

A Push Mechanism for GPRS Supporting Private IP Addresses

Yi-Bing Lin, Yung-Chieh Lo, and Herman C.-H. Rao

Abstract—General Packet Radio Service (GPRS) provides packet switched data service for mobile users. However, the existing GPRS specification does not provide the push mechanism and it is difficult to support GPRS services such as call termination (incoming call) for wireless voice over IP (VoIP). Based on short message service, this paper proposes a push mechanism for GPRS supporting private IP addresses. Our approach does not need to modify the existing GPRS structure.

Index Terms—GPRS, Push, SIP, SMS, VoIP.

I. INTRODUCTION

GENERAL Packet Radio Service (GPRS) provides packet data services for mobile networks such as GSM and UMTS [1]. The GPRS architecture is illustrated in Fig. 1(A) where the GPRS core network consists of the *Serving GPRS Support Node* (SGSN; see Fig. 1(1)) and the *Gateway GPRS Support Node* [GGSN; see Fig. 1(2)]. An SGSN communicates with a *Mobile Station* [MS; see Fig. 1(3)] through the GSM/UMTS radio system (Fig. 1(4)) and interacts with the *Home Location Register* [HLR; Fig. 1(5)] to track the location of the MS. The SGSN forward packets between the MS and the corresponding GGSN. The GGSN interworks with the external data network [see Fig. 1(D)] using, for example, the *Internet Protocol* (IP). The SGSN and the GGSN are connected through an IP-based backbone network. In most commercial GPRS implementations, an MS is dynamically assigned a private IP addresses [2]. Therefore a *Network Address Translation* (NAT) server [see Fig. 1(14)] is required to translate the IP addresses of the packets delivered between the public address realm (the external data network) to the private address realm (the GPRS network).

To access a particular GPRS service (e.g., web surfing), an MS must activate the *Packet Data Protocol* (PDP) context for this service [1]. GPRS does not provide any *push* mechanism explicitly. That is, if the MS did not activate the PDP context for a specific service, the network cannot “push” this service to the MS. In this letter, we propose a push mechanism for GPRS

supporting private IP addresses. Our solution does not modify existing GPRS components.

II. GPRS PDP CONTEXT ACTIVATION

An MS must attach to the GPRS network before it can receive any GPRS service. The simplified GPRS attach procedure is described as follows.

- Step 1) The MS initiates the attach procedure by sending the *International Mobile Subscriber Identity* (IMSI) together with other parameters to the SGSN. The IMSI uniquely identifies the MS, which is the only key to search the MS record in the HLR.
- Step 2) The SGSN accesses the HLR using the IMSI to obtain the subscriber data of the MS (including the PDP contexts of all subscribed services). Then it informs the MS that the attach is successful.

After GPRS attach, the MS is tracked by the GPRS network. Whenever it moves to a new SGSN, the SGSN uses the IMSI of the MS to obtain the subscriber data from the HLR. When the MS attempts to access a specific service, the PDP context for that service is activated as follows.

- Step A:* The MS sends the Activate PDP Context Request message to the SGSN. Note that the SGSN already has the PDP context information of the MS (see Step II in the attach procedure).
- Step B:* The SGSN sends the Create PDP Context Request message to the GGSN. The message contains the necessary information to create the PDP context of the MS in the GGSN. The activation also creates a logical link between the SGSN and the GGSN for this PDP context. The GGSN assigns an IP address x to the MS.
- Step C:* The GGSN replies the SGSN with the Create PDP Context Response message. This message provides the GGSN address and the IP address x that are stored in the PDP context of the SGSN. The SGSN sends the address x to the MS through the Activate PDP Context Accept message.

After PDP context activation, a packet-switched data connection between the MS and the GGSN is established. Sometimes it is desirable to activate a service from the external data network. In 3GPP 23.060 [1], a *network-requested PDP context activation* procedure is described. When the external data network attempts to connect to an MS, it sends the request to the GGSN. If the MS has not activated the PDP context, the GGSN

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Y.-B. Lin and Y.-C. Lo are with the Department of Computer Science and Information Engineering, National Chiao Tung University, Hsinchu, Taiwan, R.O.C. (e-mail: liny@csie.nctu.edu.tw; yjlou@csie.nctu.edu.tw).

H. C.-H. Rao is with FarEastone, Taiwan, R.O.C. (e-mail: hrao@fareastone.com.tw).

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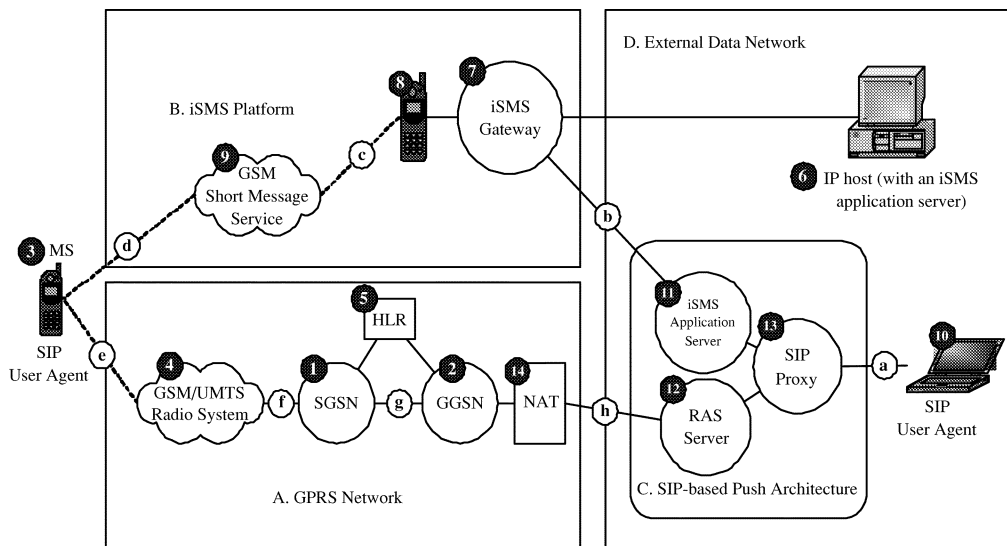


Fig. 1. GPRS, iSMS, and SIP-based Push Architecture.

needs to communicate with the HLR to create one. However, the HLR can only be accessed through the IMSI of the MS. Unfortunately, before the PDP context is created in the GGSN, the GGSN does not have the IMSI of the MS. Note that before PDP context activation, only the SGSN that involves in mobility management can obtain the IMSI to access the HLR. In some GPRS implementations, an IP-address-to-IMSI mapping function is established in the GGSN (especially when the IP addresses are statically assigned to the MSs). However, this solution is proprietary and is not appropriate when the IP addresses are dynamically allocated. The next section uses VoIP call termination (incoming call) to illustrate how to implement a push mechanism for GPRS.

III. A PUSH APPROACH FOR GPRS

We utilize an SMS-based IP service platform called iSMS [5] to implement the push mechanism. iSMS is an operator-independent platform that integrates the IP network with the Short Message Service (SMS) in mobile telephone systems. Through iSMS [see Fig. 1(B)], an IP host in the external data network [see Fig. 1(6)] can offer Internet services to an MS [see Fig. 1(3)]. Specifically, messages are created by an iSMS application server run on the IP host and then sent to the iSMS gateway [see Fig. 1(7)]. The iSMS gateway is connected to a GSM modem [see Fig. 1(8)] that delivers the messages to the MS through the short message service [see Fig. 1(9)]. Note that (9) and (4) in Fig. 1 typically utilize the same radio system. In the iSMS platform, no components in the GSM are modified. The iSMS gateway can be implemented by an off-the-shelf high-reliability PC or workstation connected to an MS.

With iSMS, we use the SIP-based VoIP call termination to illustrate our push mechanism. Specifically, when the VoIP calling party in the IP network [see Fig. 1(10)] initiates a call to an MS, the iSMS application server [see Fig. 1(11)] will issue a short message to the MS through the iSMS gateway. This short

message instructs the MS to activate the PDP context for the VoIP service. Therefore, the network-requested PDP context activation is achieved without requiring the GGSN to interact with the HLR.

Our example uses the *Session Initiation Protocol* (SIP) [4] for VoIP signaling. SIP cooperates with *Session Description Protocol* (SDP) and *Real-time Transport Protocol* (RTP) to support VoIP applications. While RTP transports the voice packets, SDP provides the RTP information such as the network address and the transport port number of the RTP connection. To support VoIP call termination to a GPRS user, we propose a *SIP-based Push Architecture* [SPA; see Fig. 1(C)]. In this architecture, a SIP proxy [see Fig. 1(13)] connects to a SIP user agent [see Fig. 1(10)] in the external data network and an MS (with another SIP user agent) through the GPRS network. An iSMS application server (Fig. 1(11)) is implemented in the SPA to support the push operation. Note that the port number of SIP is predefined. Since the NAT server distinguishes hosts by the port numbers, the fixed port number nature of SIP will result in wrong translation at the NAT server. Therefore, a *Remote Access Service* (RAS) server [see Fig. 1(12)] must be implemented to support the tunnel between the SIP proxy and an MS. Our tunnel implementation is based on the L2TP protocol [3].

Consider the SIP call setup procedure from an IP host in the external data network to an MS. The phone number of the MS is 886936105401 and the fully qualified domain name of the SIP proxy is fetnet.com. Before the call termination is initiated, the MS has not activated the VoIP service yet.

- Step 1) The calling party initiates the call to the MS by issuing the SIP INVITE message. This message contains the SDP information that provides the RTP network address and transport port number of the calling party. In VoIP, a call party is identified by its IP address. Since the IP address of the MS is dynamically assigned, this address is not available when the call termination is initiated. To resolve this issue, the MS is identified by the telephone

number 886936105401 carried by the INVITE message using the SIP Request-URI with the following format:

INVITE sip : 886936105401

The above message is routed to the SIP proxy (fetnet.com) through path (a) in Fig. 1. Upon receipt of the INVITE message, the SIP proxy instructs the iSMS application server to send a short message to the number 886936105401 (path (b)→(c)→(d) in Fig. 1). This short message carries the public IP address of the RAS server and a tunnel IP address of the SIP proxy, which will be used by the MS to establish the tunnel to the SIP proxy.

- Step 2) The short message triggers the MS to activate the PDP context for VoIP (Steps A–C in Section II). After the activation, the MS is assigned an IP address from the GGSN.
- Step 3) By using the RAS IP address and the MS IP address, the MS and the RAS server exchange L2TP messages to establish a tunnel between the MS and the SIP proxy (path (e)↔(f)↔(g)↔(h) in Fig. 1). After the tunnel is established, the MS is assigned a tunnel IP address from the RAS server. Note that this tunnel IP address is different from the MS IP address assigned by the GGSN.
- Step 4) Using the established tunnel, the MS sends its tunnel IP address and telephone number 886936105401 to the SIP proxy. This tunnel IP address and the phone number are saved in the SIP proxy. When the SIP proxy receives a SIP message with the destination phone number 886936105401, it will forward the message using the tunnel IP address of the MS.
- Step 5) The SIP proxy modifies the INVITE message received at Step 1. Specifically, the connection information field and the transport port field of the SDP are modified to the IP address and the port number of the SIP proxy, so that in the future the RTP packets will be routed from the MS to the calling party through the SIP proxy. The SIP proxy forward this message to the MS.
- Step 6) Upon receipt of the modified INVITE message, the MS answers the call by sending the SIP OK response back to the SIP proxy through the tunnel established in Step 3. The SDP of this message contains the RTP information of the MS, which is also modified by the SIP proxy similar to that in Step 5.
- Step 7) The SIP proxy forwards the OK message to the calling party. The calling party confirms this session by sending the SIP ACK message to the MS through the SIP proxy. At this point, the conversation begins. The RTP packets are routed through the path (e)↔(f)↔(g)↔(h)↔(a).

IV. CONCLUSIONS

In GPRS, the MS must activate the PDP context for a specific service before the external data network can push this service to the MS. An example is VoIP call termination (incoming call) to an MS. However, maintaining a PDP context without actually using it will significantly consume network resources. Therefore, it is desirable to devise a GPRS push mechanism that only activates a PDP context when it is needed. By using an SMS based Internet platform called iSMS, we developed a push mechanism for SIP call termination of GPRS supporting private IP addresses. A major advantage of our approach is that no GPRS/GSM nodes need to be modified. A prototype of the push mechanism has been developed and experimented in FarEasTone (a major mobile operator in Taiwan, R.O.C.).

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