

# A Software Framework to Provide Multiple MSISDN across Heterogeneous Networks

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**Abstract**— The population of cellular phone roamers has been increasing every year. Most of them may want to use their original phone numbers while others may want to use other phone numbers of visiting countries. We are interested in providing multiple phone numbers across heterogeneous networks, which will lead various business opportunities. Therefore, we present a software framework which will provide multiple MSISDN while using single IMSI. The update location procedure is modified to transfer user's additional MSISDN on an ISD message. Also, the mobile terminating call procedure is modified to indicate the dialled number to the receiver. In simulation, our scheme increases lesser traffic transmission cost than the standard scheme.

**Keywords**— Software framework, Roaming, MSISDN, IMSI, Heterogeneous networks

## I. INTRODUCTION

UMTS network provides automatic roaming across heterogeneous networks. Therefore, if International Roaming Expert Group Tests [1] and Transferred Account Data Interchange Group Tests [2] have been carried out between network providers, WCDMA cellular phone users can use voice and data services anywhere even if they are in abroad.

Furthermore, some cellular phone users may want to have another phone number which belongs to another country. For example, if Jack in Japan has a local phone number 080-1234-1234 and an USA phone number 630-248-1234 in one cellular phone, anyone in USA can call to Jack by using 630-248-1234. Since the caller in USA might think that the number is not international phone number, they will feel comfortable when they send a call to the number.

To provide such services in UMTS network, multiple Mobile Subscriber Integrated Services Digital Network Number (MSISDN) should be assigned to single International Mobile Subscriber Identity (IMSI). However, 3GPP standards [3] have

not provided these services. Since the standards only allow single MSISDN for single IMSI, users should use same MSISDN even when they go abroad if they did not change USIM cards in their cellular phone. However, network providers cannot modify SS7 protocols to provide the services since the automatic roaming will not work if network providers use different protocols that do not conform to the standards.

This paper presents Roaming Service Control Point (RSCP) software framework to provide multiple MSISDN which belong to heterogeneous networks. RSCP provides multiple MSISDN to single IMSI. Also, the standards do not have to be modified since RSCP works as a standard Service Control Point in UMTS network.

The next section introduces related works to provide multiple MSISDN. In Section 3, we propose RSCP software framework to provide the services and compare it with other related works. In Section 4, we will compare the cost of standard scheme and proposed scheme. The paper concludes with a short discussion.

## II. RELATED WORKS

There are two types of methods to provide multiple MSISDN across heterogeneous networks: a mobile station based method and a network based method. [4] suggested a mobile station based method by using a dual IMSI SIM card. Also, [5] suggested a network based method by modifying Mobile Application Part (MAP) messages.

### A. Method by Using Dual-IMSI SIM Card

The simplest way to provide multiple MSISDN is using a method based on a dual-IMSI SIM card. This method stores two pairs of IMSI and MSISDN, which are used in different networks, in a dual-

IMSI SIM card. If a user transferred in a network, a STK application [6] that is stored in the SIM card can automatically chooses the suitable IMSI and MSISDN that belongs to the network. Then the user can use the IMSI and MSISDN while sending or receiving a call. If the user wants to select a other IMSI and MSISDN manually, the automatic selection function stops working.

However, since this method uses multiple IMSI, multiple Short Message Service Center addresses and authentication keys should be stored in a SIM card. Also, a new type of SIM card is needed since it should store a STK application. Therefore, additional costs shall be added since network providers should make new contracts with SIM card manufacturers. Furthermore, the power consumption of a mobile station will be increased because the STK application should be initiated every time the location update procedure occurs.

#### ***B. Method by Modifying MAP Message***

This method modifies the Insert Subscriber Data (ISD) message of MAP to provide multiple MSISDN. When a mobile station sends an Update Location (UL) message to the Visitor Location Register (VLR) of a visiting network, a VLR transfers a UL message to the Home Location Register (HLR) of a home network through a Gateway Mobile Switching Center (GMSC). Then the HLR checks whether the user is registered to the multiple MSISDN services or not. If the user is registered, it checks whether the user has a MSISDN, which belongs to the visiting network. If the user has the number, the HLR sends the MSISDN to the VLR of the visiting network by using an ISD message. The VLR fetches and stores the IMSI and MSISDN from the message, and uses them when the mobile station initiates a call.

However, the user should only use the MSISDN that belongs to the visiting network even though the user wants to use original MSISDN in the visiting network. Furthermore, when the user receives a call, the user cannot know which MSISDN were used for the dialled number.

### **III. PROPOSED SCHEME**

This paper presents a software framework that can provide both original MSISDN of a home

network and other MSISDN of visiting networks with single IMSI. To provide such services, the location update procedure is modified, which is used when a user is transferred to a foreign network. RSCP sends an additional MSISDN to the VLR of the visiting network. Also, the mobile terminating call procedure is modified, which is used when the dialled number was an additional MSISDN.

#### ***A. Location Update Procedure***

If a user transfers to a foreign network and has an additional MSISDN that belongs to the network, the location update procedure occurs as Figure 1. First, an outbound mobile station sends an attach request message to a Serving GPRS Support Node (SGSN) that belongs to the visiting network. Then the SGSN sends an UGL message to a HLR that belongs to the user's home network through a Gateway Location Register (GLR). As a result, user's profile is transferred to the SGSN through the ISD messages and the Packet Switching (PS) update location procedure completes. Since the network performs a combined mode [7] location update procedure, the SGSN requests a MSC to perform update location procedure. Then the MSC sends an UL message to the HLR through the GLR to perform a Circuit Switching (CS) update location procedure. After the GLR receives an UL ACK message, it sends a Request Subscriber Information (RSI) message to RSCP if HPLMN and FPLMN have made a contract to provide the multiple-MSISDN service. This message includes the IMSI of the mobile station, the original MSISDN, the global title of the MSC/VLR, and the global title of the HLR. Then RSCP analyzes the RSI message and searches the additional MSISDN of the mobile station. RSCP sends the additional MSISDN to the GLR by using a RSI ACK message. Then the GLR stores the information and sends it to the MSC/VLR through an ISD message with an Originating CAMEL Subscription Information. Then finally, the location update procedure is completed.

#### ***B. Mobile Terminating Call Procedure***

When a call originates in a foreign network and terminates to an outbound roamer in the foreign network, 3GPP standards have suggested the procedure in Figure 2. If a user originates a call to an Originating-MSC (O-MSC) in a visited network,

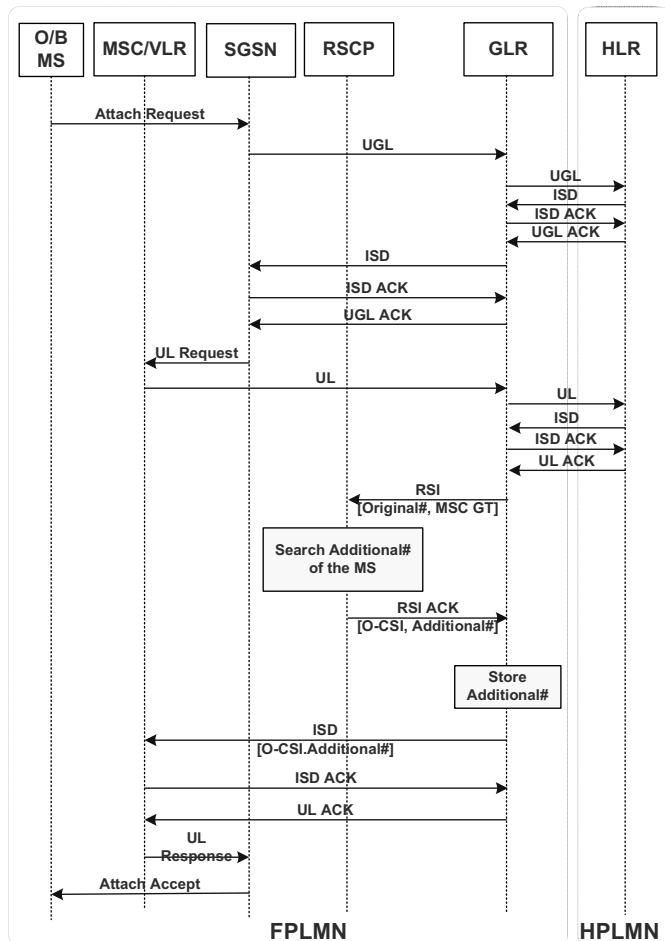


Figure 1. Modified update location procedure

the O-MSC sends an Initial Address Message (IAM) message to GMSC in the same network. Since the dialled number is an international type, the GMSC relays an IAM message to an international ISUP carrier. Also, it relays the message to the GMSC in a home network. Then the GMSC sends a Send Routing Information (SRI) message to an HLR in the home network to query the location of the terminating mobile station. The HLR sends a Provide Roaming Number (PRN) message to the GLR in the foreign network to query the Mobile Station Roaming Number (MSRN) of the mobile station. Then the GLR relays the PRN message to the Terminating-MSC (T-MSC) and the T-MSC sends a MSRN to the HLR through the GLR by using a PRN ACK message. After the GMSC in a home network receives the MSRN from the HLR through the SRI ACK message, the GMSC changes the destination address of the IAM

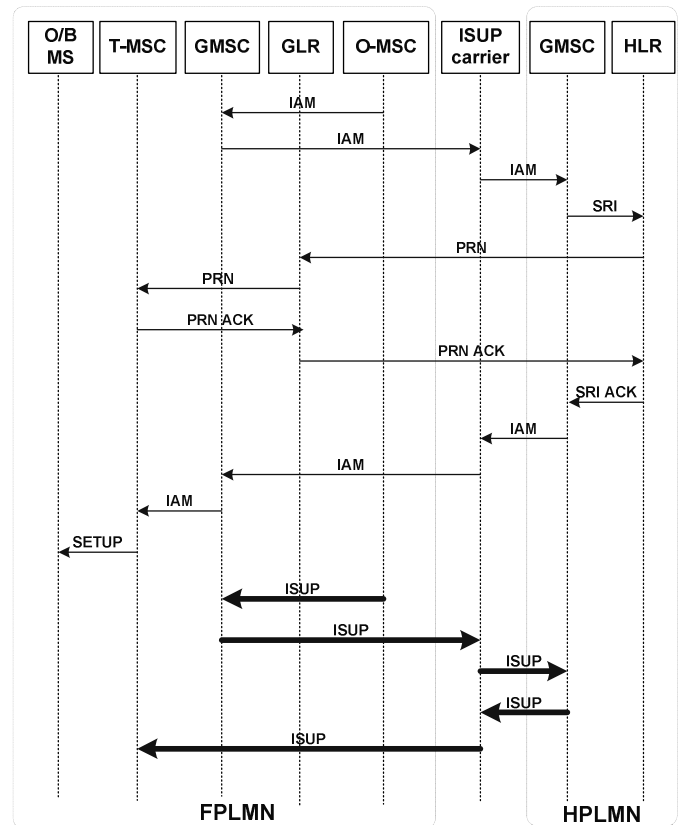


Figure 2. Standard mobile terminating call procedure

message to the MSRN and sends the message to the international ISUP carrier. It relays the message to the GMSC in the foreign network and the GMSC relays it to the T-MSC. As soon as the T-MSC receives the IAM message that has the MSRN, it pages to the terminating mobile station and completes an ISUP path.

If a user is registered in a foreign network and the user has an additional MSISDN that belong to the network and another user in the network sends a call to the additional MSISDN, the call flow of the proposed scheme is shown in Figure 3. If the originating mobile station requests to send a call to an O-MSC, the O-MSC sends an IAM message to a GMSC. The GMSC should be configured to route a call to RSCP if the dialled number is included in the additional MSISDN range. In this scenario, the Sub-System Number of RSCP becomes 6, which is a HLR. Therefore, the GMSC sends a SRI message to RSCP with an additional MSISDN. After RSCP receives the SRI message, it sends an Unstructured Supplementary Service Notify message to the receiver to indicate the user that the dialled number



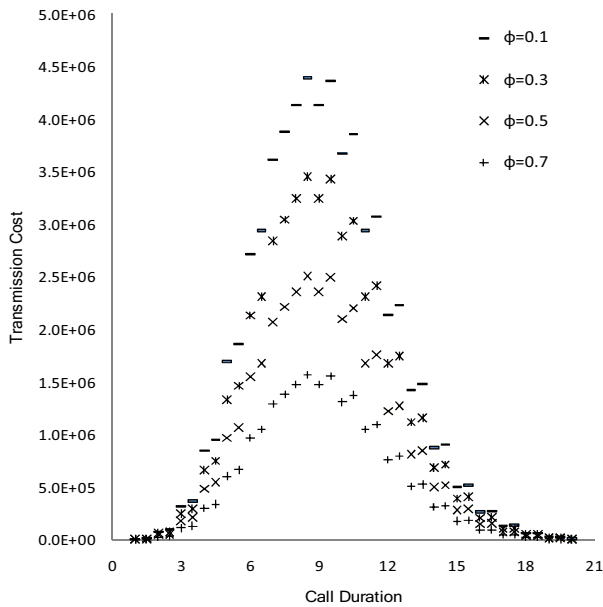


**Figure 4.** Transmission cost versus the ratio of roamers who have additional MSISDN

We assumed that if roamers were registered in the additional MSISDN service and they were roaming in the foreign network, all the incoming calls to them were dialled to the additional MSISDN. Also, we assumed that the random variable  $\chi$  has an exponential probability density function that is given by

$$f(x) = \frac{1}{\alpha} e^{-x/\alpha} \quad (2)$$

where  $\alpha$  is an average value.

Generally, since  $\rho_{FH}$  is greater than  $\rho_{FF}$ , the cost is reduced if  $\phi$  increases. To find the relation among the cost,  $\phi$ , and  $\chi$ , we conducted a

simulation with following conditions:  $\theta = 10000$ ,  $\alpha = 8$ ,  $\rho_{FH} = 410$ ,  $\rho_{FF} = 13$ .

From Figure 4, we can see that if the proportion of roamers who have the additional MSISDN increases, the cost for transmitting ISUP traffic reduces. It is because if we use the proposed scheme, the traffic does not have to pass by international ISUP carrier's network which will impose high tariffs.

## V. CONCLUSION

This work provides a software framework for providing multiple MSISDN across heterogeneous networks while using single IMSI. If mobile network providers use this scheme, the users can use not only their original MSISDN in their home network but also their additional MSISDN while they are roaming in foreign networks. Furthermore, when users receive calls which were dialled to the additional MSISDN while they are roaming, the traffic transmission cost is reduced.

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