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Handbook of RF & Wireless Technologies

Farid Dowla, Editor

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HANDBOOK OF RF AND WIRELESS TECHNOLOGIES

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PREFACE

This handbook is focused on one of the most rapidly growing areas of modern-day communications—radio frequency (RF) and wireless communications. It is intended for a broad range of readers. Indeed, RF and wireless communications is an extensive multidisciplinary field, one that includes many diverse subjects, from regulatory and standardization issues to communications theory, signal processing, microwave signal propagation, and RF transceiver and integrated circuit (IC) design. Although there is a significant amount of literature in these seemingly disparate subjects, it is difficult for both developers and technical managers in this field to keep up with all the rapid advances and nuances of a specialized engineering field.

One of the central goals of this book is to compile a set of chapters on the challenges of next generation RF and wireless communication systems, a discussion brought about by researchers actively working in the field. Both the content and the style of each chapter therefore reflect an individual expert's analysis and style. This book is thus a compilation of important topics in RF and wireless communications. Our intended audience includes engineers who are either active or on the verge of seriously embarking upon the field. The book has been arranged to appeal to serious developers of RF and wireless systems: the early chapters introduce background matter for nonspecialists who are interested in an introduction to the field, and the later chapters then discuss topics in depth for the practicing engineer.

The book is organized as follows. Chapters 1 through 4 are background material on modern wireless communications systems and standards.

Chapter 1 is a general survey of RF and wireless technology and may be particularly useful for the nonspecialist attempting to gain a history of wireless communications and understand the landscape of the field. Some state-of-the-art technologies, discussed in depth in later chapters, are also introduced. Chapter 2 is a summary of the evolution of the next generation wireless cellular networks. Various issues in cellular communications, such as mobility and handoff management, are discussed, and there is also a brief discussion of satellite and high altitude platforms. Chapter 3 addresses some of the research issues of mobile ad hoc networks. The discussion addresses the important technical challenges, including both physical and media access layers issues, such as routing protocols for mobile ad hoc networks. Chapter 4 discusses the very important subject of spread spectrum communications, explaining both direct sequence and frequency hopping methods. Particular attention is paid to important issues such as processing gain, jamming margin, interference rejection, and others. Clearly, spread spectrum is a vast topic, and the topics covered here are limited to a brief synopsis of the important technical issues in spread spectrum wireless systems.

Some of the important technical issues of RF and wireless system design are discussed in Chapters 5 through 12. Chapter 5 is an elaborate introduction on the highly active research topic in wireless communications: software-defined radio. The chapter starts with a definition and then discusses various aspects of software radio, including multiband, multicarrier, multimode, and variable bandwidth issues. Implementation issues are addressed in some detail, including a discussion on DSPs. The chapter concludes with a case study of a cdma2000 and UMTS software-defined radio receiver. Chapter 8 is a detailed mathematical and implementation level treatment of a critical synchronization device, the phase-locked loop. It has been said that the subject of synchronization is at once the most important and least understood and discussed subject in communications. The detailed treatment of this subject in this chapter is intended for the research engineer designing the circuit of a communication transceiver. Chapters 6, 7, and 9 are the subject of another critical element in any wireless communication transceiver, the RF power amplifier. A significant requirement and challenge in wireless systems is power efficiency. Power-efficient transceivers in wireless sensor

networks currently seem to be the most actively sought after requirement. Furthermore, wireless and mobility are inseparable requirements in most applications. Mobility, in turn, requires the ability to operate with batteries over a long period of time. Hence, power efficiency in wireless transceivers is critical. These chapters discuss some of the salient points of RF power amplifiers, and the research and development directions that will be needed for next generation wireless communication systems.

Chapter 10 covers another major topic in wireless communications, orthogonal frequency division multiplexing (OFDM), a multi-carrier modulation and multiplexing technique. A major advantage of OFDM is its robustness in multipath fading in wireless communications. The very popular IEEE 802.11a WLAN standard, for instance, uses OFDM with a capacity of 54 Mbps in the 5 GHz band.

In wireless communications, the need for forward error correction (FEC) is of particular importance. Turbo coding is a relatively new FEC technique that is playing a significant role in communication systems. Chapter 12 introduces the concepts behind turbo codes and includes a description of the turbo codes in cdma2000 and UMTS 3G cellular systems.

Chapter 11 introduces sensor networks in general terms, then Chapter 13 discusses a more specific sensor networking problem, that of using reliable sensor networks in an industrial settings. Chapter 14 is a basic primer on radio frequency identification (RFID), a technology that is poised to grow significantly in the next few years for security and asset management problems.

Chapter 15, like Chapters 6, 7, and 9, is an in-depth treatment of another specialized and important topic in wireless and RF communications, the use of SiGe integrated circuit fabrication for communication devices. Chapter 16 is a brief review of a radically new form of RF communication technology, the ultra-wideband (UWB) communication. The UWB communication is a unique RF technique in that there is no carrier frequency involved in the signal transmission in the classical sense.

UWB systems use sub-nanosecond or giga-Hertz bandwidth pulse for radio communication, and information is modulated on the wideband pulse itself. It is indeed an important event that the FCC has tentatively approved UWB communication at low-power levels in 2002.

Although we would like to have included other important topics such as antenna design, we realized that the timely publication of this book was important to the practicing engineer. This book was compiled within a relatively short span of time, and comments and suggestions from readers would be most welcome for improving future editions. If this edition proves to be successful, we plan to compile expanded and improved editions in the future.

Finally, I would like express my sincere thanks to all the authors for their contributions of the chapters that made this book possible.

CHAPTER 1

A SURVEY OF RF AND WIRELESS TECHNOLOGY

John T. Moring

The last two decades have been the most dynamic in the history of wireless communications [1]. Most notably, mobile voice communications has exploded from a tiny niche market to a part of our daily lives. Building on comparable advances in computers and networking technology, today's wide area and local area wireless systems are poised to take us to the next level of mobile data services, where all the capabilities of the Internet are literally at our fingertips wherever we go.

In this chapter, we briefly review the history of wireless communications, survey today's wireless landscape, and introduce some of the leading edge topics covered later in this volume [2].

A Short History of Wireless Communication

Figure 1.1 shows a time line of the development of wireless communications. We are well into the second century of radio communications. The pioneering work of Faraday, Maxwell, Hertz, and others in the 1800s led to Marconi's wireless telegraph at the turn of the century. The precursors to mobile radio as we know it have been available since the first transportable voice radios of the 1920s. Radio technology matured in the subsequent decades, with broadcast radio and television, and the portable manpack walkie-talkies of World War II. In the 1940s, cellular

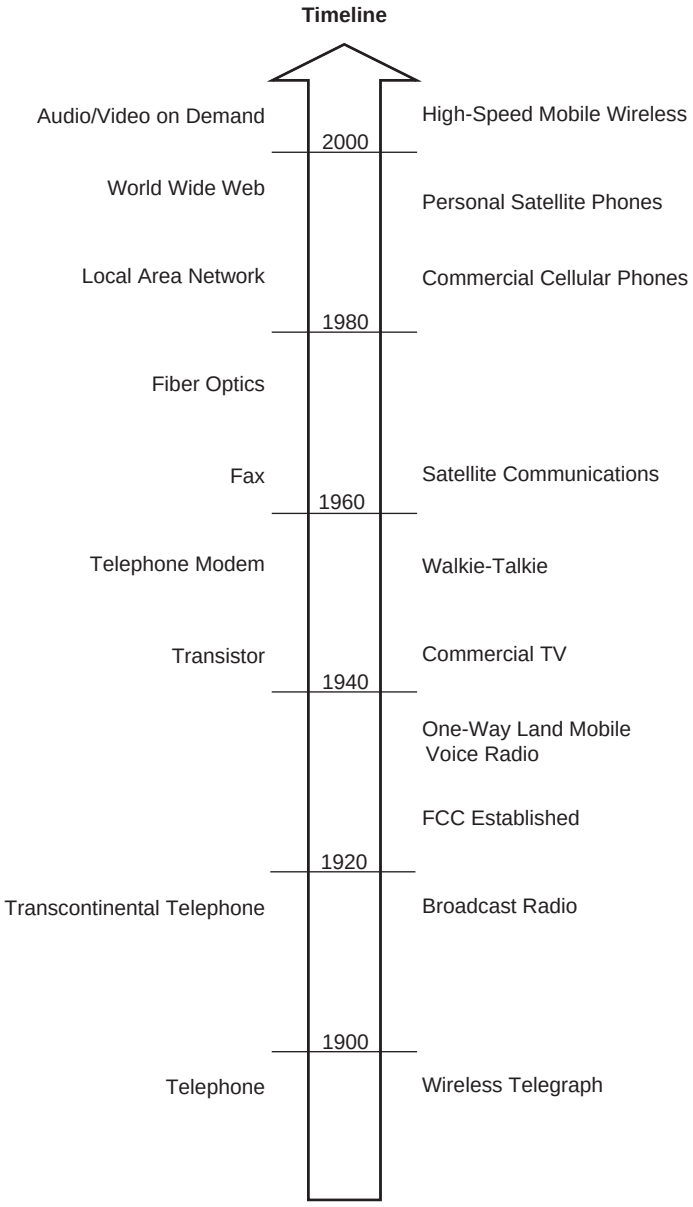

Figure 1.1

The graph indicates general telecommunications advances on the left and wireless-specific advances on the right.