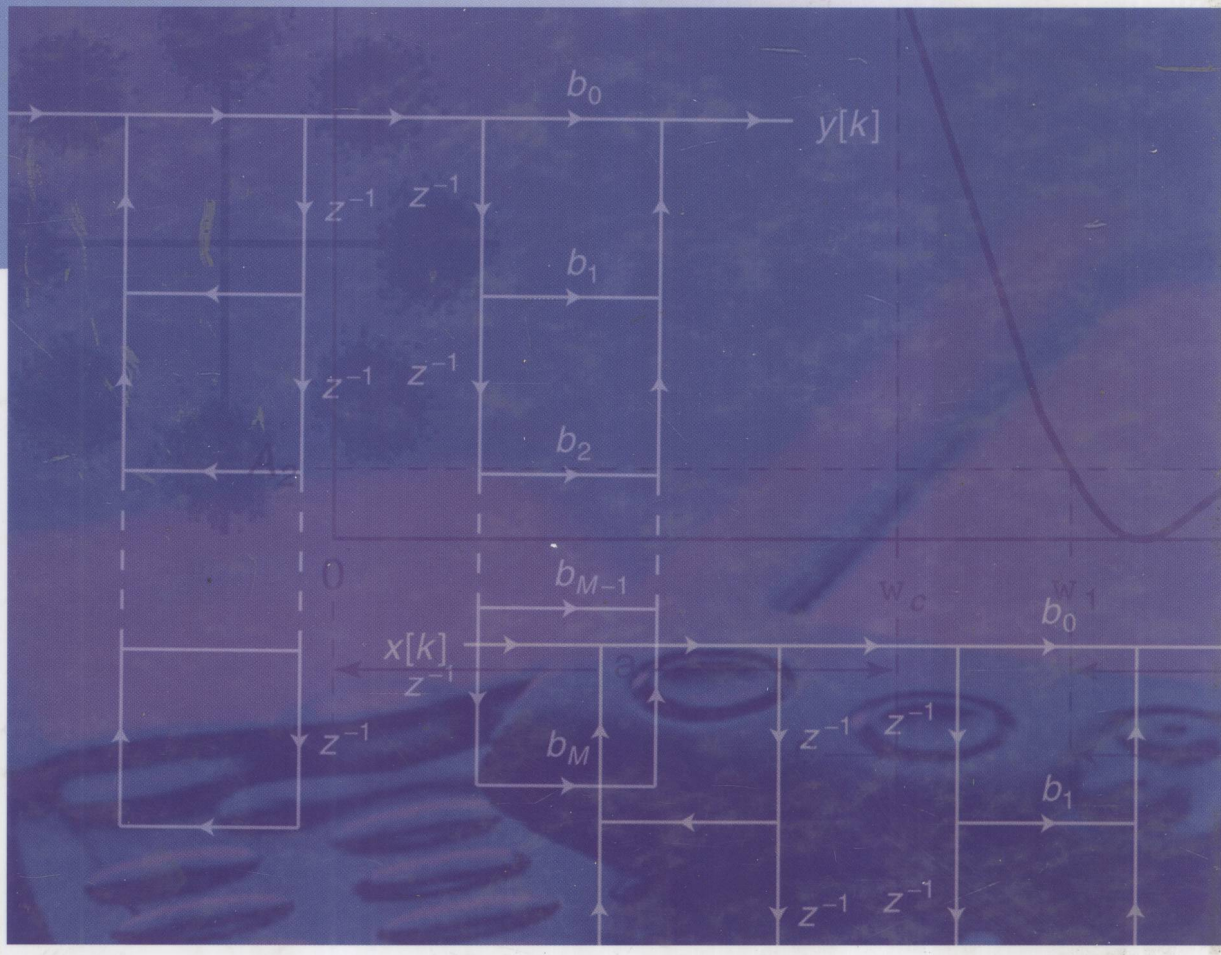
Simulating Wireless Communication Systems

Practical Models in C++



C. Britton Rorabaugh

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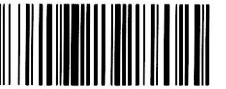

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To Joyce, Geoff, Amber, and Eleanor

PREFACE

*M*odern communications systems and the devices operating within these systems would not be possible without simulation, but practical information specific to the simulation of communications systems is relatively scarce. My motive for writing this book was to collect and capture in a useful form the techniques that can be used to simulate a wireless communication system using C++. It has been my experience that organizations newly confronted with a need to simulate a communication system are in a rush to get started. Consequently, these organizations will purchase a commercial simulation package like SPW or MATLAB Simulink without even considering the alternative of constructing their own simulation using C++. In the beginning, progress comes quickly as simple systems are configured from standard library models. Only when they begin to model the more complex proprietary parts of their systems do these organizations begin to realize how much control and flexibility they sacrificed in going with a commercial package. It is not possible for any library of precoded models to be absolutely complete. There will always be a need to build a highly specialized model or make modifications to existing models. A user attempting to do either, using a commercial package, usually spends more time dealing with the rules and limitations of the simulation infrastructure than with the details of the model algorithms themselves.

In the mid 1990s, I was the architect and lead designer for a proprietary simulation package that was used to simulate the wireless data communication links in several very large U.S. defense systems. This package wasn't perfect—software never is—but I drew upon this experience, and while writing this book, I developed a simpler simulation package that avoids many of the complexities and objectionable features of my earlier effort. This new package is called `PracSim`, which is short for Practical Simulation. All of the source code for the models and infrastructure comprising the `PracSim` package is provided on the Prentice Hall Web site (`http://authors.phptr.com/rorabaugh/`). Examples of this code are pre-

sented and discussed throughout the book, but there is far too much code to include it all in the text. The library of `PracSim` models is not intended to be complete, but rather to provide a foundation that users can modify or build upon as needed to capture the nuances of the particular systems they are attempting to model.

I didn't keep accurate records, but I'm sure that construction of the `PracSim` software took far more time than the actual writing of the text. I would like to thank my wife Joyce, son Geoffrey, daughter Amber, and mother-in-law Eleanor for not complaining too much about all the time I spent on this project and for dealing with all of the household problems that I never seemed to have time for. I would also like to thank my editor, Bernard Goodwin, for his patience despite the numerous times that I postponed delivery of the final manuscript.

CONTENTS

Chapter 1

SIMULATION: BACKGROUND AND OVERVIEW

Modern communications systems and the devices operating within these systems would not be possible without simulation. The expanded use of digital signal processing techniques has spawned cell phones and wireless transceivers that offer incredible performance and features at a per-unit cost that puts them within the reach of nearly everyone. However, these low per-unit costs are achieved through mass production of hundreds of thousands or even millions of units from a single design. The design of a new cell phone or wireless modem for a PDA is a very complex and expensive affair. Because of the complexity in such devices, it is not practical to breadboard prototypes for testing until after the design has been exhaustively tested and honed using simulation. Even after a new device has been prototyped, it is usually impractical to test it under every possible combination of operating conditions. For example, the nature of CDMA and GSM cellular phone systems is such that all of the phones in a given area unavoidably interfere with each other. The phones and base stations all include processing to mitigate this interference, but the severity of the interference and the effectiveness of the countermeasures depend upon the relative locations, with respect to the base station tower, of all the potentially interfering phones. Assessment of the interference is complicated by the fact that the phones can individually vary their transmit powers via power-control loops executing in the phones or in response to commands from the base station. Analysis is impossible and exhaustive testing is impractical. Simulation using carefully constructed models of the phones and base station is the only answer. In the design of nearly any type of communications equipment, simulation provides an inexpensive way to explore possibilities and design trades before the more expensive process of prototyping is initiated.