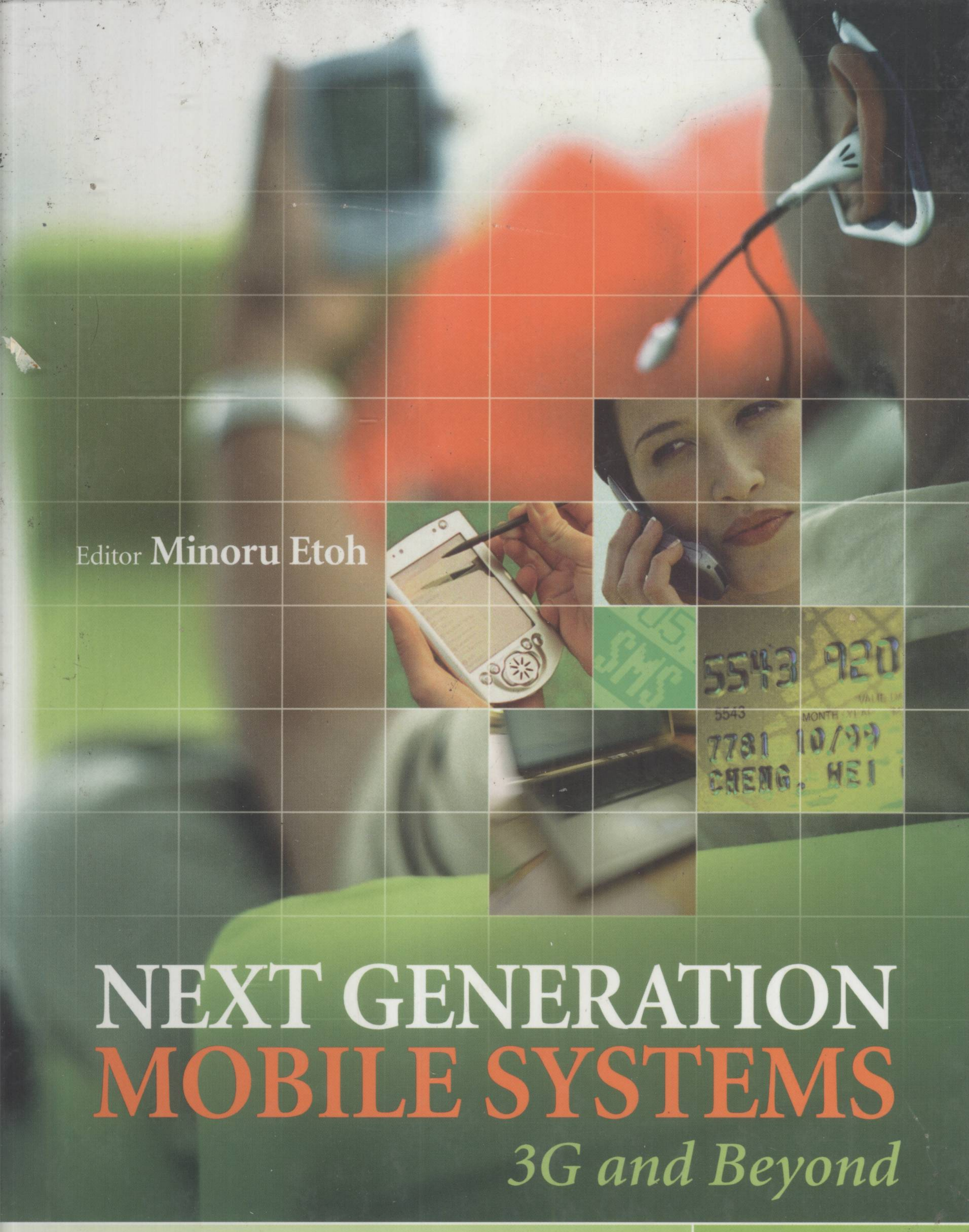

Editor **Minoru Etoh**

# NEXT GENERATION MOBILE SYSTEMS

## *3G and Beyond*

WILEY

# Next Generation Mobile Systems 3G and Beyond

Edited by

**Minoru Etoh**

*DoCoMo Communications Laboratories USA*

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# Next Generation Mobile Systems 3G and Beyond

*To all the people who are collaborating with us*

# Foreword

Thoughts on the XG system

The growth of the Internet, which I have been involved in, and the growth of mobile telephone services, which NTT DoCoMo has been a leader in, have been peculiarly interlinked and at the same time separate. The Internet is a lab experiment that broke free, and finds itself in a world of its own contriving, which it often does not understand. The mobile telephone world was developed for commercial purposes, and is in many respects the son of its father, the wired telephone system. Each seeks to bring innovative services to its users.

The two intertwine in interesting ways. Research done in the 1990s developed a way for Internet end systems to break free of their wired moorings, resulting in what we call IP Mobility, mobility in the Internet layer. Two logical users of this soon developed: the nomadic laptop driving down the street might connect to a wireless LAN, and the mobile telephone that acquired services reminiscent of that same laptop.

Both move, and both have a need to be able to participate in peer-to-peer sessions, but they serve different needs. The laptop is, in the final analysis, something we use because its screen size and general ubiquity make it a reasonable replacement for the desk-mounted system left behind, but we would not think of it as a personal communications device. If nothing else, if I attach mine to my belt, it will soon either be damaged itself or damage my belt. The mobile telephone fits my belt well, and is very appropriate as a personal communications device. But if I were to try to write these thoughts on my telephone, I would soon go crazy. The instrument is not suited to the application. Both do electronic mail, but one is for megabyte attachments and the other for pithy messages or instant messaging. Both do calendaring, but one easily lets me see a month at a glance, while the other is more suited to managing my day. They are tools, both of them, suited to their own uses, and using in many respects common technology.

The development of mobility has worked its way back into the wired Internet in interesting ways. As we develop and deploy the concepts of Anycast Routing, in which a set of computers collaborate to offer a service, and I use Internet routing to attach to whichever happens to be closest at the moment, IP Mobility solves a problem for a stationary system. If I open a TCP connection to the nearest computer in an Anycast service, and then either I move or routing changes, I might find myself talking to another server without warning. Since the state I shared with the first is unknown to the second, I lose everything I have done to that point and must start over. But, if I treat the Anycast address as the Home Address of a mobile node and then use Optimized Routing to tie the mobile session to the particular server as a Care-of Address, my session remains stable even as routing changes. Treating the stationary node as a mobile node solves a difficult application problem.

To understand the network, one must, I think, grasp it at many layers simultaneously. One must understand the implications of the transmission layers, physical and link, and the intranetworking layer that builds a network of like systems under a common administration. One must go on to understand how these intranets interconnect at the Internet layer, and how various transports use them and respond to their anomalies. In the end, one must understand and be prepared to deal with the requirements of the application and the user who uses it. This is true because, in the end, the networked device, and the user, looks no further than the application concerned. The network must make that application work well for the user, or find another reason to exist.

I found myself, recently, thinking of ways to use the wired, wireless, and mobile Internets together. In December 2004, a tsunami swept hundreds of thousands of people – we may never really know how many – to their deaths, and the Internet community asked "how might we have helped?" The answer turns out to use interesting aspects of both types of communication systems. A Tsunami Warning Center, had one existed (as one does in the mid-Pacific) in the Indian Ocean, might have encoded a message using the Common Alerting Protocol, which is an information model for agency-to-agency distributions regarding disasters. They would have sent this message in any number of ways to subscribing centers run by appropriate authorities in various countries. Many of those would be by Internet – the web, RSS feeds, authenticated electronic mail, and so on. These centers would then consider what areas are likely to be affected, the level of urgency, certainty, and severity, and what the appropriate message might be, and then sent the message on to citizens likely to be affected. An obvious way to locate the people in a locality is to ask if their mobile telephone is registered in the cell in the locality. An obvious way to get their attention is to call each such registered telephone with a voice message, or to send a text message using cell broadcast, as is available in GSM and being deployed in Europe. The Internet and the mobile telephone system each are then used to distribute a message from a regional center through a crisis management agency, and finally to a person sleeping on the beach or in the projected path of a storm.

The authors collaborating on this work have tried to step aside from the marketing terminology of "next generation", to think about what kinds of systems they would really like to deploy, and why they would deploy them. To their credit, they have not thought of their system as taking over the world, as many in our industry do when they dream up new technologies. It is enough to find one's place in the world and serve a targeted set of needs well. In this book, they have explored the kinds of applications that will adapt well to a personal communication device. They have considered the kinds of transports these applications will use, how they interact with the rest of the Internet, and how they interact with the peculiar transmission systems – radios of various kinds – used in the mobile telephone world, and the aspects and algorithms of mobility that enhance that experience.

They point us in an interesting direction. And for that, I thank them.

Fred Baker
*Cisco Fellow, California*

# Preface

The aim of this book is not to describe new wireless access technologies that will replace the third generation (3G) technologies, but to describe a complete ecosystem of technologies, including access technologies that will be essential for the development of a new mobile environment beyond the 3G era. The mobile applications currently envisioned for this future platform will be augmented by others that will arise because of the innovative opportunities offered by the new environment, and will change the nature of the mobile communications business.

Daily life is becoming increasingly dependent on mobile communication. This trend began with the first mass uptake of cellular telephones in the mid-1980s and continues with evermore diverse services being offered by a growing number of operators., There is every indication that this trend will continue and even accelerate as networks become more powerful and devices become more ubiquitous.

Throughout the evolution of the mobile network industry, mobile networks have been nominally characterized by the generation of their wireless access technology. At the time of publishing, year 2005, it is commonly accepted that there have been three generations of wireless technology, called 1G, 2G, and 3G.

The third generation was officially launched by NTT DoCoMo, Inc. in October 2001, and is, in effect, the "current generation," although we are early in this generation's predicted life cycle. Third-generation wireless technology is well defined, and devices that use 3G technology are entering, and even becoming commonplace in, the market.

Wireless connectivity, simple speech services, and computing devices are becoming commodities. The user community now demands evermore powerful functionality and continuously improving applications. This new and more sophisticated user demand is driving the research community to look toward the future of wireless networks. As a result, mobile communication researchers are starting to focus on the technology required for the next generation of mobile systems. This new focus creates a need for the research community to begin a dialogue about the future of mobile networks and communications. Throughout this book, we use the term "Next-generation (XG) mobile systems" to describe a complete mobile communication system beyond 3G that includes the whole technology "value chain" of future wireless networks. Our definition of XG is complex and inclusive, from future heterogeneous service platforms to the core network and from the heterogeneous access network to the user terminals. On the other hand, the term "Fourth Generation" (4G) mostly implies the fourth-generation radio access networks (RAN). The technologies required to realize XG systems are clearly not limited to new wireless access methods, as is sometimes proposed. We must pay attention to a wide range of emerging and existing research topics such as IP backbone networks, open and heterogeneous service platforms, terminal software, and multimedia applications. It is our belief that these technologies will be implemented and will evolve continuously, rather than suddenly, supplanting 3G technology in a revolutionary way. In this sense, although the next generation can be seen as a logical evolution of 3G, the XG image is very different and will require breakthrough technologies in many diverse areas. We firmly believe that the future mobile world will not be defined only by new wireless access technologies. We propose a clear distinction between two terms: the 4G Radio Access Network (RAN) and the XG mobile system. The 4G RAN part is clearly an important component of XG mobile systems, but it is insufficient to define it. We will discuss some existing and emerging technologies that we think are necessary for our definition of Next Generation in this book.

NTT DoCoMo, Inc. has created a research lab specifically to work on next-generation mobile system technology issues and to help lead the community in these discussions. The company believes that it is timely and in the best interests of the whole industry to share our vision of the future of the wireless networking industry, and the technologies required to define the industry beyond the current third generation.

This book examines the issues that are currently driving technology development in the wireless world. It surveys the technologies that are, in our opinion, most likely to become part of the foundation for mobile systems in the post 3G era.

Each chapter covers a different technology area. The current technology base is summarized, and the demands for new functionality and how these demands stress current 3G systems is discussed. Where appropriate, we employ existing standards as a tool to describe the current status of the industry, and emerging standards as a tool to anticipate the medium-term future. Emerging standards provide a comprehensive and commercially neutral indication of the most likely direction of mobile systems in the medium term (five to six years). Finally, current research is presented, including discussions about DoCoMo Labs USA group's research into future XG mobile system architectures.

**A Note on Terminology:** The world of future wireless networking systems is dogged by misunderstanding due to the confusing terminology that unfortunately must be used. The difficulties arise because the same terms have different meanings depending on which side of the Pacific or Atlantic you happen to be on. In this book, we use the following terms with the following meanings.

**Next-generation mobile system.** This refers to the whole (beyond 3G) mobile communication system in its entirety, including the whole technology "value chain" of the wireless ecosystem from the service platform, through the core and access networks to the user terminal and applications.

**Next-generation mobile network.** This refers to a subset of the "Next-generation Mobile System" defined above. The Next-generation Mobile Network includes the core network and radio access networks only. Please note that in keeping with established industry practice the shorthand "XG" may be substituted for the term "Next Generation".

**4G radio access network (or 4GRAN).** This refers specifically to the radio access network in the “Next-generation Mobile System”. This is the radio/wireless network connecting the user terminal to the edge of the core network.

**4G Wireless access technology.** This is a reference to the technology employed in the 4GRAN and may occasionally be used in the same context as 4GRAN.

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# List of Contributors

**Frank Bossen, Wai Chu, David Espinosa, Minoru Etoh, Xia Gao, Craig Gentry, Nayeem Islam, Ravi Jain, Moo Ryong Jeong, Toshiro Kawahara, James Kempf, Khosrow Lashkari, Ged Powell, Zulfikar Ramzan, Manuel Roman, Muhammad Mukarram Bin Tariq, Fujio Watanabe, Dong Zhou**, 181 Metro Drive, Suite 300, San Jose, California 95110, USA

**Xiaoning He**, xiaoning@parawireless.com

**Henry Song**, cs_yus@yahoo.com

**Gang Wu**, wu@parawireless.com

**Alper E. Yegin**, Alper.Yegin@Samsung.com

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