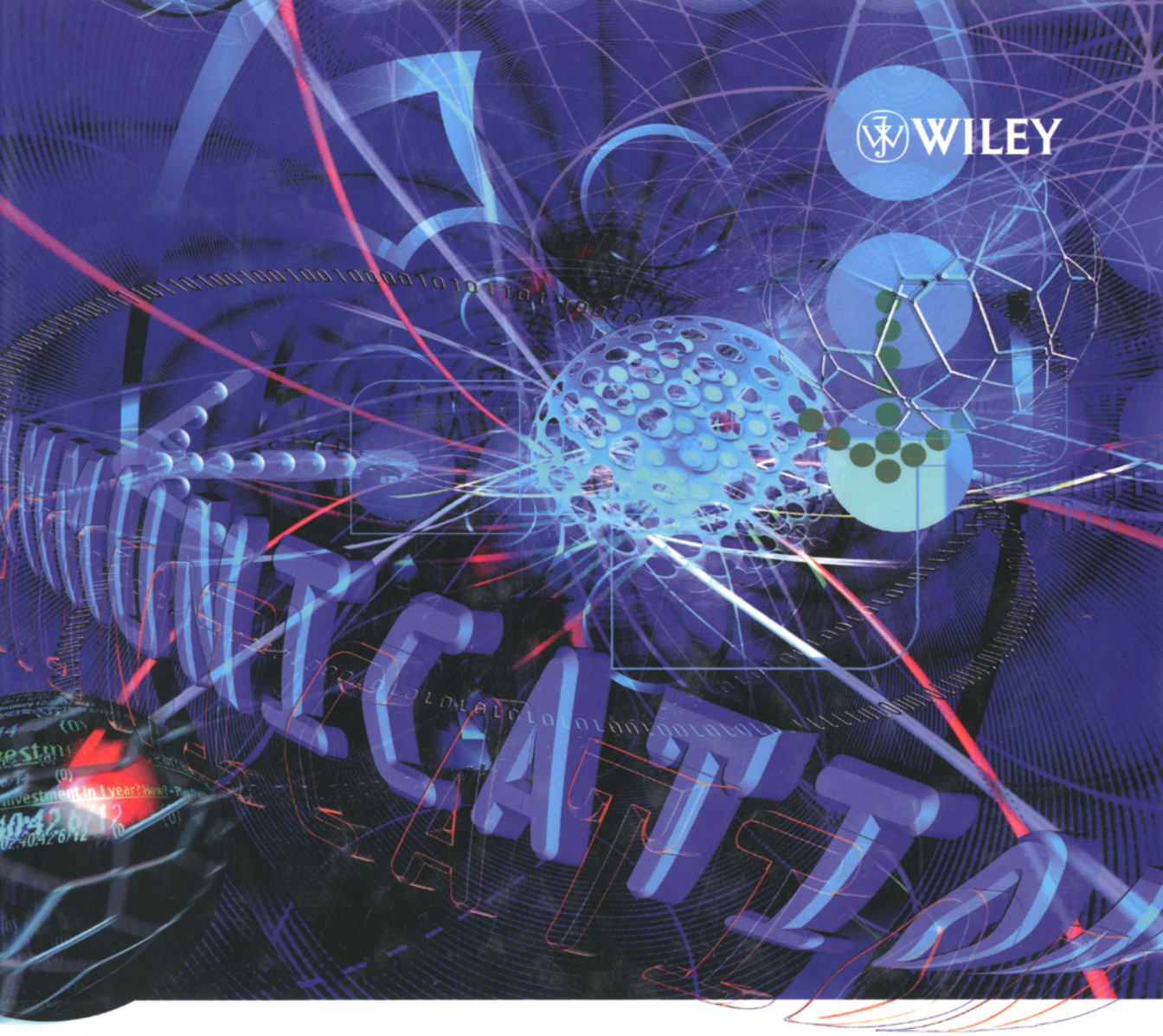

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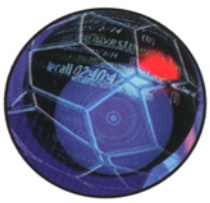

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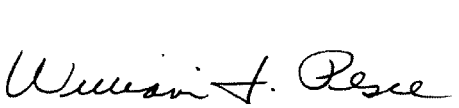

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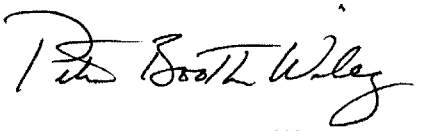

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To Margaret,
For whom my love and devotion are infinite and everlasting.

CONTENTS

PREFACE

I was a civil engineering student in Berlin. Berlin is a nice town and there were many opportunities for a student to spend his time in an agreeable manner, for instance with the nice girls. But instead of that we had to perform big and awful calculations.

Konrad Zuse, 1910

Those of us who have been involved in communications technology for any number of years have witnessed a transformation that truly is revolutionary. The *big and awful* calculations got even bigger and more awful as the technologies became more complex. Yet, the old voice network remained much the same from the late 1800s through the 1960s—Alexander Graham Bell would have recognized it clearly and understood it completely. Around the time of World War II, however, dramatically new technologies started to make their presence felt. Microwave radio systems began to appear and the foundation for electronic computer systems was laid. Soon thereafter, serious computer systems began to emerge and the need to network them soon became obvious. Over time, the networks themselves gradually became computerized. During the 1940s, the groundwork also was laid for the development of fiber optic transmission systems, which have the ability to transport incredible volumes of information over very long distances and with crystal clarity. Videoconferencing systems began to emerge in the 1960s, although they became practical only in the last few years and have yet to gain widespread acceptance. Local Area Networks (LANs) appeared in the early 1980s with the development and standardization of Ethernet.

The rate of development of the underlying system and network technologies gathered speed in the last 20 years to the point that it has become difficult for even the most technically astute to keep pace with the rate of change, much less the depth and breadth of its impact. Copper wires have yielded to glass fibers. Rather than flowing through networks in continuous streams over connections, information

often moves in packets, frames, and cells—sometimes on a connectionless basis. Worldwide, the volume of data traffic now exceeds voice traffic. Increasingly, however, the definition of *data* is no longer confined to computer data. Rather, data now include voice data, video data, image data, and even multimedia data. The networks not only connect telephones and computers but also have become networks of computers themselves. Wired networks no longer are just supplemented by wireless network technologies but in many applications are now being challenged by them, especially where portability and mobility are advantageous. In fact, there now are more cellular phones in the world than there are wireline phones, and a great many people now use cellular phones as their primary and even sole telephone.

Government regulation of monopolies has yielded to free market competition, a trend that began in 1984 with the Modified Final Judgment (MFJ) in the United States. Monopolistic companies have been torn apart in the interests of increased competition only to be reconstituted in altered states when the regulators became convinced that the market, indeed, is the best regulator. Competition has become rife in virtually every sector of the communications world, bringing with it the inherent advantages of alternative choice, improved performance, greater creativity, enhanced technology, lower cost, and a bewildering range of options. Community Antenna TeleVision (CATV) providers have entered the fray, offering voice services and Internet access over cable systems originally put in place for entertainment TV, and telephone companies are now beginning to offer cable TV service. The Internet has been commercialized and now is available in every corner of the world, supplanting more traditional means of communication and even threatening more traditional voice and data networks. Underlying Internet technologies and protocols have become the foundation for next-generation networks that are virtually certain to replace the circuit-switched network that served us so well for over 100 years. Audio, images, animated images, and even video clips are attached to electronic mail. Once available only to the technically elite digiterati working in privileged circumstances with dumb terminals connected to mainframe computers, e-mail now is available to all of us, just about anywhere, and through devices as simple and mobile as cell phones.

This book delivers a comprehensive overview of a wide range of communications systems and networks, including voice, data, video, and multimedia. It is written in plain English and provides a commonsense basis for understanding system and network technologies, their origins and evolutions, and the applications they serve. Further, it discusses the origin, evolution, and nature of many relevant standards and explores remaining standards issues. It also provides a view of the evolution and status of regulation and examines a number of key regulatory issues awaiting resolution. From fundamental concepts through the convergence of voice and data networks, this book offers a single source of information for those who need to understand communications networking.

Reserving most discussion of volts, amps, ohms, algorithms, and the like for a later date and another book by another author, this one weaves a fabric of understanding through a complex set of technologies that underlie meaningful contemporary and future applications. Further, this book serves as a language primer, providing a short course in the vocabulary and syntax of the language of telecommunications—having read this book, you will be conversant in telecommunications techno-speak. Finally, you will understand how networks work and why.