network and domains. Only handovers requiring a change of IP address on dual homing devices will considered in our solution. xMIPv4/xMIPv6 and mSCTP lack of integration in IMS systems. mSCTP is not yet standardized and implemented in IMS. xMIPv4/xMIPv6 supports mobility funtionalities in LTE architecture but hides IP modification from IMS. Mobility awareness can be introduced in Proxy-CSCFs/Interrogating-CSCFs to ease the integration of media handling functions in mobility phase. Mobility Aware-P/I-CSCFs (MA-P/I-CSCF) comprises mobility detection and automatic RTP duplication and switching. This functionalities are combined with two MN modifications that will leverage the P/I-CSCF evolution. MN will add a Route Header targetting to the current P/I-CSCF involved in the SIP signaling. Moreover, a new jitter buffer algorithm will be introduced in the MN to smoothen the RTP stream switching.

A. Architecture

As discussed in section 2, our solution requires to handle handovers in roaming and non roaming use-cases. Figure 3, 4, 5 and 6 show the corresponding architectures. In the non roaming use-cases, the wifi access gateway can be connected to the P-GW through the S2c interface if the operator has a LTE access network as depicted in Figure 3 or through a separate P-CSCF 2 if the operator does not fully comply to LTE or provides only 3G access as shown in Figure 4. Figure 6 depicts the roaming use case where a MN registered in the IMS domain "A" switches from its LTE or 3G connection towards a WiFi hotspot managed by another IMS domain "B". Each IMS domain uses I-PCSCF to protect and hide its IMS core network towards other operators. In Figure 3 and 5, P-CSCF is assumed to be MA-P-CSCFs. In Figure 4, both P-CSCF1 and P-CSCF2 are MA-P-CSCFs as MN is assumed to support mobility in both direction. Finally in Figure 6, I-CSCF A is assumed to be MA-I-CSCF as the latter is linked to the CN. It is also assumed that Mobility Awareness functionalities are enforced in either a P-CSCF or a I-CSCF located in the MN's HPLMN.

Our solution handles all these 4 showcases.

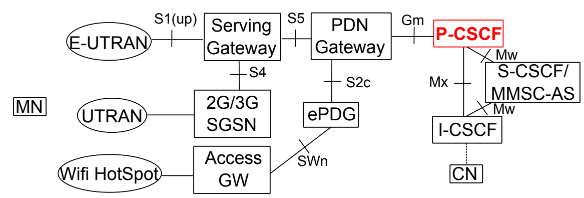

Figure 3: Architecture for non roaming-LTE

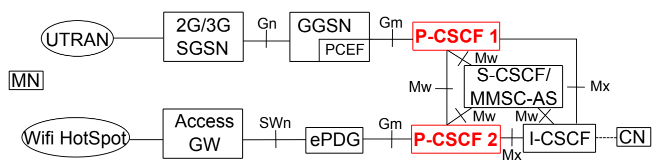

Figure 4: Architecture for non roaming-IMS only

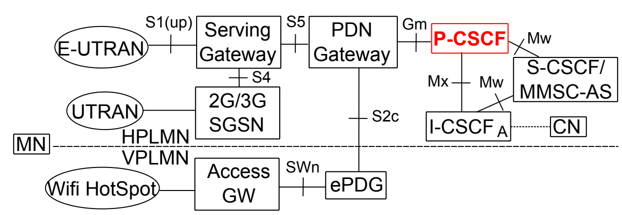

Figure 5: Architecture for roaming-LTE

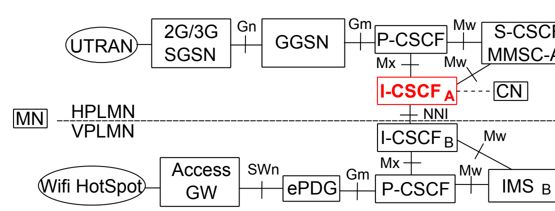

Figure 6: Architecture for roaming-IMS

B. Functionalities

1) Mobility-Aware P/I-CSCF:

Mobility Detection : each time an INVITE Request reaches the Mobility-Aware P/I-CSCF, the latter contacts the RTP Proxy that will reserve media port on the involved interfaces for RTP forwarding. The RTP Proxy also compares Call-ID and SIP-URI of Caller/Callee for of all media streams that is in charge with. If the 2-tuple Call-ID, Caller/Callee is matching with an existing media stream then the MA-P/I-CSCF switches to mobility mode.

RTP duplication and switching : when the MA-P/I-CSCF is in mobility mode and receives a 200 OK from the MMSC-AS, the RTP Proxy opens up the new ports on the corresponding interfaces and starts to duplicate RTP packets on both link (i.e. WLAN and 3G paths) at the same time. Due to network characteristics disparity, RTP packets reach the MN at different time and sometimes with burst of 3-4 packets.

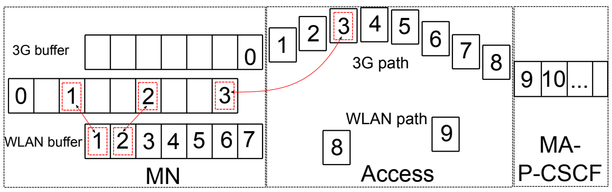

Figure 7: Jbuf Sechuling

2) MN modification:

Route header : our solution requires the old P/I-CSCF in the path of signaling in order detect mobility and switch the media when MMSC-AS has accepted the mobility request. SIP Re-Invite request keeps the same route header as the SIP Invite but with the new entry at the top position. This inserted route forces the request to be forwarded to the 'new' P/I-CSCF and not the old one as before.

Jitter buffer algorithm : Figure 7 shows the new approach to curb the increase of jitter during the mobility between a wlan to a 3G access network on the downlink side. Indeed, this algorithm tries to overcome the delay variation created by the new path by scheduling packets received from the WLAN buffer with some virtual delay while waiting 3G buffer to be filled with RTP packets. It is supposed that duplicated data packets travel faster through WLAN access than 3G access. For instance, in the Figure 7, each slot represent a data packet generated (i.e. usually every 20ms for VoIP packet). The duplicated packet starts from packet 0 and ends at number 10. The WLAN buffer is full with the duplicated packet whereas 3G buffer still waits for incoming duplicated packets. The algorithm principle described above is to drift audio packet scheduling inserting empty packets to overcome the jitter increase.

C. Example of scenario for non roaming in one IMS network

We propose to use SIP mobility through two ANs attached to the same IMS home network as depicted in Figure 4. MN uses 3G network to dialog with CN as shown in Figure 8. The red and blue arrows show respectively the SIP signaling and the media flow. As described in Figure 9, our solution is to insert a route header in the SIP Re-Invite forcing the SIP signaling to go through the new P-CSCF 1 and keeping the same path through the MA-P-CSCF and IMS core network. The MA-P-CSCF requests the RTP Proxy to open media

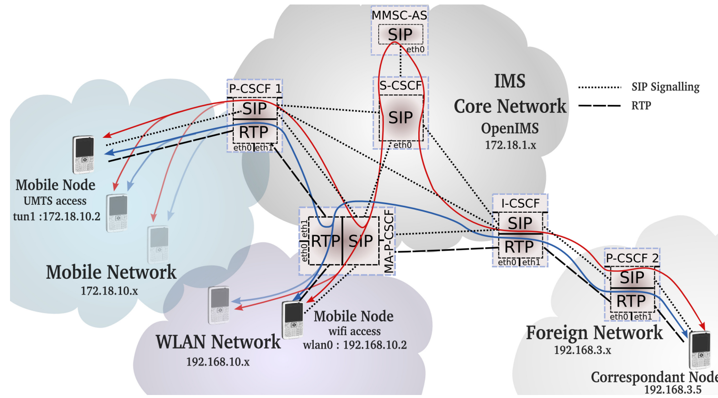

Figure 8: Solution Architecture

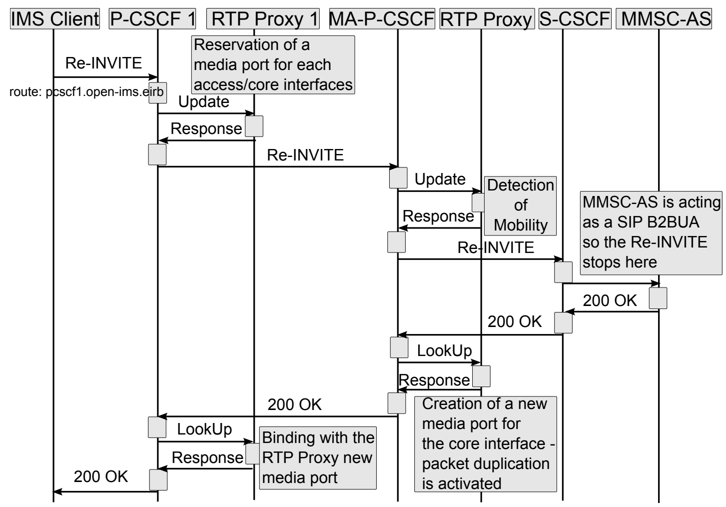

Figure 9: Handover Signaling

ports and detects if an existing media stream is ongoing with the same Call-ID and same interlocutors. RTP Proxy detect that an existing media session has the same Call-Id and involved SIP URIs. It switches to mobility mode. Then the MMSC-AS accepts the mobility request and sends a 200 OK back to the MA-P-CSCF and forwards the incoming RTP stream through both ANs during a predefined period. The MA-P-CSCF forwards definitely packets to the new path and releases unused resources when the MN sends the SIP ACK. This SIP Re-Invite method is considered as a session update and not as a separate session. Thus, there is no need to terminate the 'old' session by sending a SIP BYE.

IV. Results

A. Test-Bed

The test-bed is a live test-bed with a 3G connection on Orange network and WLAN connection from a Netgear WNR3500L router. A SSH tunneling has been done between the 3G equipment and test-bed hosted in our premises. For now, the MN is a Acer Aspire One working on Ubuntu 10.04. The MN settles a VPN with the IMS testbed through a 3G tethering configuration. The VoIP client is a modified

PJSUA sip client handling several network interfaces and mobility signaling. Some effort has been done also on the PJMEDIA in order to enable the jitter buffer scheduling to enhance QoE. GSM and G711 codecs are used as voice codec.

B. Performance Evaluation

Table II summarizes the total signaling cost of the processes for a IMS network hiding its topology which means that all signaling messages are going through the I-CSCF for security reasons. Our SIP handover solution is compared against results given by [7] which is treating mobility between two visited network. In order to compare the signaling cost of our solution, we consider that all SIP signaling goes through an I-CSCF and that the mobility is done in this central equipment. This condition is not changing our results. The normal SIP handover is the solution based on SIP Re-Invite through IMS until the CN. mSCTP-based solution for IMS presented in [7] needs 58 messages for the full handover. Our solution requires 19 messages as depicted in Figure 9. Note that 100 Trying and ACK messages are not shown for the simplicity of the figure.

Table II: Signaling Messages

Operation	Number of signaling messages during HO		
	mSCTP [7]	SIP [12]	MA-PCSCF
Registration/LU	24	24	24
Session Establishment	66	46	46
Full Handover Process	58	46	19

V. Conclusion

In this paper, we presented the Mobility Aware P/I-CSCF solution combining simplicity of standard SIP mobility solution in IMS and an algorithm scheduling media packets leveraging the usage of multi-homing. Session-based mobility is foreseen to satisfy requirements of NGN and end user expectations. A complete classification of mobility solutions including LTE standard is presented and discussed. Table I summarizes the mobility protocol functionalities. Our MA-P/I-CSCF solution is transparent to existing architecture and requires less signaling compared to other solutions. Only small modifications in MN and P/I-CSCF are required. Another strong aspect is that the user interest is involved in the handover process using efficiently several network interfaces available. More qualitative results such as QoS/QoE curves are foreseen in the near future.

References

[1] 3GPP, "IP Multimedia Subsystem (IMS); Stage 2," 3GPP, TS 23.228, Sep. 2010.

[2] I. Akyildiz, J. Xie, and S. Mohanty, "A survey of mobility management in next-generation all-ip-based wireless systems," *Wireless Communications, IEEE*, 2004.

[3] H. Soliman, "Mobile IPv6 Support for Dual Stack Hosts and Routers," RFC 5555 (Proposed Standard), IETF, Jun. 2009.

[4] 3GPP, "Architecture enhancements for non-3GPP accesses," 3GPP, TS 23.402, Jun. 2011.

[5] B. Obele and M. Kang, "Mobility management: A proactive qos-aware proxy mip with improved handover latency for end-to-end qos provisioning in a proxy mip domain," in *ICACT 2009.*, vol. 03, feb. 2009, pp. 1867 –1869.

[6] J.-I. Kim, S.-J. Koh, and N.-S. Ko, "B-pmipv6: Pmipv6 with bicasting for soft handover," in *ICACT*, vol. 01, feb. 2009, pp. 218 –221.

[7] N. H. Thanh, N. T. Hung, T. N. Lan, T. Q. Thanh, D. Hanh, and T. Magedanz, "mSCTP-based proxy in support of multimedia session continutity and QoS for IMS-based networks," in *ICCE*, Jun. 2008, pp. 162 –168.

[8] T. Kwon, M. Gerla, and S. Das, "Mobility management for voip service: Mobile ip vs. sip," *Wireless Communications, IEEE*, vol. 9, no. 5, pp. 66 – 75, oct. 2002.

[9] A. Dutta, S. Madhani, W. Chen, O. Altintas, and H. Schulzrinne, "Fast-handoff schemes for application layer mobility management," in *PIMRC 2004*, vol. 3, sept. 2004.

[10] N. Banerjee, S. Das, and A. Acharya, "Sip-based mobility architecture for next generation wireless networks," in *PerCom*, march 2005, pp. 181 –190.

[11] C.-M. Huang, C.-H. Lee, and P.-H. Tseng, "Multihomed sip-based network mobility using ieee 802.21 media independent handover," in *ICC*, june 2009, pp. 1 –5.

[12] K. Choong, V. Kesavan, S. Ng, F. de Carvalho, A. Low, and C. Maciocco, "Sip-based ieee802.21 media independent handover a bt intel collaboration," *BT Technology Journal*, vol. 25, pp. 219–230, 2007, 10.1007/s10550-007-0047-z.

[13] J. Arnaud, D. Negru, M. Sidibe, J. Pauty, and H. Koumaras, "Adaptive iptv services based on a novel ip multimedia subsystem," *MTAP, Springer*, pp. 1–20, 2010.

[14] 3GPP, "Feasibility study on multimedia session continuity; Stage 2," 3GPP, TR 23.893, Jun. 2008.

[15] M. J. Yu, J. M. Lee, S. G. Choi, E. Kim, and J. Jee, "Performance comparison of existing mobility management schemes for ngn," in *ICACT*, Feb. 2006, pp. 991 –995.

[16] R. Shacham, H. Schulzrinne, S. Thakolsri, and W. Kellerer, "Session Initiation Protocol (SIP) Session Mobility," RFC 5631 (Informational), IETF, Oct. 2009.

[17] 3GPP, "Proxy Mobile IPv6 (PMIPv6) based Mobility and Tunnelling protocols; Stage 3," 3GPP, TS 29.275, Jun. 2011.