THIRD EDITION

GONZALO CAMARILLO
MIGUEL A. GARCÍA-MARTÍN

THE 3G IP MULTIMEDIA SUBSYSTEM (IMS)

MERGING THE INTERNET AND THE CELLULAR WORLDS

WILEY

The 3G IP Multimedia Subsystem (IMS)

Merging the Internet and the Cellular Worlds

Third Edition

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The 3G IP Multimedia Subsystem (IMS)

To my parents, Anselmo and Isabel; my brothers, Alvaro, Daniel, and Ignacio; and Viviana. They all are a source of energy and motivation in everything I do.

Gonzalo

To my daughter Maria Elizabeth, who was born at the time I started writing this book – she is the sunshine of my life; my wife Jelena, who provided me with all the support and love I needed; my parents, José and Mari-Luz, my aunt Feli, my brother Javier José who, through the distance, encouraged and supported me during this project.

Miguel Angel

Foreword by Stephen Hayes

3GPP, or the Third Generation Partnership Project, was formed in late 1998 to specify the evolution of GSM into a third generation cellular system. Although much focus was placed on new higher bandwidth radio access methods, it was realized that the network infrastructure must also evolve in order to provide the rich services capable of taking advantage of higher bandwidths. The original GSM network infrastructure was very much circuit- and voice-centric. Although data capabilities were added over time the system retained much of its circuit-switched heritage and its inherent limitations. A new approach was needed.

IMS, or the IP Multimedia Subsystem, represented that new approach. The development of IMS was very much a collaborative effort between the leading cellular standards organization (3GPP) and the leading Internet standards organization (IETF). IETF provided the base technology and protocol specifications, while 3GPP developed the architectural framework and protocol integration required to provide the capabilities expected of a world-class mobile system, such as inter-operator roaming, differentiated QoS, and robust charging.

Since the initial specification of IMS, IMS has been adopted by 3GPP2 (the other major cellular standards organization) and it is the leading contender as the base of the ITU work on Next Generation Networks. In the upcoming decades an understanding of IMS will be as important and fundamental for the well-rounded telecom engineer as ISUP knowledge was in previous decades.

IMS is a system. It is designed to provide robust multimedia services across roaming boundaries and over diverse access technologies. To understand IMS, you must understand the underlying protocols and how IMS uses them within its architectural framework. This book facilitates that understanding by explaining first the underlying protocols, such as SIP, and then explaining how IMS makes use of those protocols. This approach allows the user to easily grasp the complex relationship between the protocols and entities as developed in the IETF and their usage and extensions as defined in IMS.

The two authors are uniquely qualified to explain not just the inner workings of IMS but also the rationale and tradeoffs behind the various design choices. Miguel Angel García-Martín was and still is a key contributor within 3GPP. He was one of the principal designers of IMS and authored the initial protocol requirements draft as well as other 3GPP-specific SIP drafts and RFCs. Gonzalo Camarillo was similarly a key contributor within IETF, where he is currently a SIPPING WG co-chair. He has written many RFCs that are key components of IMS. Both authors have been involved with IMS since its inception and do a good job of explaining not only what IMS is but also how it came to be.

Stephen Hayes
Chair – 3GPP Core Network

Foreword by Allison Mankin and Jon Peterson

The Session Initiation Protocol (SIP) is one of the most active initiatives underway in the Internet Engineering Task Force (IETF) today. While the IETF has standardized a number of Internet applications that have turned out to be quite successful (notably, email and the web), few efforts in the IETF have been as ambitious as SIP. Unlike previous attempts to bring telephony over the Internet, which relied extensively on the existing protocols and operational models of the Public Switched Telephone Network (PSTN), SIP elected to use the best parts of email and web technology as its building blocks, and to construct a framework for establishing real-time communication – be it voice, video, instant messaging, or what have you – that is truly native to the Internet.

SIP is a rendezvous protocol – a protocol that allows endpoints on the Internet to discover one another and negotiate the characteristics of a session they would like to share. It converges on the best way for users to communicate, given their preferences, and the capabilities of devices they have at their disposal. Even though it establishes sessions over numerous communications media, it allows policies and services to be provided at the rendezvous level, which greatly simplifies the way end-users and operators manage their needs.

This approach has garnered the attention of almost all of the major vendors and service providers interested in telephony today. But the adoption of SIP by 3GPP has been a special, definitive success for SIP in the global marketplace. 3GPP promises to place SIP firmly in the hands of millions of consumers worldwide, ushering in a whole new paradigm of Internet-based mobile multimedia communications. The IP Multimedia Subsystem (IMS) of 3GPP is the core of this strategy, and it is a SIP-based core.

The IETF has created and continues to develop SIP, and the other protocols for real-time communication and infrastructure: RTP, SDP, DNS, Diameter,... As 3GPP builds its successive IMS releases, towards a SIP-based multimedia Internet, IETF and 3GPP have grown into a close, working partnership, initiated by our liaison (RFC3113). Both committed to the Internet style afforded by SIP, two worlds with very different perspectives, the 3GPP world of mobile wireless telephony, and the IETF world of the packet Internet, have learned each other's considerations. There remain some differences, in the security models, in some aspects of network control. It's a tribute to the communications, the design work, and not least, to work by the authors of the present volume, that such differences have nonetheless resulted in interoperable SIP, SIP with a coherent character.

Gonzalo Camarillo has been one of the protagonists in SIP's development. In addition to his work editing the core SIP specification (RFC3261) within the IETF, Gonzalo has

chaired the SIPPING Working Group of the IETF (which studies new applications of SIP) and authored numerous documents related to interworking SIP with the traditional telephone network, ensuring that SIP is IPv6 compliant, and using SIP in a wireless context.

Miguel A. García-Martín is one of the principal designers of the IMS, and has also somehow found the time to be one of the main voices for 3GPP within the IETF SIP community. The application of SIP to the mobile handset domain gave rise to numerous new requirements for SIP functionality, many of which would not be obvious to designers unfamiliar with the intricacies of wireless roaming, bandwidth constraints, and so on. As such, Miguel provided some very valuable guidance to the IETF which ensured that SIP is well-tooled to one of its most promising applications.

This book is a milestone presenting the first in-depth coverage of the 3GPP SIP architecture. It is difficult to overestimate the importance of the 3GPP deployment, and this book will position readers to participate in the engineering of that network.

Allison Mankin
Jon Peterson
Directors of the Transport Area of the IETF

About the Authors

Gonzalo Camarillo

Gonzalo Camarillo leads the Multimedia Signaling Research Laboratory of Ericsson in Helsinki, Finland. He is an active participant in the IETF, where he has authored and co-authored several specifications used in the IMS. In particular, he is a co-author of the main SIP specification, RFC 3261. Gonzalo is a member of the IAB (Internet Architecture Board) and the IETF liaison manager to 3GPP. In addition, he co-chairs the IETF SIPPING working group, which handles the requirements from 3GPP and 3GPP2 related to SIP, and the IETF HIP (Host Identity Protocol) working group, which deals with lower-layer mobility and security. He is the Ericsson representative in the SIP Forum and is a regular speaker at different industry conferences. During his stay as a visitor researcher at Columbia University in New York, USA, he published a book entitled "SIP Demystified". Gonzalo received an M.Sc. degree in Electrical Engineering from Universidad Politecnica de Madrid, Spain, and another M.Sc. degree (also in Electrical Engineering) from the Royal Institute of Technology in Stockholm, Sweden. He is currently continuing his studies as a Ph.D. candidate at Helsinki University of Technology, in Finland.

Miguel A. García-Martín

Miguel A. García-Martín is a System Expert of Ericsson in Madrid, Spain. In the past he has been a Senior Standardization Specialist in the Industry Environment unit of Nokia Siemens Networks in Espoo, Finland and a Principal Research Engineer in the Networking Technologies Laboratory of Nokia Research Center in Helsinki, Finland. Before joining Nokia, Miguel held several positions with Ericsson Finland and Ericsson Spain related to the development of IMS. Miguel is an active participant of the IETF, and for a number of years has been a key contributor in 3GPP. For some time he has also been participating in the specification of NGN in ETSI. In the IETF, he has authored and co-authored several specifications related to the IMS. In 3GPP, he has been a key contributor to the development of the IMS standard. Miguel is also a regular speaker at different industry conferences. Miguel received a B. Eng. degree in Telecommunications Engineering from Universidad de Valladolid, Spain.

Preface to the Third Edition

When 3GPP started standardizing the IMS a few years ago, most analysts expected the number of IMS deployments to grow dramatically as soon the initial IMS specifications were ready (3GPP Release 5 was functionally frozen in the first half of 2002 and completed shortly after that). While those predictions have proven to be too aggressive owing to a number of upheavals hitting the ICT (Information and Communications Technologies) sector, we are now seeing more and more commercial IMS-based service offerings in the market. At the time of writing (May 2008), there are over 30 commercial IMS networks running live traffic, adding up to over 10 million IMS users around the world; the IMS is being deployed globally. In addition, there are plenty of ongoing market activities; it is estimated that over 130 IMS contracts have been awarded to all IMS manufacturers. The number of IMS users will grow substantially as these awarded contracts are launched commercially. At the same time, the number of IMS users in presently deployed networks is steadily increasing as new services are introduced and operators running these networks migrate their non-IMS users to their IMS networks.

On the terminal side, estimations indicate that more than 100 million mobile terminals with support for at least one IMS service will be shipped in 2008. In addition, the fixed version of IMS has made a big effort to be compatible with any standard off-the-shelf SIP-based phone, making the number of available fixed terminals suitable for IMS close to unlimited.

The most common applications running on IMS commercial deployments are IP telephony in fixed and mobile networks, IP centrex, messaging (including text, pictures, and videos), Push-to-talk, video sharing, and presence. However, there is much ongoing work on additional IMS applications. In particular, applications involving machine-to-machine communications (e.g., in sensor networks) are getting much attention. At present, most of the already deployed IMS networks run a specific service instead of using the IMS as the service delivery platform, as the IMS was once envisioned. We expect the market to evolve towards multi-service IMS networks in the following years.

When it comes to current standardization activities in the IMS area, the most relevant activities have to do with multi-access networks. Current IMS networks provide service to endpoints that use several different types of fixed and mobile access technologies, such as WCDMA, WLAN, ADSL and PacketCable. In order to have all these different accesses seemlessly integrated in the IMS architecture, there is still some work to be done to coordinate the specifications coming from 3GPP, 3GPP2, TISPAN, and PacketCable. In the past, there have been a few overlaps between specifications from different organizations. The idea is to minimize those overlaps by clarifying which parts of the architecture each organization should be working on. Additional standardization work includes simplifications of the IMS

architecture and the development of new extensions to implement new services or provide new functionality.

The third edition of this book includes a great deal of new material. We have added new chapters discussing emergency calls, service configuration (XCAP and OMA XDM 2.0), conferencing, and Voice Call Continuity (VCC). We have updated the description of the PCC (Policy and Charging Control) architecture to 3GPP Release 7, OMA Presence 2.0, and PoC (Push-to-talk over Cellular) to OMA PoC 2.0. We have added detailed flow descriptions to each multimedia telephony service (or PSTN/ISDN simulation services). We have included discussions on GRUUs (Globally Routable User agent URIs) and their use in the IMS. We have described new NAT traversal techniques such as ICE (Interactive Connectivity Establishment), protocols such as STUN and TURN, and how they apply to the IMS. We have introduced new service and application identification concepts such as ICSI (IMS Communication Services Identification) and IARI (IMS Application Reference Identifier). We have included a description of combinational services. The Security in the IMS chapter has been updated with HTTP Digest Access Authentication and TLS, Early IMS Security Solution, NASS-IMS bundled authentication, and TLS for Network Security. The Instant Messaging on the Internet chapter now discusses the 'isComposing' feature, MESSAGE URI-list services, chat rooms, and file transfer operations with SIP and SDP.

Based on feedback from instructors and lecturers, we have also improved the companion website to this book. We have made all the figures of this book available to our readers in a high-quality format, so that they can be easily imported to slide shows and presentations. Please refer to the companion web site at:

http://www.wiley.com/go/camarillo

Overall, we have put a considerable amount of effort into updating the book and creating this third edition. We hope our readers find the new material interesting and easy to understand, and continue finding the book a valuable reference on the IMS and its related Internet technologies.

Preface to the Second Edition

The pace at which new IMS-related technologies have been developed in the last year has been impressive. Based on the deployment experiences of their members and on feedback from several organizations, 3GPP and 3GPP2 have worked extensively to update the IMS architecture so that it supports a wide range of new services.

While many of these updates consist of extensions to provide more functionality, some of them consist of simplifications to the IMS architecture. These simplifications make the IMS architecture more robust and reliable, or increase the performance of services implemented on top of it.

Examples of organizations that provide feedback to 3GPP and 3GPP2 on how to evolve the IMS are the OMA (Open Mobile Alliance) and the standardization bodies involved in the developing of NGN (Next Generation Networks). These organizations use the IMS as a base to provide different types of services.

The second edition of this book, in addition to describing updates to the IMS architecture, includes extensive discussions on the NGN architecture and the services it provides, and on the OMA PoC (Push-to-talk over Cellular) service. We are confident that the reader will find the chapters on these IMS-based services useful.

From the feedback received on the first edition, it seems that many readers found the structure of the book novel and useful. Readers agreed that first describing how a technology works on the Internet before discussing how it applies to the IMS provides a wider perspective than studying the technology in the IMS context alone.

Of course, we have also updated the sections dealing with Internet technologies. These sections include some of the latest protocol extensions developed in the IETF.

Based on the feedback received during the IMS seminars we have given around the world, we have clarified those concepts which were difficult to understand in the first edition.

Finally, also new to the second edition is a companion website on which instructors and lecturers can find electronic versions of the figures. Please go to

http://www.wiley.com/go/camarillo

Preface to the First Edition

The IMS (IP Multimedia Subsystem) is the technology that will merge the Internet with the cellular world. It will make Internet technologies, such as the web, email, instant messaging, presence, and videoconferencing available nearly everywhere. We have written this book to help engineers, programmers, business managers, marketing representatives, and technically aware users understand how the IMS works and the business model behind it.

We have distributed the topics in this book into four parts: an introduction, the signaling plane in the IMS, the media plane in the IMS, and IMS service examples. All four parts follow a similar structure; they provide both Internet and IMS perspectives on each topic.

First, we describe how each technology works on the Internet. Then, we see how the same technology is adapted to work in the IMS. Following these two steps for each technology provides the reader with a wider perspective. So, this book is not a commented version of the IMS specifications. It covers a much broader field.

Reading this book will improve anyone's understanding of the Internet technologies used in the IMS. You will know how each technology is used on the Internet and which modifications are needed to make it work in the IMS. This way you will understand how the use of Internet technologies in the IMS will make it easy to take advantage of any current and future Internet service. Finally, you will appreciate how operators can reduce the operational cost of providing new services.

Engineers who are already familiar with the IMS or with any of the IMS-related Internet protocols will also benefit substantially from this book. This way, engineers from the IETF (Internet Engineering Task Force) will understand which special characteristics of the IMS makes it necessary to add or remove certain features from a few Internet protocols so that they can be used in the IMS. On the other hand, engineers from 3GPP (Third Generation Partnership Project) and 3GPP2 will gain a wider perspective on IMS technologies. In addition, any engineer who focuses on a specific technology will gain a better understanding of the system as a whole.

Readers who want to expand their knowledge of any particular topic will find multiple references to 3GPP and 3GPP2 specifications, ITU recommendations, and IETF RFCs and Internet-Drafts in the text. Moreover, Appendix A contains a list with all the 3GPP and 3GPP2 specifications that are relevant to the IMS.

Now, let us look at each part of this book. Part I provides an introduction to the IMS: its goals, its history, and its architecture. We highlight the gains the operators obtain from the IMS. Besides, we discuss what the user can expect from the IMS. In addition, we describe how existing services, such as GPRS, WAP, SMS, MMS, and video-telephony over circuits relate to the IMS.

Part II deals with the signaling plane of the IMS, which includes protocols, such as SIP (Session Initiation Protocol), SDP (Session Description Protocol), Diameter, IPsec, and

COPS (Common Open Policy Service). As we said earlier, we describe each protocol as it is used on the Internet and, then, as it is used in the IMS.

Part III describes the media plane of the IMS. We describe how to convert audio and video into a digital form and how to transport it using protocols, such as RTP (Real-Time Transport Protocol) and RTCP (RTP Control Protocol). Furthermore, we introduce Internet protocols such as DCCP (Datagram Congestion Control Protocol) and SRTP (Secure RTP) that are not currently used in the IMS, but might be in the future.

Finally, Part IV provides IMS service examples, such as presence, instant messaging, and Push-to-talk. These examples illustrate how to build meaningful services using the technologies described in Parts II and III.

Essentially, this book is useful to a wide range of technical and business professionals because it provides a thorough overview of the IMS and its related technologies.

Acknowledgements

Without the encouragement we received from Stephen Hayes we would not have written this book. He was the first to see the need for a book on the IMS that provided the IETF perspective in addition to the 3GPP and 3GPP2 perspectives. In addition, he and Allison Mankin did an outstanding job coordinating the IMS standardization from 3GPP and from the IETF, respectively.

Once we decided, pushed by Stephen, to start writing this book, our management in Ericsson Finland fully supported us in this endeavor. In particular, Stefan Von Schantz, Christian Engblom, Jussi Haapakangas, Rolf Svanback, and Markku Korpi understood from the beginning the importance of the IMS and of spreading knowledge about it.

Our technical reviewers helped us fix technical errors in early versions of the manuscript. Andrew Allen provided useful comments on the whole manuscript. Harri Hakala, Arto Mahkonen, Miguel Angel Pallares, Janne Suotula, Vesa Torvinen, Magnus Westerlund, Brian Williams, Oscar Novo, Jari Urpalainen, Joël Repiquet, Mari Melander, Hannes Tschofenig, Javier Pastor, Jan Holm, Ari Keränen, and Vesa Lehtovirta provided suggestions on different parts of the book. Takuya Sawada and Takuya Kashima performed a thorough review of the manuscript during its translation to Japanese. Anna Reiter provided guidance on language and writing style.

Our editor at John Wiley & Sons, Ltd, Mark Hammond, believed in this book from day one and supported us at every moment.

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