WIRELESS AND MOBILE DATA NETWORKS

AFTAB AHMAD

WILEY-INTERSCIENCE

A JOHN WILEY & SONS, INC., PUBLICATION

WIRELESS AND MOBILE DATA NETWORKS

WIRELESS AND MOBILE DATA NETWORKS

AFTAB AHMAD

WILEY-INTERSCIENCE

A JOHN WILEY & SONS, INC., PUBLICATION

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

Library of Congress Cataloging-in-Publication Data:

Ahmad, Aftab, 1961–
Wireless and mobile data networks / Aftab Ahmad.
p. cm.
Includes bibliographical references.
ISBN-13 978-0-471-67075-9 (cloth)
ISBN-10 0-471-67075-8 (cloth)
1. Wireless communication systems. 2. Mobile communication systems. 3. Computer networks. I. Title.
TK5103.2.A43 2005
621.382—dc22

2004025911

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

To Mahmooda

CONTENTS

PREFACE

As broadband access reaches more and more homes and businesses, paradigm changes are occurring in all aspects of data communications. Security in Wireless LANs is becoming an ever more important issue, cellular networks are geared toward a service-oriented design, broadband access does not necessarily imply 'fixed' networks and, above all, network architectures with a range of data rates for personal operating space have been specified. Various factors, both international and national, have impacted the interoperability endeavors and we see an unprecedented collaboration among operators, vendors and standardization agencies. A large number of wireless data technologies provide solutions for users of wireless data. Arguably, the 'secret ingredient' in all the new and traditional technologies seems to be the Internet Protocol (IP). Without IP, a networking technology, wireless or not, seems to be destined to . . . including IP. However, each of the various network architectures has its own place in the market. Each wireless network relieves its users from some restrictions, such as having a plethora of wires and, many times, provides the freedom to move while connected.

The kind of freedom that wireless networking has promised is not only irreversible, but is also subject to growth, in strides, that is. The depth of knowledge in wireless networking has gone to a point where we talk about changing and choosing modulation schemes from burst to burst, of mobility in excess of 200 kmph, and of license-exempt bandwidth topping 1.5 GHz. Putting it all together in one book is practically impossible without sacrificing one thing or the other. However, it is possible to have a book with a theme, for example, to give enough breadth that the knowledge gained covers sufficient types of networks, and enough depth that the knowledge obtained is not superfluous.

This book tries to meet this general goal of providing a breadth of the technologies in wireless data networks while requiring a respectable background in communications network architecture and some background in fundamental algebra. The emphasis is on data networks.

When we talk about 'data networks', we usually imply packet-switched communications, of which voice could be a very important application. Following this logic, we describe only the 'data' part of networks, where both voice and data parts exist. Also, 'multimedia' in packet-switched networks includes voice communications as well. Therefore, voice, such as in voice over IP (VoIP) is automatically a part of discussing data networks. However, while voice is QoS-intensive, it does not shine as a killer application for high-speed networks, including wireless networks. A killer application would ideally be the one that requires network capability to the fullest and would be in demand to the fullest as well. New architectures for cellular networks seem to have decided to deploy sufficient infrastructure and leave the question of killer application to future, thus providing the scope for third-party service development environment. Nevertheless, the question of a killer application does not really exist in all types of network architectures, specifically, the ones used for access or the ones designed for specific applications. The example of the former are the WLANs and broadband wireless access networks, and the examples for the latter are sensor networks designed specifically for a certain application. We have included a wide range of network architectures, along with chapters to enhance their understanding.

The first three chapters have the goal of enhancing the understanding of later chapters. First chapter gives a bird's eye view of various wireless and mobile network types. It ends with a discussion on the frequency spectra allocated for these networks. Chapter 2, in continuation, discusses the protocol architectures of various network types. Even though we classify networks as personal, local, metropolitan and wide area networks, their real classification is in terms of protocol planes. Chapter 3 discusses various components of wireless LANs. A wireless LAN is much more complex than the wired counterpart and utilizes many concepts that are relatively more advanced. Instead of explaining these concepts as a digression, we have included them in a separate chapter. Following Chapter 3, there are two chapters on WLANs: Chapter 4, on descriptions of the physical layer (PHY) standards, and Chapter 5, an account of the medium access control (MAC) layer standards. The material presented in these chapters is organized in a convenient sequence. Also, the chapter on components of a WLAN (Chapter 3) is kept in view while organizing Chapters 4 and 5. In a way, WLANs are for low-level mobility (link-level). The next step in mobility would be the wide area mobility for wireless data terminals. The next three chapters and Chapter 10 cover this topic.

In Chapter 6 we discuss the two main Internet protocols that bear the responsibility of wide area mobility provision, the mobile IP and the session initiation protocol (SIP). Mobile IP provides what is called macromobility and SIP provides signaling mechanisms for macromobility on a higher protocol

level, so that the mobile user does not lose established associations while on the move. Together, mobile IP and SIP provide the IETF 'open' architecture for the next generation of cellular networks, discussed in the next two chapters, that is, Chapter 7 and Chapter 8. Chapter 7 is on the cdma2000 network, that is, the 3G evolution from the North American systems based on CDMA. The cdma2000 is now developed under the partnership project 3GPP2 and has Release D as the latest one. The chapter focuses on the packet data part of the network. Chapter 8 does the same for W-CDMA, which is an evolution from the European Union's TDMA+FDMA network, that is, the GSM network. W-CDMA is now developed as part of another partnership project, 3GPP. In this chapter, we also take the opportunity to bring to light the open service access (OSA) capability and Internet multimedia service (IMS) that are the service development environments for the open service architectures. The wide area coverage continues in Chapter 10, with a discussion on routing in an ad hoc network. However, after discussing WLANs and cellular networks, we have a look at the security issues in wireless data networks, that is Chapter 9.

The topic of security is heavily influenced by political and trade issues and lacks in enforcement in real life. Perhaps due to the dependence of security technology on trade relations it could not really be a regular part of network architectures. However, the scenario is changing rapidly and the latest encryption standard of the wireless data in the United States (Advanced Encryption System) is actually not designed within the United States. Since it is our view that security was just as complex as the network architecture, if not more, the chapter is a little longer than other chapters. We discuss various concepts relating to wireless data security, from the very basic to what is going on most recently. In terms of the security protocols and architecture standards, we discuss mainly the WLANs, as that is where most vulnerability lies. After discussing security, we continue further network architectures in Chapters 10, 11, and 12.

In Chapter 10 we discuss routing in local area networks. The routing is made complex when there is no infrastructure. Consequently, most of the chapter is on mobile ad hoc networks (MANETs). Due to the numerous idiosyncratic characteristics of such networks, there are a large number of routing protocols proposed. Instead of making the chapter a comparative study of these mechanisms, we take a good look of one mechanism (Dynamic Source Routing), as proposed in a recent Internet-draft, and switch to a serious issue of deciding how to compare routes in order to prioritize them. In this discussion, we go a little higher in level and bring forward an analysis framework that can be developed and worked out to compare and optimize routing protocols for MANETs. More research is needed in this framework, and it is being carried out. Chapter 11 presents a discussion on low area coverage wireless networks, called wireless personal area networks (PAN)s. Even though it may be the Bluetooth standards that brought the word out about PANs, we stick to IEEE standards recommendations on it. In fact, IEEE 802.15.1, which is

Bluetooth v1.1 adopted as such (along with some new interface definitions), is an admission of the fact that Bluetooth has established its recognition, beyond doubt. The Working Group IEEE 802.15, however, did not stop at that, and covered a range of PANs for high-data rates (IEEE 802.15.3 and IEEE 802.15.3a) and low rates (IEEE 802.15.4). These are discussed in this chapter. The ultrawide band (UWB), to be standardized as IEEE 802.15.3a, has a lot more than meets the eye at this time. Research and developments in this band (or set of bands) has to continue for many years before we can truly utilize the bandwidth and properties at this small wavelength and power.

Chapter 12, the last chapter, is on wireless broadband access (WBA). It is our view that actual growth of technology in this area lags behind the possibilities and potential applications. With the WiMAX initiative, however, this might change. The IEEE standards 802.16 and 802.16a, discussed in this chapter, could very well be responsible for future developments. The chapter also includes a few words about a current IEEE initiative about mobile broadband Internet access. The Working Group IEEE 802.20 is considering this initiative and hopes to have a standard in near future.

The book can be used by developers, IT managers in wireless data networks, professors for a graduate level or senior undergraduate level course on wireless data networks, and for professional training. The author does not propose various routes for a single-semester course, as the link among various chapters can be easily identified. Every group of users can develop their own course. The overall presentation is short enough to be used within one semester with appropriate adjustments in coverage. I hope that you find the book useful in enhancing the understanding of wireless data networks. If you are a developer, then it is my advice that you use specifications for actual development, and not this book. In order to assist instructors in textbook adoption for academic and professional training, slides of chapters and quizzes will be made available at the following FTP site: ftp://ftp.wiley.com/public/sci_tech_med/wireless_networks/.

AFTAB AHMAD