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Wireless Telecommunications Networking with ANSI-41

s e c o n d e d i t i o n

- **ANSI-41 for CDMA and TDMA cellular and PCS networks**
- **Over-the-Air Service Provisioning**
- **Enhanced Emergency Services**
- **Location Services**
- **Wireless Number Portability**

➤ **Randall A. Snyder**

➤ **Michael D. Gallagher**

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Second Edition

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Wireless Mobile Networking with ANSI-41

DEDICATION

From Mike: I would like to dedicate this book to Halina, Samuel, Alexandra, and Kira, our most recent family addition. Thanks for the love.

From Randy: I would like to dedicate this book to my wife, Cecilia, whom I love dearly and to my dog Fred who kept me company while I typed away at the manuscript.

FOREWORD

The wireless phone has gone from a gee-whiz gizmo to a commonplace fact of everyday life. Every one and a quarter seconds, 24 hours a day, 365 days a year, a new wireless subscriber signs on in the United States. This subscriber growth has been driven by two factors: competition and functionality. The wireless industry is the most competitive facility-based segment of all telecommunications. That competition, in turn, has driven technical innovation such as the amazing ability to have a call to your wireless phone number find you thousands of miles away—even if you are in another country.

Behind the tremendous growth in subscribership and functionality of the wireless phone is an underlying technology, known by the unlikely name of IS-41 (now known as ANSI-41). It is the *lingua franca* of the wireless age, the common protocol that underlies many wireless phone's features. The evolution of the ANSI-41 standard has been a critical element behind the majority of the enhancements in the current wireless environment. The fact that we, as consumers, take it for granted is a testament to its success.

This is a book for those who want to understand that *lingua franca* and, thus, understand the underpinning of the wireless revolution. The first decade of the 21st century will be the wireless decade, and a principal backbone technology for that reality is IS-41. Randy Snyder and Mike Gallagher have done a wonderful job in this book of helping us all—whether engineer or simply interested observer—understand one of the engines that will drive the decade.

*Tom Wheeler, President & CEO,
Cellular Telecommunications & Internet Association (CTIA)*

PREFACE

As the wireless industry continues to move forward at lightning speed, so has the development of new technologies and standards to support those technologies. Since the first edition of this book was published in 1997, many, many innovations have occurred. The basic technology standards of IS-41 are still intact; however, additions such as Over-the-Air Service Provisioning, new data services, new subscriber identifiers and a host of feature enhancements warrant an update to this text. Not only that, but since the first edition of this book was published, the IS-41 interim standard has been elevated to a full national standard, now known as *ANSI-41 Revision E*.

Who Should Read This Book

The subject matter of the ANSI-41 national standard for wireless telecommunications has typically fallen into the purview of telecommunications system engineers and equipment software developers only. This book attempts to serve many purposes, the primary one being to expand the understanding of ANSI-41 beyond this select group. For system engineers and software developers, this book can serve as a reference to the ANSI-41 standard, as well as explaining some of the more complex technical features of the standard. For wireless telecommunications technical and marketing managers, as well as executives, this book is intended to also be a learning tool. Although the ANSI-41 standard itself is the focus of the book, there is enough information included about wireless and cellular telecommunications networking to provide a better understanding of wireless network architecture and functionality.

This book is a direct result of our involvement as engineers in the wireless industry participating in the creation of the ANSI-41 standard, as well as many others. The bulk of the material is derived from the ANSI-41 standard itself, however there is valuable information provided to expand one's understanding beyond the standard. Information about the application of ANSI-41 in the real world, deployment strategies,

insights into network architectures and the standards-making process are provided so that this book serves as more than just a reference for a single industry standard. The intent of this book is to provide a comprehensive introduction to ANSI-41, as well as a reference for those already familiar with the protocol.

All standards are open to interpretation and ANSI-41 is no different. Although we have taken part in the development of the ANSI-41 standard and the design of systems that use ANSI-41, the substance of this book reflects our understanding and interpretation of the standard. This understanding certainly should not be taken as a unique view. The ANSI-41 specification and related standards are the primary references for this book and we disclaim any responsibility for any usage of the interpretations described in this book.

Graphical Map of This Book

This book is divided into three parts. The subject matter of each part logically builds on the information presented in the previous part. Part 1 provides an introduction to the concept of wireless telecommunications networking, network architecture, and functions that enable mobility within the telecommunications network. Part 2 provides a full description of ANSI-41 including revisions, operational details and protocol usage with a focus on ANSI-41 Revision E. Part 3 provides ANSI-41 network implementations including network interconnections and practical information about network interoperability, roaming, and related technologies.

A Few Words about Terminology

Terminology can be a major stumbling block in the understanding of technical subject matter, and wireless telecommunications networks are no exception. Seemingly familiar terms develop new meanings and engineers begin to drown in a sea of acronyms. Also, informal usage of synonyms for many of the technical terms can lead to confusion and semantic arguments. This section presents an explanation of some commonly misunderstood and confusing terms that should help with the understanding of this book. Of course, anyone familiar with these terms can still find some ambiguity in our descriptions and definitions; however, it is our intention to clarify some of these semantics, provide distinctions between similar terms and provide a basis for consistent usage within this book.

Part 1**Introduction to Wireless Telecommunications**

Understanding Network Modeling,
Architectures, and Functions

Part 2**ANSI-41 Protocol Described and Explained**

Revisions,
Scenarios, Operations,
Messages, Parameters

Part 3**ANSI-41 Implementation Information**

Network Interoperation,
Roaming Issues,
Network Routing,
Implementation Issues,
Related Technologies

WIRELESS, CELLULAR, PCS, AND MOBILE

These terms can be very confusing based on the context in which they are used. Many standards bodies have vehemently argued the meaning of these terms from a technical, political and commercial perspective. The term *wireless* can encompass nearly any type of communications without the use of wires. Good examples are radio and infrared communications. Cellular systems, personal communications services (PCS), paging, wireless local area networks, and even remote control units are considered to be types of wireless communications.

The terms *cellular* and PCS are used in the U.S. to specifically refer to the current operating wireless telecommunications systems and are the type of systems referred to by ANSI-41. Cellular systems can be considered a subset of wireless communications employing certain unique characteristics, such as high extensible capacity, frequency reuse and

mobility management, that controls communications to and from specific cells. The term cellular is sometimes used politically and commercially to differentiate first generation wireless telecommunications systems from next generation personal communications services systems. Technically, however, many systems considered to be PCS actually do employ cellular technology. This is an important concept. Generally, the terms cellular and PCS simply denote the differences in bandwidth allocated to wireless operating licenses (i.e., cellular in the 800 MHz–900 MHz range and PCS in the 1800 MHz–1900 MHz range). ANSI-41 can support any system based on these cellular technologies and the term wireless often times refers to both cellular and PCS networks.

The term *mobile* is generally used as a synonym to cellular and PCS technology systems. However, many wireless technologies exist that do not support *mobility*. Some of these technologies are known as *fixed wireless systems*. The terms *mobile* and *wireless* are used within this book to refer to systems employing both cellular and cellular-based PCS technologies.

INTERSYSTEM VERSUS INTERNETWORK

The ANSI-41 standard specifies cellular network *intersystem* operations. A system is generally defined as a single mobile switching center (MSC) system and its peripheral functionality (i.e., its associated HLR, VLR, etc.). The term *intersystem* in this context implies operations between MSC systems used to support wireless telecommunications. The term *internetwork* sometimes implies conversion of network messages between non-homogeneous networks.

Operation versus Message An ANSI-41 operation refers to an entire operation process which includes all components of the information exchange used to effect that operation. An ANSI-41 message refers to each specific component of a given operation. For example, the Registration Notification operation consists of the entire information exchange process including the “Registration Notification Invoke” component as well as the “Registration Notification Return Result” component. Each of these components can be considered an individual ANSI-41 message.

Subscriber versus End-user These terms are generally used synonymously. *Subscriber* is used throughout the ANSI-41 specification to mean the end-user of the wireless network services. The subscriber is the human using the mobile station (MS).

FEATURE VERSUS SERVICE

These terms are generally used synonymously. The term service is somewhat all encompassing and represents any function that can be

supported in the wireless network. In the context of ANSI-41, the term feature specifically refers to a specific supplementary service provided to a subscriber, such as call waiting or call forwarding.

CDMA AND TDMA

Code division multiple access (CDMA) and time division multiple access (TDMA) are general categories of digital radio technology. There are many wireless radio standards (both national and international) that are based on these technologies. However, in reference to ANSI-41-based networks, the terms have specific meaning. In this book, CDMA specifically refers to the *ANSI/TIA/EIA-95* family of related standards and TDMA specifically refers to the *ANSI/TIA/EIA-136* family of related standards. The ANSI/TIA/EIA-136 TDMA family of standards is sometimes referred to as digital AMPS or D-AMPS (refer to the Bibliography for these standards).

CCITT VERSUS ITU-T

The original CCITT (International Telegraph and Telephone Consultative Committee) which published the well known *Blue Book* technical standards, officially changed its name to ITU-T (International Telecommunications Union--Telecommunications) in 1993. International standards published from this organization before 1993 carry the name CCITT, while those published after 1992 carry the name ITU-T. The appropriate term is used within this book depending on when the actual standard referred to was published.

CELL

An individual geographic area that is the topological component of a cellular or personal communications services system. The area is defined by the telecommunications coverage of the radio equipment located at the cell site. A *cell sector* is a geographic portion of a cell (typically a third) that is served by directional antennas dividing the coverage area of the original cell. The aggregate of the cell sectors that form an entire cell increases capacity by providing frequency reuse among the sectors. A *cell site* is the physical location of a cell's radio equipment and supporting systems. This term also refers to the equipment located at the cell site.

PROTOCOL

A protocol is simply a set of rules or conventions governing the interactions of processes, applications and components in a communications

system. ANSI-41 is a standard protocol governing the communications among cellular telecommunications network elements.

ANSI-41 PARTS, CHAPTERS, AND SECTIONS

ANSI-41 is one of the few Telecommunications Industry Association (TIA) specifications that is divided into multiple parts (i.e., ANSI-41.1, ANSI-41.2, ANSI-41.3, ANSI-41.4, ANSI-41.5 and ANSI-41.6). These parts are sometimes referred to as chapters. Within each part of ANSI-41 is a Table of Contents where topics are divided into sections (e.g., Section 5.4.3 of Part ANSI-41.3).

REVISION 0

The term *Revision 0* is an informal term used to refer to the initial version of a standard or specification published by the TIA. This revision number is not officially listed as an actual revision number by the TIA. Subsequent revisions to an initial specification are officially denoted as *Revision A*, *Revision B*, *Revision C*, etc. Revision 0 documents carry no revision designator in their title.

1G, 2G, 2.5G, AND 3G

The term *3G* has become quite ubiquitous in the wireless industry. Generally, *1G* or first generation wireless technologies, refers to the original analog cellular telecommunications systems that are still in use today. *2G* or second generation wireless technologies, refers to the evolution of analog to digital cellular and PCS telecommunications systems. *2G* systems include the GSM, TDMA, and CDMA systems operating today. These systems enable a variety of enhanced features and services such as short messages service (SMS), voice privacy, and a host of call features. *2.5G* wireless technologies refer to enhanced digital data capabilities that are interim technologies toward the evolution to full *3G* wireless technology services. Examples of *2.5G* services are the general packet radio service (GPRS) for GSM and TDMA systems, and enhanced high-speed data services for CDMA systems. *3G* or third generation wireless technologies, refers to the newest generation of digital wireless telecommunications services being standardized today. The International Telecommunications Union (ITU) is standardizing *3G* technology as IMT-2000. Characteristics of these networks include true broadband data, multi-media messaging, and a new paradigm for the deployment of wireless data and telecommunications services.

Michael D. Gallagher
Randall A. Snyder

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