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SMS and MMS Interworking in Mobile Networks

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Introduction

In December 2002, an invitation to lecture at the Belgacom Corporate University (Brussels) offered the opportunity to put together several years of research on the subject of short message service. The *Global System for Mobile Communications* (GSM) includes a large number of beautifully specified standards, with visionary ideas. Comparatively, IS-41 (the U.S.-originated mobile standard specifications for CDMA and TDMA) is much less developed. The GSM specifications are a wonderful reference but they give only a canonical description of the subject.

Short message service (SMS) is a very clever and economical resource that was designed back in the 1980s when GSM specifications were taken from CNET (the research center of France Telecom) and redeveloped as a worldwide standard. These services have been tremendously successful and *multimedia messaging* (MMS) will have the same success. For the same network resources as a telephone call, SMS services provide about 100 times more revenue to the operators.

I have been interested in the subject of SMS and now MMS for several years. Currently, when a telephone call is made to any number in the world, the called party is reached. For SMS, this is not yet the case by far because of a lack of connections, lack of commercial agreements, and differences in standards among GSM, IS-41 (CDMA, TDMA), and others, including Japanese standards. While developing solutions to interwork SMS and later MMS, several nonstandard (noncanonical) procedures were implemented to provide termination and two-way SMS, such as the dynamic reply path procedure.

When I was working at FERMA, a French voice mail manufacturer, we received in 1995 our first order from Telkomsel (Indonesia) for a distributed *voice mail system* (VMS) covering 22 provinces. It was also to be equipped with 22 simplified *SMS centers* (SMSCs) for SMS notification: Each time a message was left on one of the VMSs, its associated SMSC would send the called party the information that they had one new message. It was very basic and we did not anticipate the future interest in sending SMS to other networks. I left FERMA at the end of 1998; after 15 years as chairman-founder-CEO, I thought that I had given everything to voice processing, and wanted to do something completely different.

In early 1999, at NILCOM (Paris), I started working on SMS interworking, that is, the ability to use SMS with anyone in the mobile world. We conducted several experiments with cell phones that could be controlled (with a V24 data cable) by an outside PC, which could change the service center address. We found that many SMSCs accepted the SMSs (with a French operator's originating address) and sent the SMS to their own subscribers along with the true originating addresses. We naively thought that if this was made general, we would have a "worldwide" system. We then attempted to build a "worldwide numbering plan" so that from a destination number, we would get the service center number. This prompted our interest in building an accurate numbering plan with *mobile number portability* (MNP, whose first appearance was in Hong Kong in 1999), but this was just part of the problem. We then created a start-up company to commercialize this PC software.

At the beginning of 1999, we found that when sending an SMS (for a French operator's number) to a Luxembourg SMSC, the SMS reached this French operator with the real originating number! We therefore got the wrong idea that the Luxembourg SMSC was copying the SMS to the French operator's SMSC, using a SMS-MO procedure, to an open SMSC.

By mid-1999, we had created our first SMS interworking gateway, based on the above method. This first gateway was installed in Taipei for a Taiwan operator with my friend Alain Lardenois. The routing strategy was to relay the SMS to the destination SMSC (over an SS7 roaming agreement), the *SMS mobile originated* (SMS-MO) method. It worked well because (although we did not know this at the time) most of the SMSCs were open and SMS-MOs were not charged. From these Taiwanese roaming agreements, we could reach about 70 networks by July 1999, 470 by September 2000, 530 by December 2002, and more than 600 by the end of July 2003.

We had started using the standard *SMS message terminated* (SMS-MT) procedure immediately after the Taiwan experiment: Address the *home location register* (HLR) to get the routing information and send the SMS-MT. We thought, however, that we needed the real HLR address for each addressed mobile number. Hence we began to research the process of HLR finding. Understanding came in September 1999 from a discussion with an expert colleague at France Telecom about *mobile station international ISDN number* (MSISDN) addressing. However, many mobile networks had not implemented a translation facility in the gateway MSC of their network, so direct HLR addressing was kept as backup.

Our full understanding of the subject came in April 2000, after we had installed another SMS interworking gateway in Singapore and conducted extensive tests with our partner. That was when we discovered all of the billing issues. Our backup SMS-MO procedure (we were forcing the originating address to equal the destination address whenever it was rejected) was creating complaints because the recipient was charged! This was because the call detail records of the SMSC were being used for billing in certain Asian countries. From then on, we knew that only SMS-MT standard (or derived) procedures could be used. As a result, we discovered all the procedures associated with the "*network destination code* (NDC) not opened" situation so that our backup direct HLR addressing procedure had to be used and was very useful.

At the beginning of 2000, we also installed an SMS gateway in Indonesia and one of our partners asked us if we could provide two-way SMS; that is, provide a way to receive SMS from another network. This was the demand behind the automatic reply path technique, which we first implemented in March 2000. With these other nodes, we could materialize the relaying techniques, where one node sends to another node, which roams with the destination network. In an important effort to make the software stable, one can say that by the end of 2000, all the ideas concerning the SMS interworking had been identified.

In mid-2000, we also discovered HLR barring with my friends at Chungwha Telecom (Taiwan) who pointed out the effect in SMS-MT *called detail records* (CDRs) at the receiving *mobile switching center* (MSC) of the wrong originating SC addresses.

We had signed a SMS interworking contract with Scancom (Ghana), which had a talented group of engineers, and they asked us if we could provide an *unstructured supplementary service data* (USSD) platform for value-added services, such as registration on a portal for breaking news or demands for weather forecast. USSD allows conversational services, using text, with a server. It exists in GSM 2G, 2.5G, and 3G and is somewhat ignored. USSD is a better alternative to SMS in conversational application cases such as chat, service registration, and customer provisioning.

With Scancom, we also implemented the notion of a private SS7 network with a *signaling transfer point* (STP) in Monaco and the virtual SMSC concept that we had patented. The use of private leased lines was justified by the high traffic and the savings on the volume-dependent charges of the international SS7 carrier. We also acquired a lot of practical experience on the configuration of STPs and SCCP address translation. As a result of teaching operations research for more than 30 years, it was inevitable that many ideas on routing SMS were drawn from this experience. Routing algorithms are instrumental to these nonstandard SMS interworking methods. To implement them easily, one must rely on the SS7 network. The description of the network layer (SCCP and MTP) of SS7 is therefore necessary and is found in Chapter 2.

Working on the standard SMS-MT procedure, we wanted to provide receiving time zone accuracy; that is, when an SMS is received, the time stamp should be that of the receiving region. So we developed a huge MSC database, which today has more than 4,000 entries. The idea of developing a *mobile location center* (MLC) arose very early. The coming of *general packet radio service* (GPRS) and *customized application for mobile network* (CAMEL) made it easy as more and more networks implemented the additional software and hardware facilities that could provide localization data. We delivered our first MLC early in 2002. MLCs use the SMS procedure in the initial phase (gross resolution location). The subject has been included, as well as the original work on the best approximation of the position.

MMS is a very promising topic for future business because 2 years from now, there will not be any costs associated with an MMS-enabled phone. With MNP, it is a key interworking issue. With our work on MNP, we thought that we had a several-years edge for providing MMS interworking as well as MM5 network name resolution.

Also we met in 2002 with the problem of interworking in the fast growing fixed-line SMS market. Our approach with a domain resolution server (which uses the same idea for SMS as a DNS for the Internet) proved well worth pursuing for MMS interworking (described in Chapter 9). You will see that the interworking issue is quite different from the mobile GSM interworking.

Maximizing the operating margin of SMS interworking is a key issue: Optimal routing algorithms will be required to decide the best paths over which to forward the SMS traffic. The algorithm uses the multicommodity flow model described in Chapter 10 and requires linear and nonlinear programming. My goal is for the modeling to be understandable by any reader, although the solution algorithms are for specialists.

Many of the acronyms used in this book are known to people who work in the subject. Those who are unfamiliar with the acronyms will find them defined at the end of the book and detailed explanations in the main text.

This book is aimed at marketing, sales, technical, and operations professionals working with mobile operators or *application service providers* (ASPs) as well as consultants. They will understand the business, billing, and very detailed technical issues associated with SMS and MMS interworking, that is, with the exchange of SMS and MMS among all of the world's mobile operators as well as with content providers. The book will also be useful to SMSC and *multimedia messaging center* (MMSC) manufacturers, because it provides a global view of interworking that they can integrate into their designs.

The text of this book has been used for teaching nonengineer, business graduates and engineering students without difficulty, including its worked-out examples and exercises.

Those who do not have a second-year college level in mathematics can skip the appendixes on the location-based methods (Chapter 13) and the second part of Chapter 15, which is on computation of numbering plans. To understand Chapter 10 (optimal routing algorithms in SMS/MMS interworking networks), you must have studied graph theory and linear/nonlinear programming.

Throughout the book, we assume that the reader has a basic knowledge of graph theory vocabulary, which is common now in many courses. The rest is self-contained including the necessary explanations of the SS7 network (the packet-based network used to exchange data between mobile operators).

Contents