

Integration of the ORBCOMM satellite network with the GSM Short Message Service

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Abstract. This paper deals with the interworking between the GSM Short Message Service (SMS) and the ORBCOMM satellite system. This latter is a global coverage satellite system including 36 LEO (Low Earth Orbit) satellites. In particular, the paper deals with the so-called INTERGO service which permits the sending of messages from the standard GSM terminals (GSM Mobile Stations (MSs)) to the ORBCOMM terminals (ORBCOMM Subscriber Communicators (SCs)) and vice versa. Moreover, an enhanced version of the INTERGO service, referred to as “INTERGO+”, allows, in case of GSM terrestrial segment unavailability, the automatic rerouting, via the ORBCOMM satellite network, of the GSM Short Messages addressed towards Dual-Mode users (GSM + ORBCOMM).

The design of the so-called ORBCOMM SMSCE (Short Message Service Center Extension), which is the core of the INTERGO application, is presented. This entity is a gateway, which interfaces the GSM network with the ORBCOMM system using the Internet as a communication bridge. This paper shows that such equipment can be easily implemented without entailing any modification either in the GSM or in the ORBCOMM networks; the main importance of this paper lies in the fact that the underlying approach can also be applied for the interconnection of other pairs of networks.

Keywords: GSM, ORBCOMM, Short Message Service, Integration

Abbreviations

BSS	(GSM) Base Station System
GCC	(ORBCOMM) Gateway Control Center
GES	(ORBCOMM) Gateway Earth Station
GSM	Global System for Mobile communications
HLR	(GSM) Home Location Register
IWMSC	(GSM) Interworking Mobile services Switching Centre
MO	Mobile Originated
MS	(GSM) Mobile Station
MSC	(GSM) Mobile services Switching Centre
MT	Mobile Terminated
PLMN	Public Land Mobile Network
SC	(ORBCOMM) Subscriber Communicator
SM = sm	Short Message
SMPP	Short Message Peer to Peer
SMS	(GSM) Short Message Service
SMSC	Short Message Service Center

SMSCE	(ORBCOMM) Short Message Service Center Extension
SMTP	Simple Mail Transfer Protocol
VLR	(GSM) Visitor Location Register

1. Introduction

In recent years, the interconnection of mobile and terrestrial networks has become more and more important, in order to provide users with a global world-wide access and to allow an “intelligent” routing of calls through the integrated network. In general, terrestrial and satellite networks have been independently developed and are provided with procedures tailored to their specific needs. So, a basic problem is to design appropriate gateways between the networks to be interconnected. These gateways should

- (i) interact with the protocols and procedures of the interfaced networks without entailing any impact on these networks (i.e., the insertion of the gateways must be transparent with respect to the interfaced networks);
- (ii) be relatively simple, cheap, modular and easily scalable.

In the above-mentioned context, this paper deals with the interworking of the ORBCOMM satellite system with the GSM Short Message Service (SMS).

The ORBCOMM satellite network [1] includes 36 LEO (Low Earth Orbit) satellites, providing a global world-wide coverage and operating in the frequency bands 137–138 MHz (downlink) and 148–150.5 MHz (uplink). The fixed terrestrial part of the ORBCOMM network is organized in the so-called *ORBCOMM regions*. Each ORBCOMM region includes a certain number of *Gateway Earth Stations (GESs)* (e.g., 4 GESs have been presently implemented in the North America ORBCOMM region) linked, according to a star topology to a single *Gateway Control Center (GCC)*. The GESs only contain transmission functionalities, while all control functionalities are concentrated in the GCC. The mobile terrestrial part of the ORBCOMM network includes handheld terminals, referred to as *Orbcomm Subscriber Communicators (SCs)*, able to transmit data at a bit rate of 2.4 kbps. The communications between the ORBCOMM entities (SCs, satellites, GESs and GCC) occurs by means of proprietary ORBCOMM protocols. As for the communications between the ORBCOMM network and the outside world, the GCC is provided with an ORBCOMM Mail Server which is connected with the Internet. Each ORBCOMM SC is identified by a standard E-mail address; the ORBCOMM users can address a message to a terminal either within or without the ORBCOMM network by dialling the terminal E-mail address. The ORBCOMM system is already operational in the USA and Canada (North America ORBCOMM region), the GCC being located at Washington-Dulles (USA), and is entering into operation also in Europe (Europe ORBCOMM region) where it is handled by the company MCS Europe, which also operates the European GCC (located at Fucino in Italy).

The GSM Short Message Service (SMS) is the well-known GSM data service supported by the GSM Stand Alone Dedicated Control Channels (SDCCH) and GSM Slow Associated Control Channel (SACCH) [2]. One is reminded that the transmission of Short Messages is always relayed by appropriate Short Message

Switching Centers (SMSCs), considered to be outside GSM. The GSM recommendation [2] specifies how a SMSC has to interface to the GSM network. The Short Message Entities (SMEs) are defined as entities able to both send, and receive Short Messages. The SMEs can be either included (*PLMN-SMEs*), or not included (*non-PLMN-SMEs*) in the GSM Public Land Mobile Network (PLMN); so, the standard GSM MSs are *PLMN-SMEs*, while the non-GSM SMEs directly linked to the SMSCs are *non-PLMN-SMEs*.

The aim of the proposed interworking is to allow the GSM MSs to send Short Messages to the ORBCOMM SCs and to allow ORBCOMM SCs to send ORBCOMM messages to the GSM MSs. In addition, the interworking in question must guarantee that users provided with Dual-Mode (ORBCOMM + GSM) terminals can send and receive messages through the GSM network as long as a GSM link is available and through the ORBCOMM network in the periods of GSM link unavailability. This last facility will be hereinafter referred to as *Automatic Re-routing facility*.

The interworking takes place by means of a gateway whose design satisfies the requirements (i) and (ii) presented at the beginning of this section. It is important to stress that the interworking approaches presented in this paper can be reused for the interconnection of other pairs of networks. In this respect, the proposed approach has the basic advantage of allowing the interworking between heterogeneous networks with a minimum effort, i.e., without any modification of the usual working of the equipment and protocols in the two networks. Clearly, something has to be paid in terms of the effectiveness of the realized interworking with respect to a solution fully integrating the two networks. Nevertheless, the simplicity, flexibility and practicality of the proposed approach fully justify the solution detailed in this paper.

The paper is organized as follows: Section 2 reports the integrated system architecture and describes the INTERGO and INTERGO+ services. The former provides the capability to send Short Messages from the GSM network to the ORBCOMM network and vice versa, while the latter also provides the Automatic Re-routing facility. Sections 3 and 4 deal with the INTERGO and INTERGO+ services, respectively.

2. Integrated system architecture

Figure 1 shows the architecture integrating the GSM network with the ORBCOMM network. The key en-

tity for interworking is the *ORBCOMM Short Message Service Centre Extension (SMSCE)* which is the gateway between the GSM Short Message Service (SMS) and the ORBCOMM satellite network. As shown in Fig. 1, the SMSCE is linked, via the Internet Network, to the ORBCOMM GCC and to the Short Message Service Centers (SMSCs). Communications among the ORBCOMM SMSCE and the SMSCs takes place by means of the so-called *SMSC Proprietary Protocols* (see Fig. 1); these last are the protocols, described in [5], used by the SMSC to interface the *non-PLMN-SMEs* (the ORBCOMM SMSCE is regarded by the SMSCs linked to it as if it were a non-PLMN-SME).

The proposed interworking will be developed in two steps. In the first step, the ORBCOMM SMSCE deals with the “translation” of the Simple Mail Transfer Protocol (SMTP) into the SMSC Proprietary Protocols. The above-mentioned translation allows a Short Message sent by a GSM MS to reach an ORBCOMM SC and vice versa. The interworking service developed in the first step will be referred to as **INTERGO** service. This service has currently been implemented by MCS Europe.

In a second step, the ORBCOMM SMSCE is enhanced so that the Automatic Re-routing facility can be implemented. This facility can be exploited by the so-called *Dual-Mode users*, who are equipped with both an ORBCOMM SC and a GSM MS. In fact, the ORBCOMM SMSCE tries to send a message (originated either from an ORBCOMM SC, or from a GSM MS) to the Dual-Mode user via the GSM link, and, only if such link is unavailable, it will re-route the message via the ORBCOMM network. The usefulness of Automating Re-routing should be quite clear: virtually, a Dual-Mode user extends the GSM coverage throughout the ORBCOMM coverage. Moreover, it must be noted that the GSM MS and the ORBCOMM SC of a Dual-Mode user do not need to be integrated. They can even be kept separated. For instance, a Dual-Mode user who is aware that he is going to a place outside the GSM coverage can choose to bring only the ORBCOMM SC with him, being sure that every GSM Short Message addressed to him will reach him via the ORBCOMM network.

As for billing issues, the same approach as in the GSM voice service has been adopted (to charge the called MS in case it is roaming outside its home coun-

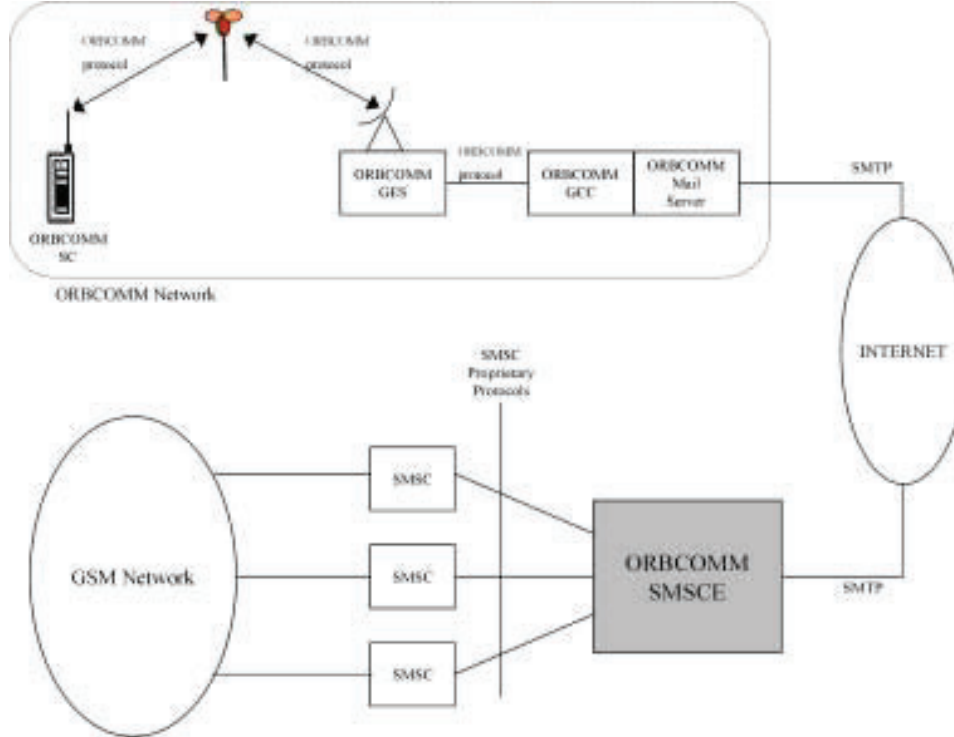


Fig. 1. Integrated system architecture.

try). Since the user originating the message cannot be aware that a message directed to a Dual-Mode user can be re-routed via satellite, the possible satellite cost is charged to the Dual-Mode user receiving the message. As this cost is much higher than the GSM one, the Dual-Mode user, in every moment, can enable or disable the Automatic Re-routing facility.

The interworking service developed in the second step will be referred to as **INTERGO+** service. This service is going to be implemented by MCS Europe.

3. INTERGO service

3.1. Sending a message from an ORBCOMM SC to a GSM MS

Figure 2 shows the path (dashed line) followed by the message through the various networks.

The procedure evolves according to the following steps:

- the ORBCOMM user inputs the message in his ORBCOMM SC and addresses it to an E-mail address of the kind *GSM-MSISDN@msgwnode.operatordomain*, where the local part of the E-mail address, i.e., *GSM-MSISDN*, is the MSISDN number of the GSM MS to which the message is addressed. The simplest solution, in order to assign an Internet E-mail address to identify each GSM MS, is to use the GSM MS telephone number (i.e., the MSISDN number) as a part of the E-mail address;
- the ORBCOMM GCC sends the message, through Internet, towards the ORBCOMM SMSCE which corresponds to the domain-name *msgwnode.operatordomain*;
- the ORBCOMM SMSCE receives an E-mail addressed to the GSM user whose telephone number is *GSM-MSISDN*. It then modifies the E-mail body to allow its transmission via SMS (fragmentation in blocks, modification of some characters, etc.) and forwards the obtained Short Messages to the correct SMSC;

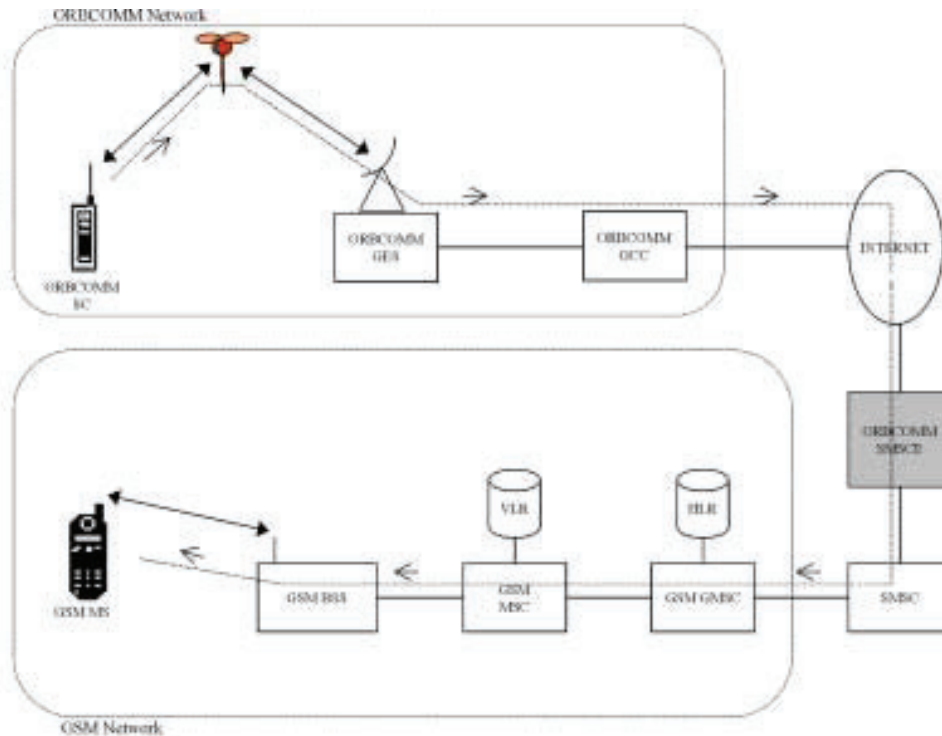


Fig. 2. Path followed by a message from an ORBCOMM SC to a GSM MS.

- as the SMSC receives the Short Message, it acknowledges the message reception to the ORBCOMM SMSCE according to the SMSC Proprietary Protocols [5], and it forwards the Short Message to the GSM MS corresponding to the *GSM MSISDN*, according to the GSM SMS Mobile Terminated protocols [2].

3.2. Sending a Short Message from a GSM MS to an ORBCOMM SC

Figure 3 shows the path (dashed line) followed by the message through the various networks.

The procedure evolves according to the following steps:

- the GSM user inputs the Short Message and inserts in the message body the E-mail address of the ORBCOMM SC to which the Short Message must be delivered. The E-mail address must be the first character sequence (not divided by any blank space) contained in the Short Message body. Then, the GSM user has to dial the ORBCOMM SMSCE access number, since the GSM operator has assigned to the ORBCOMM

SMSCE a service access number, mapped in the E.164 telephonic plan [4]. All Short Messages sent to this service access number are routed by the SMSC to the ORBCOMM SMSCE;

- as the SMSC receives the Short Message, it confirms its successful reception to the GSM MS by a *Delivery Report*, in accordance with the standard GSM SMS Mobile Originated protocols [2]. Then, it forwards the Short Message to the ORBCOMM SMSCE;
- in accordance with the *SMSC Proprietary Protocols* [5], the ORBCOMM SMSCE acknowledges the successful reception of the Short Message by the SMSC. Then, the ORBCOMM SMSCE extracts from the Short Message body the E-mail address of the ORBCOMM SC to which the message is addressed and forwards, via Internet, the resulting Short Message to this E-mail address.

3.3. ORBCOMM SMSCE architecture

The ORBCOMM SMSCE has the modular architecture shown in Fig. 4. In addition to these modules, an

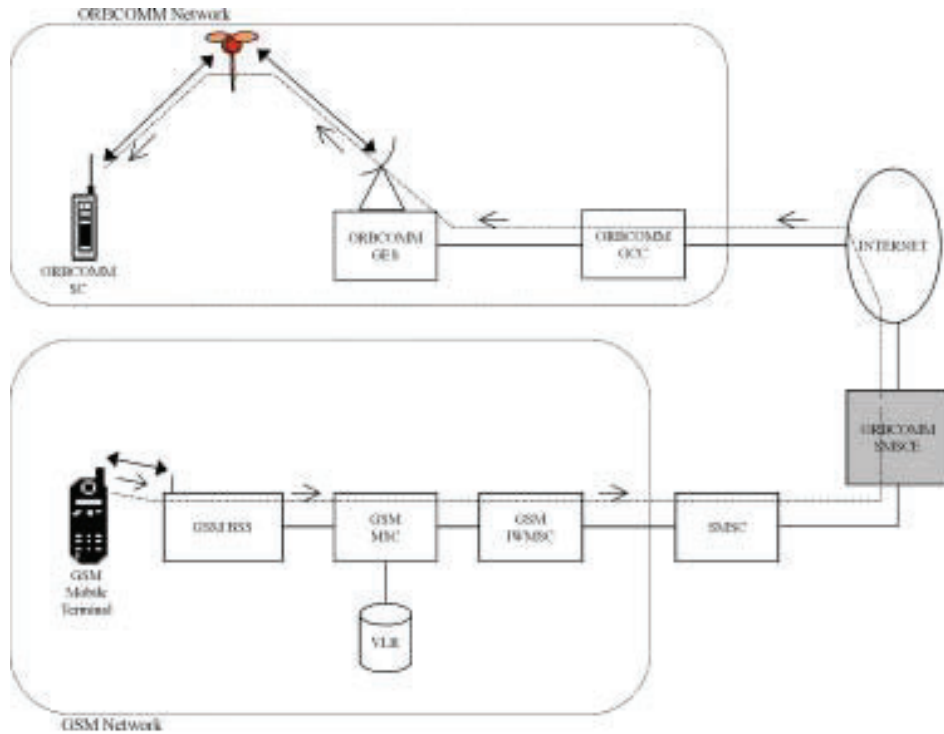


Fig. 3. Path followed by a message from a GSM MS to an ORBCOMM SC.

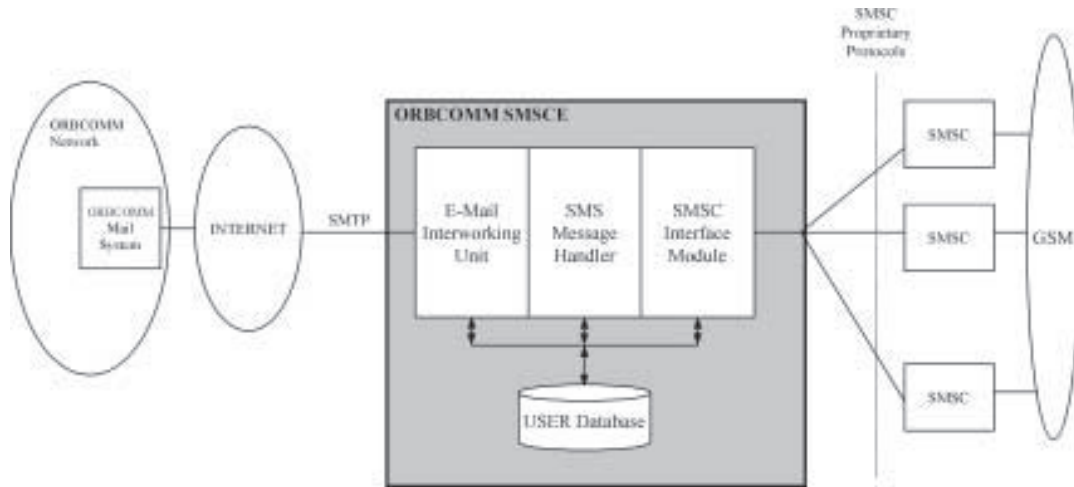


Fig. 4. ORBCOMM SMSCE architecture – INTERGO.

Operation and Maintenance System (OMC) monitors the message processing flow through the modules, and the way in which the modules interface with the different communication channels.

The *E-Mail Interworking Unit* acts as an SMTP module receiver in the ORBCOMM→GSM direction, and as an SMTP module sender in the GSM→ORBCOMM direction (it implements a subset of the RFC 821 specifications [3]). The *User Database* stores ORBCOMM user profiles. The *SMSC Interface Module* provides the interface with the SMSCs and hence must be able to implement the various *SMSC Proprietary Protocols* (e.g., Aldiscon SMPP, Nokia CIMD, ETSI UCP protocols). Even if these protocols are, in general, proprietary, they use similar primitives to send, receive, and modify Short Messages [5]. The *SMS Message Handler* (see Fig. 5) is the core of the INTERGO application, since it is the actual contact point between GSM and Internet. It consists of a set of processes.

The basic processes inside the SMS Message Handler are the *Gateway Processes*, which translate the SMTP messages into a correct format for the SMSC Proprietary Protocols, and vice versa. In particular, *Gateway Processes A* and *B* operate in the direction from ORBCOMM to GSM and vice versa, respectively (see Fig. 5). Let us first consider the *Gateway Process A*. The *E-Mail Interworking Unit* passes the E-mail (whose address is of the kind *GSM-MSISDN@smgwnode.operatordomain*) to the *Gateway Process A*. The MSISDN number of the addressed GSM MS appearing on the left side of the “@” must

include the international code, as if the GSM MS was called from outside its home country. Then the *Gateway Process A*

- (i) extracts the MSISDN number(s) of the addressed GSM MS(s) from the SMTP header fields *To:*, *Cc:*, *Bcc:*, etc.,
- (ii) adds, at the beginning of the SMS message body, the *sender address* and the *subject*, taken from the SMTP header fields *From:* and *Subject:*,
- (iii) if necessary, translates the characters used in the E-mail body into characters suitable for GSM Short Messages,
- (iv) if necessary, fragments the E-mail body into more than one Short Message, since only 160 characters (140 bytes) can be sent in a GSM Short Message.

Afterwards, the Short Message(s) are passed to the *Message Router* which chooses, according to the addressed MSISDN number(s), the right “route” for the Short Message(s), i.e., the right SMSC(s) to which the Short Message(s) must be sent. The number of this/these SMSC(s) is/are communicated to the *SMSC Interface Module*.

As for the *Gateway Process B*, the *SMSC Interface Module* passes a received GSM Short Message (which includes the E-mail address of the addressed ORBCOMM SC in its message body) to *Gateway Process B*. Then, the *Gateway Process B*

- (i) decides whether or not to forward the Short Message to the ORBCOMM user, according to the information stored in the *User Database*,

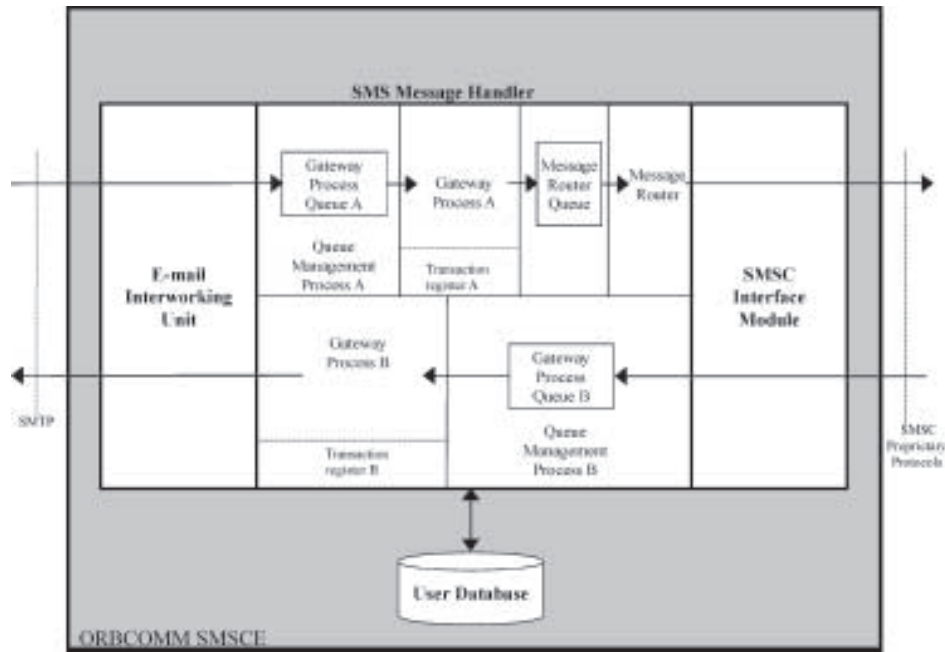


Fig. 5. ORBCOMM SMSCE and SMS Message Handler architecture – INTERGO.

- (ii) extracts from the Short Message body the ORBCOMM user E-mail address and, possibly, the message subject (which must be positioned just after the E-mail address, between the special characters “(”, “)”),
- (iii) accordingly, fills in the SMTP header fields *To:* and *Subject:*,
- (iv) fills in the SMTP header fields *From:* and *Reply-to:* on the basis of the MSISDN number of the GSM user originating the message.

Finally, the *Transaction Registers* are files which contain the accounting information concerning the messages exchange between ORBCOMM and GSM users. They are kept up-to-date by the two just-described gateway processes. The messages are queued in proper FIFO (First In First Out) *Gateway Process Queues* before being handled. The two *Queue Management Processes* verify whether the traffic amount to be handled does not exceed the maximum handling capacities (e.g., in terms of maximum number of messages which can be handled in a certain time interval) of the two Gateway Processes.

4. INTERGO+ Service

The enhancement of the INTERGO+ service consists of the Automatic Re-routing facility.

As detailed in the following, the *SMSC Proprietary Protocols* contain primitives which allow the implementation of the Automatic Re-routing facility. For the sake of clarity, in the following, we will refer to a specific *SMSC Proprietary Protocol*, namely the *Short Message Peer to Peer (SMPP)* [5]. Similar considerations apply to the other SMSC Proprietary Protocols. The INTERGO+ addressing principles are the same as for the INTERGO service. The only difference is that the ORBCOMM SMSCE must be upgraded (with respect to that for the INTERGO service) with a new module, the *Re-routing Module*, which must be added in the *SMS Message Handler*. So the INTERGO service is easily scalable into the INTERGO+ service.

The following four cases can occur:

- (1) Short Message sent from a GSM user to a Dual-Mode user – GSM link available,
- (2) Short Message sent from a GSM user to a Dual-Mode user – GSM link unavailable,
- (3) Short Message sent from an ORBCOMM SC to a Dual-Mode user – GSM link available,
- (4) Short Message sent from an ORBCOMM SC to a Dual-Mode user – GSM link unavailable.

Case 2, which fully exploits the Automatic Re-routing facility will be expanded. The way the other three cases work can be easily deduced from case 2.

In case 2, a Short Message is sent from a GSM user to a Dual-Mode user and the GSM link is unavailable. Under these circumstances, the path followed by the message is indicated by the dashed line in Fig. 6.

The Short Message path can be described by the following five consecutive procedures:

Procedure 1:

This procedure is the GSM SMS Mobile Originated procedure (see Fig. 7). Note that a *Delivery report*, informing that the SMSC has successfully received the Short Message, is sent to the GSM MS originating the message [2].

Procedure 2:

This procedure consists of the transmission of the Short Message from the SMSC to the ORBCOMM SMSCE. In particular, the Short Message arrives at the *SMSC Interface Module* which, by implementing the SMPP protocol, extracts the Short Message text and passes it to the *SMS Message Handler* (see Fig. 8).

In order to implement the Automatic Re-routing facility, the *Re-routing Module* is inserted in the *SMS Message Handler*. For each ORBCOMM user, the

User Database stores its E-mail address, the information concerning whether or not the user is presently enabled to avail itself of the Automatic Re-routing facility and, for the positive case, the associated MSISDN number. As the *Re-routing Module* receives a Short Message, it consults the *User Database* (using the ORBCOMM E-mail address of the addressed user as access key) in order to recognize whether or not the addressed user is presently enabled to avail of the Automatic Re-routing facility. For the positive case, the *Re-routing Module* forwards the Short Message to the *Message Router Queue*. From the *Message Router*, the Short Message passes to the *SMSC Interface Module*. In addition, the *Re-routing Module* stores in a record of the so-called *Pending Message File* the Message_ID, the ORBCOMM E-mail address of the destination user and the Short Message text.

Note that if the Short Message is addressed to an ORBCOMM user which is not a Dual-Mode user, the Short Message would have been transferred by the *Re-routing Module* into *Gateway Process Queue B* and the message processing would have been just the same as for the INTERGO service.

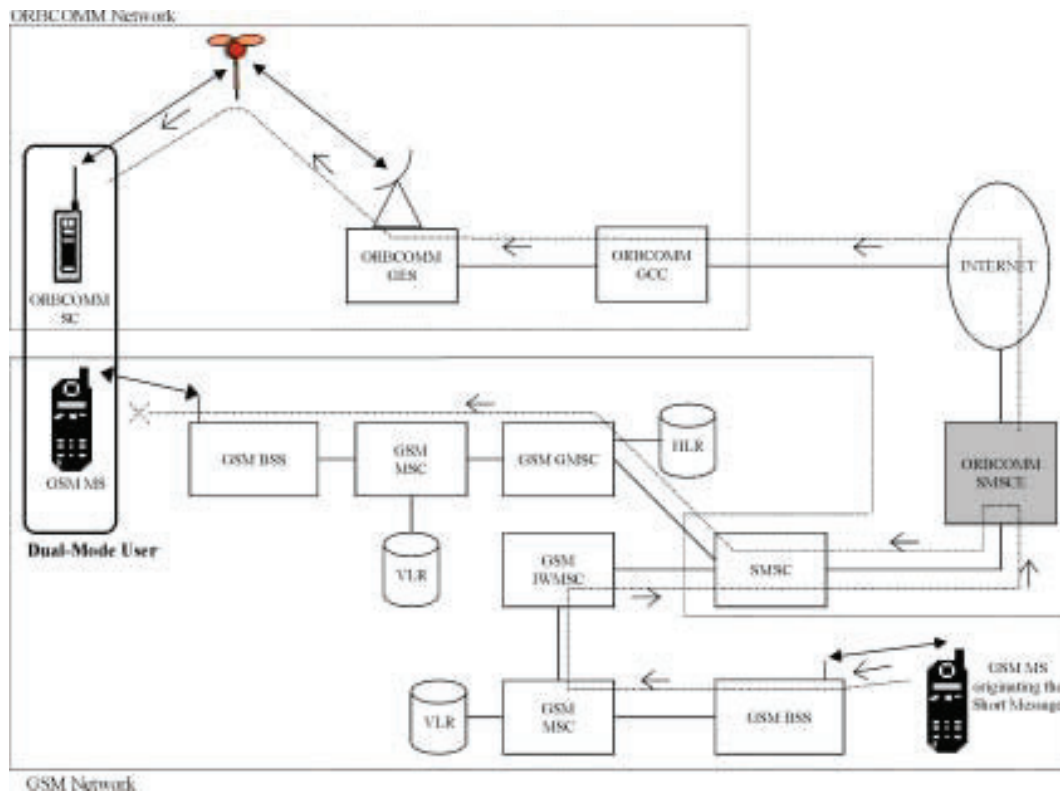


Fig. 6. Sending of a Short Message from a GSM user to a Dual-Mode user – GSM link unavailable.

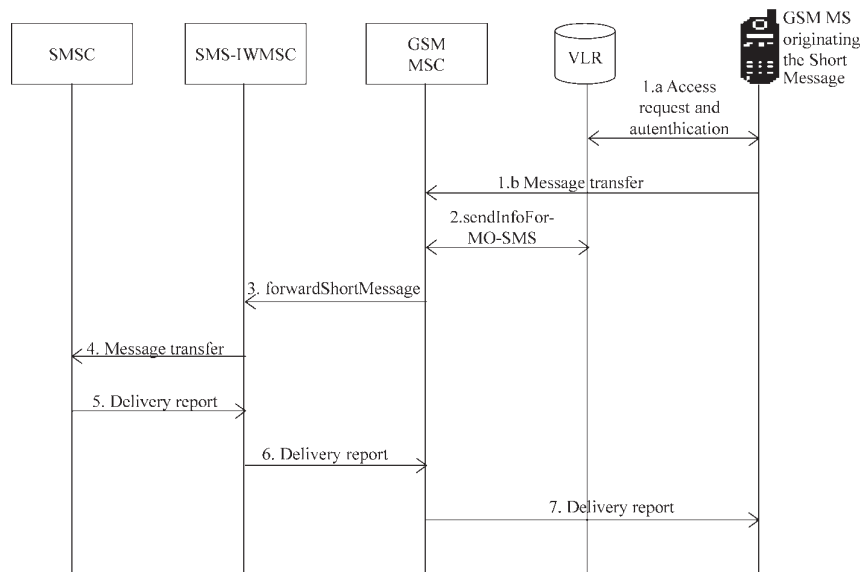


Fig. 7. SMS Mobile Originated signalling exchange [2].

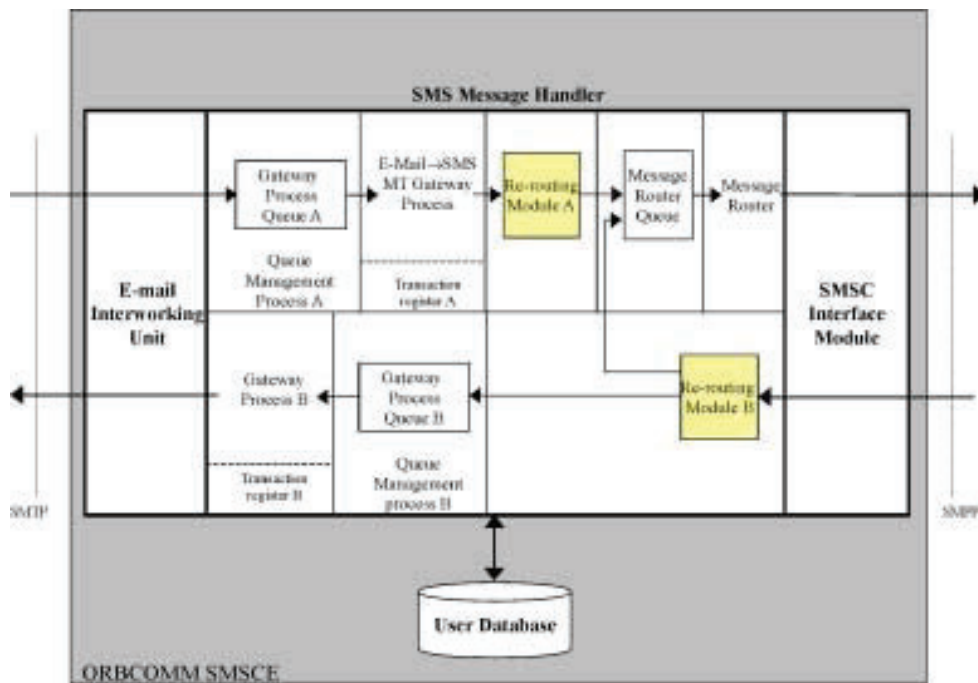


Fig. 8. ORBCOMM SMSCE architecture – INTERGO+.

Procedure 3:

This procedure consists of sending the Short Message from the ORBCOMM SMSCE to the SMSC. The *SMSC Interface Module* asks the SMSC for a *Deliv-*

ery Notification concerning whether the Short Message has been successfully received by the addressed GSM MS. This request is of basic importance for allowing the Automatic Re-routing facility.

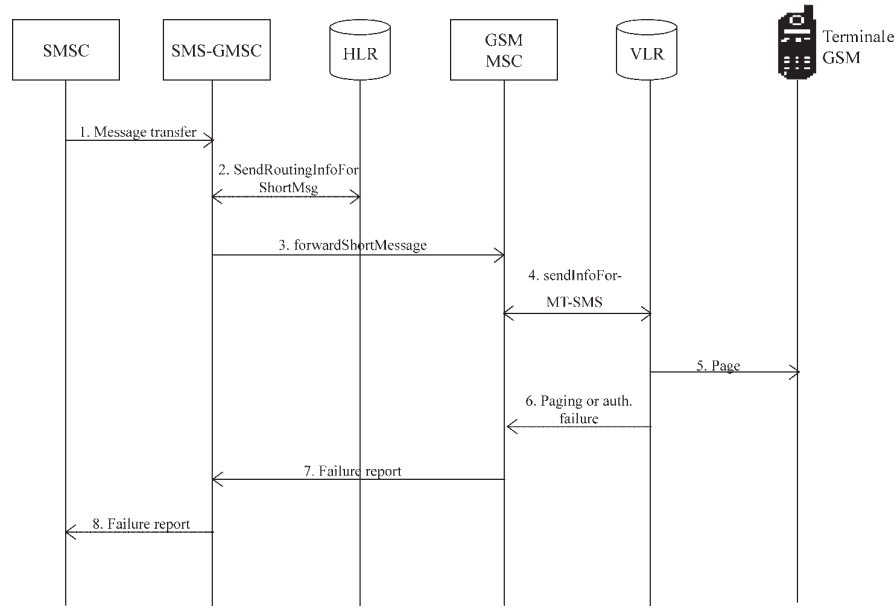


Fig. 9. SMS Mobile Terminated unsuccessful signalling exchange [2].

Procedure 4:

This procedure consists of the SMSC attempt to deliver the Short Message to the Dual-Mode user GSM MS. For case 2 this attempt is unsuccessful since the GSM link is unavailable. Figure 9 shows the SMS Mobile Terminated signalling exchange by which the SMSC is advised of the delivery failure, e.g., caused by radio coverage loss [2]. Other failure causes can be due to errors revealed by the SMS GMSC, by the MSC, by the HLR, or by the VLR. Whatever the failure reason is, the SMSC tries to re-send the Short Message to the GSM MS until the expiry of the Short Message Validity-Period [2].

Procedure 5:

This procedure consists of the sending the Delivery Notification of the delivery failure from the SMSC to the ORBCOMM SMSCE [5]. The procedure is triggered by the SMSC as soon as the Short Message Validity-Period is expired and the GSM system has not been able to successfully deliver the Short Message. The *SMSC Interface Module* forwards the Delivery Notification to the *Re-routing Module* which (i), by using the Message_ID as an access key, retrieves from the *Pending Message File* the Short Message text (not delivered via GSM), and the ORBCOMM SC E-mail address of the Dual-Mode user, (ii) provides this text and this E-mail address to *Gateway Process B*. This last process delivers the subject Short Message via the

ORBCOMM network as described for the INTERGO service.

5. Conclusions

This paper has presented a simple approach for interconnecting the ORBCOMM satellite network with the GSM network, in order to send Short Messages from the GSM MSs to the ORBCOMM SCs and vice versa. The realized interworking does not entail any modification of the standard protocols of the supporting networks (ORBCOMM, Internet, GSM), but it is realized by implementing a relatively simple gateway, the so-called ORBCOMM SMSCE. The underlying approach is based on the concept that the ORBCOMM network has to see the ORBCOMM SMSCE as a *standard* source of Internet traffic and the SMSCs have to see the ORBCOMM SMSCE as a *standard* non-PLMN SME; this approach can also be applied for the interconnection of other pair of networks.

The design of the ORBCOMM SMSCE is modular and easily scalable so that, in a second evolutionary phase, it is possible to easily upgrade the ORBCOMM SMSCE to allow the Automatic Re-routing, via the ORBCOMM satellite network, of messages which cannot be sent via the GSM network. The Automatic Re-routing facility holds a remarkable importance since it

allows a Dual-Mode user to extend the terrestrial coverage to include satellite coverage. In fact, a terminal sending a message to a Dual-Mode user does not need to be aware of the fact that the addressed terminal is provided with such a facility.

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