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A Software Framework for Providing Multiple VPMN MSISDNs in a UMTS

Dongcheul Lee[1] and Byungjoo Park[2*]
[1,2]Department of Multimedia, Hannam University, Daejeon, Korea
[1]jackdclee@gmail.com, [2]bjpark@hnu.kr
**Correspondent Author: Byungjoo Park* (bjpark@hnu.kr)*

Abstract

Mobile service providers allow their customers to use roaming services when they travel to other countries. In the standard mobile call setup procedures, multiple VPMN MSISDNs cannot be provided to the roamers. Also, call setup to the roamer is indirectly routed through the home network of the roamer, which results in the usage of expensive international carrier's trunks. In this paper, we propose a software framework that provides multiple VPMN MSISDNs in a UMTS. The proposed framework solves the indirect routing problem and can be easily deployed to mobile operators since it does not modify standard telecommunication protocols.

Keywords*: MSISDN, roaming, UMTS, tromboning, software framework*

1. Introduction

Cellular networks have been evolving very quickly in the last decade. Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular technology for networks based on the Global System for Mobile Communications (GSM) standard which was developed by the 3rd Generation Partnership Project (3GPP) [1]. UMTS phones can roam easily onto other UMTS networks if the providers have roaming agreements in place. Roaming agreements between networks allow for calls to a customer to be redirected to them while roaming. The user is uniquely identified by an International Mobile Subscriber Identity (IMSI) associated with an UMTS network mobile phone user. It is stored in the Universal Subscriber Identity Module (USIM) card inside the phone and sent by the phone to the network so that the network can identify and authenticate the IMSI. Therefore, UMTS users can use their phones while they are in foreign countries without changing their handsets or phone numbers.

Some users who roam frequently between two countries may want to have local numbers in foreign countries. The reason is that local users can call them at a cheap rate without worrying about international IDD calls. Also, local users who receive calls from them will identify calling numbers as local numbers, which are familiar to them. In addition, the users can present a multi-national appearance to local users.

However, UMTS does not provide this service. It only allows a single Mobile Subscriber Integrated Services Digital Network Number (MSISDN) with a single IMSI. This paper presents a software framework that supports providing mobile communication devices with multiple MSISDNs using one IMSI. This framework does not require a new type of USIM card in a mobile device. It can be implemented on a Service Control Point (SCP), which is a standard component of an intelligent network telephone system, so that it can be adapted to the existing UMTS easily. The standard components of UMTS and Signaling System 7 (SS7) protocols are not need to be modified and it does not affect an automatic roaming function. The framework allows operators in one country to cooperate with operators in another country to offer a local MSISDN in the visited country without changing an USIM card. Also, a mobile device must perform a location update procedure

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in the operator's network to use the service, thereby creating a monetarily beneficial relationship to both operators and the roaming users.

The next section introduces related works to provide multiple Visited Public Mobile Network (VPMN) MSISDNs to a mobile device. In Section 3, we propose the software framework to provide a local MSISDN at each partner network for a subscriber. The paper concludes with a short discussion.

2. Related Works

Currently, there are two types of schemes to provide multiple VPNM MSISDNs to a mobile device: a USIM-based scheme and a Mobile Application Part (MAP)-based scheme. The USIM-based scheme utilizes a multi-IMSI USIM card and the MAP-based scheme modifies the Update Location (UL) message and the Insert Subscriber Data (ISD) message which are the standard services of MAP [2].

2.1. USIM-based Scheme

A subscriber who frequently roams between Home Public Mobile Network (HPMN) and VPMN has a need for local MSISDNs in both networks. The simplest way to fulfill the need is buying pre-paid subscriptions in VPMN and using that number to make outgoing calls. However, if the roamer has only one mobile device and has swapped out the HPMN USIM card, the roamer will not be able to receive calls on the HPMN MSISDN. Also, when the roamer returns in HPMN, the roamer cannot receive calls on the VPMN MSISDN.

The USIM-based scheme solves this problem by using a multi-IMSI USIM card. In this scheme, multiple pairs of IMSI and MSISDN that can be used in each VPMN are stored in the USIM card so that subscribers do not have to swap their USIM cards or buy pre-paid subscriptions. Also, multiple VPMN Short Message Service Center addresses and authentication keys should be stored in the USIM card. When subscribers move to a new VPMN, an STK application in the USIM card automatically chooses a suitable IMSI and MSISDN that can be used in the VPMN. Then the subscribers can send or receive a call by using the MSISDN [3].

Even though the caller and the receiver are in the same network, the voice traffic must pass two international voice trunks. This is so called tromboning problem [4]. Skype and other voice over Internet protocol solutions resolve tromboning problem for Internet users [5]. However, they do not work for E.164 telephone numbers because the Gateway MSC (GMSC) is controlled by the telecom network and is always connected in the voice call path [6]. To resolve tromboning issue, 3GPP 22.079 describes a solution that requires a caller to dial a special code, which is not attractive to the subscribers [7].

Since this scheme use a new type of USIM card that includes the special application, HPMN should extend existing or create new USIM agreements with USIM card manufacturers, further adding costs and complicating the logistics process. Also, each time a routing area changes, the STK application needs to check to see if it is in a network that requires another IMSI. This can drain the battery power of a mobile device significantly. In addition, IMSI-based services, such as Unstructured Supplementary Service Data (USSD) and General Packet Radio Service (GPRS) can be less transparent since this scheme uses multiple IMSIs. For GPRS, if the VPMN IMSI is chosen as the home IMSI, this can introduce problems to Access Point Name (APN) and Packet Data Protocol (PDP) contexts set up.

2.2. MAP-based Scheme

The MAP-based scheme modifies the MAP UL and ISD messages to provide multiple VPNM MSISDNs. The scheme uses the special Signaling Gateway (SG) to support outbound roamers having permanent local numbers as well as providing temporary local

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numbers. When a mobile device moves to a new VPMN, it sends the UL message to the Mobile Switching Center (MSC) of the VPMN. The MSC sends the UL message to the Home Location Register (HLR) of HPMN. Then the HLR checks whether the subscriber has additional VPMN MSISDNs and searches the proper MSISDN of the VPMN. If it is found, the HLR sends the MSISDN to the MSC by using the ISD message. Then the Visitor Location Register (VLR) stores the MSISDN and uses it when sending or receiving a call.

However, this scheme needs to modify the existing mobile telecommunications systems of the mobile operators of both countries due to the modification of MAP. Also, this scheme restricts the subscriber's MSISDN choices. It forces using a VPMN MSISDN when a subscriber sends a call in the VPMN even though the subscriber wants to use a HPMN MSISDN. Also, a subscriber cannot distinguish whether a called number is a HPMN MSISDN or a VPMN MSISDN when receiving a call.

3. Proposed Scheme

This paper presents a software framework that supports providing mobile communication devices with multiple VPMN MSISDNs using one IMSI. The service should be offered in collaboration with a participating operator in a foreign country and HPMN should have bilateral roaming agreements with the VPMN operator for multiple MSISDN services. The MSISDN ranges for the service should be fixed and be exchanged between the operators. The subscribers do not have to change their USIM cards and need not be concerned with whether they are in the home country or in abroad when registering their locations. The procedure for updating location information in VPMN is modified. In this procedure, the Roaming SCP (RSCP) is introduced to manage VPMN MSISDNs and transfer them to VPMN MSCs. The standard procedure can be used between HPMN and other 3rd party VPMNs that do not support the service. Also, the procedure for the mobile-terminated call is modified so that the subscriber can receive a call in HPMN or VPMN when the called number was the VPMN MSISDN. The standard procedure for the mobile-terminated call to the HPMN MSISDN does not have to be changed. The procedure in HPMN or the 3rd party VPMN follows the standard. Since this scheme use CAMEL Application Part (CAP) rather than modifying MAP, it does not need to modify the existing mobile telecommunications systems of mobile operators. This means that adopting this solution to mobile operators becomes simpler than other related schemes.

3.1. Location Update in VPMN

When a mobile device moves to a VPMN, the location update procedure is occurred as follows. When an outbound mobile station sends the attach request message to a VPMN MSC, the MSC sends the UL message to the HPMN Gateway Location Register (GLR) through international carriers. Then the GLR forward the message to the HPMN HLR. The HLR searches the profile of the mobile station by using the IMSI in the UL message and sends the profile to the GLR on the ISD message. The GLR sends the ISD acknowledge message to the HLR and the HLR sends the UL acknowledge message to the GLR. The GLR sends the Send Subscriber Information (SSI) message to the RSCP. The message contains IMSI, HPMN MSISDN, the global title of the MSC and the HLR. The RSCP searches for VPMN MSISDN by using the information in the message and sends it back to the GLR on the SSI acknowledge message. The GLR sends the VPMN MSISDN and the Originating Customized Applications for Mobile Enhanced Logic Subscription Information (O-CSI) to the MSC on the ISD message. The service key for the multiple MSISDN service in the O-CSI is set to 1 and the Service Control Function address is set to the address of the RSCP. The O-CSI is used when a mobile station originates a call so that the MSC can retrieve the VPMN MSISDN from the RSCP by using the CAP Initial Detection Point (IDP) message and the CAP Connect message.

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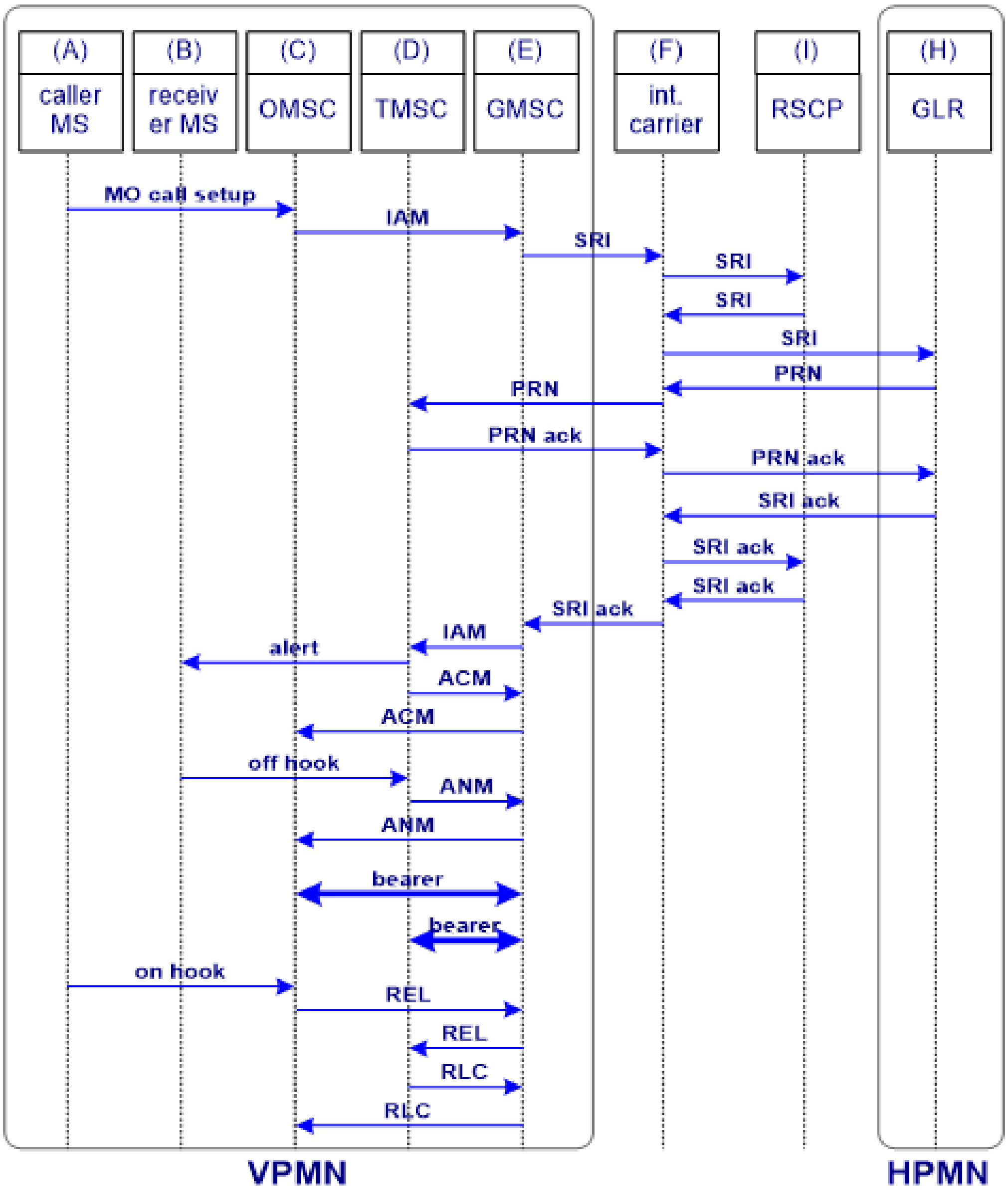

Figure 1. Mobile-terminated Call Flow of the Proposed Scheme in VPMN

3.2. Mobile-terminated Call in HPMN

When a caller sends a call to VPMN MSISDN and the subscriber receives the call in HPMN, the procedure is performed as follows. The originating MSC (OMSC) sends the Initial Address Message (IAM) to the GMSC. The GMSC should be configured to route the Send Routing Information (SRI) message to the RSCP for the specified MSISDN range, which includes VPMN MSISDNs. Thus the RSCP emulates HLR behavior for processing SRI. The GMSC sends the SRI message to the RSCP. The RSCP changes the called number from VPMN MSISDN to HPMN MSISDN and adds Calling Name Presentation (CNAP) information. The CNAP is included in the DISPTEXT parameter and contains the called number so that the receiver can identify the called number. Also, the Generic Number parameter in the Additional Signal Information (ASI) contains the VPMN MSISDN. The RSCP relays the message to the GLR. Since the subscriber is in HPMN, the GLR does not have the profile. Thus the GLR rejects the SRI by setting the

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OR Not Supported parameter on the SRI acknowledge message. Then the RSCP sends the CSI to the GMSC on the message. The GMSC sends the IDP message to the RSCP for retrieving the HPMN MSISDN of the receiver by using the CSI. The RSCP sends the HPMN MSISDN to the GMSC on the Connect message. The GMSC sends IAM to the HPMN GMSC through international carriers. The GMSC sends the SRI message to the HPMN HLR and the HLR sends the Provide Roaming Number (PRN) message to the Terminating MSC (TMSC). The TMSC sends the Mobile Station Roaming Number (MSRN) to the GMSC on the PRN acknowledge and the SRI acknowledge message. The GMSC sends IAM to the TMSC and the TMSC pages the mobile station. Further ISDN User Part (ISUP) procedures are executed by using Address Complete Message (ACM), Answer Message (ANM), Release (REL) and Release Complete (RLC).

3.3. Mobile-terminated Call in VPMN

When a caller sends a call to VPMN MSISDN and the subscriber receives the call in the VPMN, the procedure is performed as Figure 1. The OMSC sends IAM to the GMSC. As the call flow in HPMN, the GMSC sends SRI to the RSCP. Then the RSCP forwards SRI to the HPMN GLR. Since the GLR knows that the subscriber is roaming, it sends PRN to the VPMN TMSC with the ASI and the DISPTEXT. The TMSC stores the GN and the DISPTEXT and sends the MSRN of the mobile station to the GLR on the PRN acknowledge. The GLR forwards the MSRN to the GMSC on the SRI acknowledge. Then the GMSC sends IAM to the TMSC. The TMSC pages the mobile station and sends the DISPTEXT and the VPMN MSISDN on Redirecting Party BCD Number. Then remaining ISUP procedures are executed. The voice bearer path is (C)-(E)-(D).

If we compare the mobile-terminated call procedures of the schemes in VPMN, the USIM-based scheme has the longest bearer path. Furthermore, the path consists of international voice trunks, which cause the tromboning problem. The MAP-based scheme and the proposed scheme have the identical voice bearer path and do not have the tromboning problem. However, their signaling paths are different.

4. Conclusions

This paper introduces a new scheme for providing multiple VPMN MSISDNs to roamers and compares with other related schemes. Proposed scheme uses the RSCP software frame work to provide the service. It does not need a new type of a USIM card and eliminates the tromboning mobile call setup for international roaming users. Also, since it uses standard telecommunication protocols, such as MAP, CAP, and ISUP, without modification, adopting this framework to existing mobile telecommunications systems of mobile operators becomes simple. Future work will include the analysis of the computational complexity of the execution of signaling in 3GPP wireless networks, and how it impacts the cost of the network.

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Authors

Dongcheul Lee, He has been an assistant professor in the Department of Multimedia at Hannam University, Korea since 2012. He received the B.S. and M.S. degrees in Computer Science and Engineering from POSTECH, Korea in 2002 and 2004, respectively, and Ph.D. degrees in Electronics and Computer Engineering from Hanyang University, Korea in 2012. He had been a senior researcher at the KT Mobile Network Laboratory, Korea from 2004 to 2012. His main topics of interests have been communication in mobile applications, rich communication service, software framework for mobile games and machine learning in games.

Byungjoo Park, He received the B.S. degree in electronics engineering from Yonsei University, Seoul, Rep. of Korea in 2002,and the M.S. and Ph.D. degrees (first-class honors) in electrical and computer engineering from University of Florida, Gainesville, USA,in 2004 and 2007, respectively. From June 1, 2007 to February 28, 2009, he was a senior researcher with the IP Network Research Department, KT Network Technology Laboratory, Rep. of Korea. Since March 2, 2009, he has been a Professor in the Department of Multimedia Engineering at Hannam University, Daejeon, Korea. He is a member of the IEEE, IEICE, IEEK, KICS, and KIISE. His primary research interests include theory and application of mobile computing, including protocol design and performance analysis in next generation wireless/mobile networks. He has published approximately 35 research papers on the theory and application of mobile computing, IPTV, Internet Application. Since 2004, his activities have focused on IPv6, IPv6 mobility, media independent handover, and cross-layer optimization for efficient mobility support on IEEE 802 wireless networks. He is an honor society member of Tau Beta Pi and Eta Kappa Nu.

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