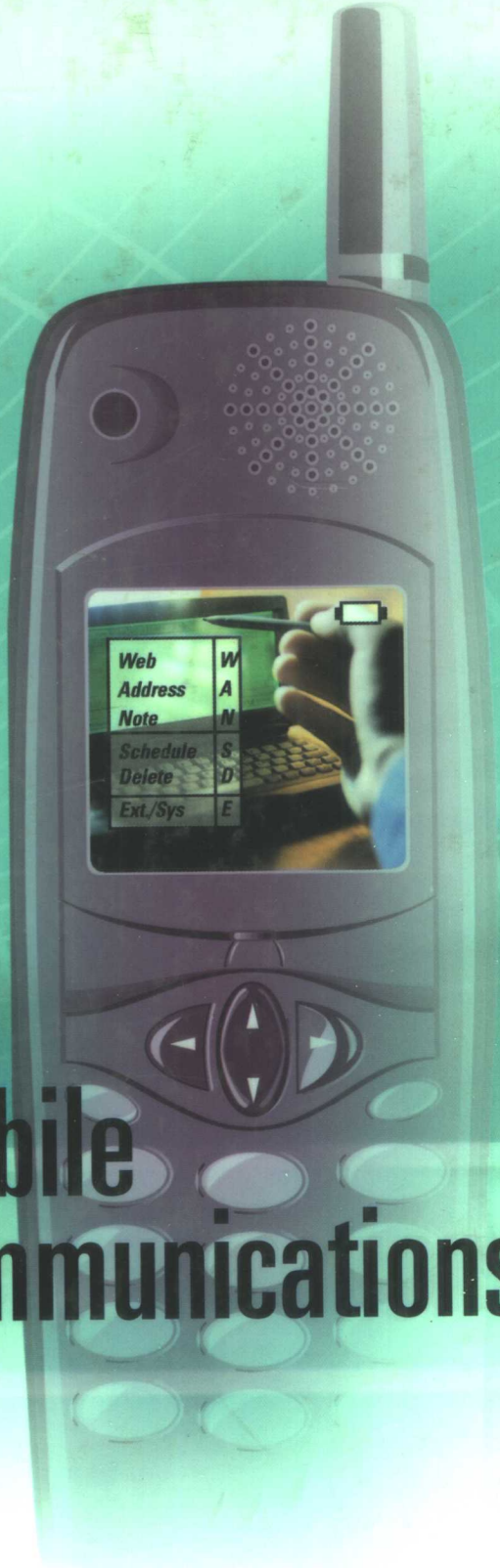
mobile communications series

Juha Korhonen

# introduction to 3G mobile communications



# Introduction to 3G Mobile Communications

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# Preface

The third-generation mobile communication system, or 3G as it is known, is the next big thing in the world of mobile telecommunications. The first generation included analog mobile phones (e.g., TACS, NMT, and AMPS); the second generation, digital mobile phones (e.g., GSM, PDC, and D-AMPS). The third generation will bring digital multimedia handsets with high data-transmission rates, capable of providing much more than basic voice calls.

This book was written to provide the reader with an information source that explains the principles and basic concepts of the most important of the 3G telecommunications systems—UMTS or 3GPP—in an easily understandable form. Some comparative information on the other 3G systems (cdma2000 and UWC-136) appears in the early sections of the text. But the UMTS/WCDMA version of 3G is the largest and most important of the 3G initiatives, and it is the primary subject of the book. All the significant 3G versions serve to protect their corresponding 2G system investments. Since UMTS/WCDMA is a GSM extension, and 2G is mostly about GSM (not CDMA or TDMA), UMTS plays a key role in 3G.

Numerous research papers and technical specifications about 3G are available, but these are generally quite difficult to understand, especially if the reader does not have substantial experience in telecommunication engineering. A typical specification contains exact rules on how a certain technical feature will be implemented. It does not explain why it is implemented in a certain way, nor does it tell us how this feature fits into the big picture; that is, into the entire 3G system. In this book I have deciphered that information, added my own analysis about the subject, and provided it to the reader in plain English. The result is an entry-level introduction to 3G, with an emphasis on the

3GPP-specified FDD mode system, which will most probably be the most widely used 3G system.

It is not the intention of this book to go into great detail. 3G is a broad subject, and it would be impossible to provide a detailed analysis of every aspect in one volume. Instead, the basics are discussed and references to other information sources provided, so that interested readers can study specific subjects in more depth if they so wish. The Internet is also a very good information source where telecommunications is concerned, and the references include appropriate Web addresses.

I have also tried to avoid mathematics as much as possible in this book. I have found that mathematics most often prevents rather than furthers an understanding of a new subject. A theoretical approach is generally useful only when a topic is analyzed in depth.

The book starts with an overview of mobile communication systems. The history is briefly discussed, because an understanding of the past aids in the development of an understanding of the present. The second-generation systems are briefly introduced here, then the various proposals for 3G technology are explained. There are several different standards below the 3G banner, and these are also discussed in the opening chapter.

Most 3G networks will be based on the wideband CDMA (WCDMA) air interface, and thus a crash course on CDMA principles is given in Chapter 2. TDMA was the most popular technology in 2G systems, and this chapter concentrates especially on the differences between the CDMA and TDMA systems. Thus a reader already familiar with 2G TDMA (especially GSM) systems will get intensive instruction on this new generation.

The wideband CDMA (as specified by 3GPP) air interface is an important component of the 3G system and it is discussed in several chapters. We start with a general physical-layer presentation in Chapter 3, followed by a more detailed discussion about some special physical-layer issues, such as modulation techniques (Chapter 4), spreading codes (Chapter 5), and channel coding (Chapter 6).

WCDMA air interface protocol stack (layer 2 and 3 tasks) is discussed in Chapter 7. The most important functions of these protocols are explained briefly. What is new here are the access stratum (AS) protocols, or protocols specific to the WCDMA air interface. They include the layer 2 protocols, and the lower end of layer 3. The upper end of layer 3 forms the non-access stratum (NAS), which is more or less a replica of GSM/GPRS systems.

The network (both the radio access and the core network) is discussed in three chapters. Chapter 8 covers the architecture of the network. Network planning and network management are both difficult arts, and they are discussed in Chapters 9 and 10, respectively.

Chapter 11 presents the most common signaling procedures of the 3G system. Signaling flow diagrams are given for each procedure, as this is the most efficient way to describe the functionality. Again, it is impossible to include all signaling procedures in a work of this scope, but the cases discussed comprise the most common and interesting scenarios.

Chapter 12 contains a selection of new and interesting concepts in the 3G system. The list of issues handled here is by no means exhaustive, but I have tried to choose those concepts that cannot be found in the current 2G systems and that are likely to raise questions in the mind of the reader. Note that the core network to be used in most 3G networks is an evolved GSM/GPRS core network, and thus many of these concepts can also be used in the future GSM networks.

3G services and applications are discussed in Chapters 13 and 14, respectively, although these are closely related subjects. Applications are very important for every communication system, and especially for the 3G. They are the reason consumers buy handsets and consume services. Without good applications, even the most advanced and technically superior telecommunication system is useless. In 3G systems many of the applications will be totally new; they will not have been used or tested in any other system. Finding the right application and service palette will be important as well as challenging for operators and service providers.

In Chapter 15 we take a look into the future and try to see what comes after the 3G as we know it today. Foretelling is always difficult, and foretelling the future of telecommunications technology is even more so. This chapter tries to predict what kind of telecommunication systems and services we will be using in the year 2010. The development cycle of a new mobile telecommunication system is around ten years. The development work of UMTS (3G) began in the beginning of the 1990s, and the first systems will be launched in 2001-2002. Work toward the 4G has already started, but it will be around the year 2010 before something called the 4G is actually in use.

The book also includes a set of interesting appendices. Among these, standardization organizations and the most important industry groups are presented briefly here. Today, the new systems are most

often developed in industry-driven working groups, and the specifications produced are then accepted by the appropriate official standardization bodies. This practice can produce the specifications at a relatively quick pace, although it may not provide the technically best result, but rather the one that best suits the big names in the industry.

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The person who has suffered most from this book project and who deserves the most thanks is my wife, Anna-Leena. She has had to live with a grumpy old man for the last 12 months. During this time I have spent all my free time, including many long nights, with the manuscript. She has taken it all remarkably well.

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# Contents

CHAPTER 1

# Overview

## 1.1 History of Mobile Cellular Systems

### 1.1.1 First Generation

The first generation of mobile cellular telecommunications systems appeared in the 1980s. The first generation was not the beginning of mobile communications, as there were several mobile radio networks in existence before then, but they were not cellular systems. The capacity of these early networks was much lower than that of cellular networks, and the support for mobility was weaker.

In mobile cellular networks the coverage area is divided into small cells, and thus the same frequencies can be used several times in the network without disturbing interference. This increases the system capacity. The first generation used analog transmission techniques for traffic, which was almost entirely voice. There was no dominant standard but several competing ones. The most successful standards were Nordic Mobile Telephone (NMT), Total Access Communications System (TACS), and Advanced Mobile Phone Service (AMPS). Other standards were often developed and used only in one country, such as C-Netz in West Germany and Radiocomm 2000 in France (see Table 1.1).

NMT was initially used in Scandinavia and adopted in some countries in central and southern Europe. It comes in two variations: NMT-450 and NMT-900. NMT-450 was the older system, using the 450-MHz frequency band. NMT-900 was launched later, and it used the 900-MHz band. NMT offered the possibility of international roaming. Even as late as the latter half of the 1990s, NMT-450 networks