Foreword

Smart antennas have undergone dramatic changes since they were first considered for wireless systems. At first they were extremely expensive, using discrete components with analog combining, and suitable only for high-cost military systems. In the 1980's and 1990's, however, came the development of smart antenna concepts for commercial systems, and increases in digital signal processing complexity that pushed single-antenna wireless systems close to their theoretical (Shannon) capacity. Smart antennas are now seen as the key concept to further, many-fold, increases in both the link capacity, through spatial multiplexing, and system capacity, through interference suppression and beamforming, as well as increasing coverage and robustness. Furthermore, decreases in integrated circuit cost and antenna advancements have made smart antennas attractive in terms of both cost and implementation even on small devices. Thus, the last few years have seen an exponential growth in smart antenna research, the inclusion of smart antenna technology into wireless standards, and the beginnings of widespread deployment of smart antennas in wireless networks. This explosive growth has created a strong need for a handbook summarizing the most recent advancements to keep wireless engineers up-to-date on current developments.

This book presents 25 chapters covering key recent advancements in smart antenna technology. It consists of four sections: algorithms, performance issues, applications, and experiments and implementation. The first section provides an overview of existing smart antenna combining algorithms, followed by recent advancements including those on eigenbeamforming, robust adaptive beamforming using the min-max criterion, minimum symbol-error-rate beamforming, and sample matrix inversion, each of which can provide substantially improved performance. For sensor networks, the concept of collaborative beamforming is introduced, which can beamform using arbitrarily located sensors. Next, space-time coding is discussed and recent advancements including space-time coding with low complexity, memory, and blind channel estimation are presented. Finally, techniques for adaptive beamforming and direction finding in compact arrays using a single-port electronically steerable parasitic array radiator are presented.

The next section discusses performance issues with smart antennas. The first chapter describes why electromagnetic effects need to be included in the analysis of smart antenna systems. Then the key issues for transmit diversity: feedback, sounding, and calibration, are discussed and new approaches for better performance are presented. Next joint beamforming and space-time coding, and then adaptive coding and modulation with smart antennas, are analyzed. Finally, two new approaches of relaxation detectors and non-iterative multiple-user spatial multiplexing techniques are presented.

Applications of smart antennas are presented in the third section. The first system application described is CDMA, where more effective modeling and simulation techniques are presented, and then the improvements with cross-layer optimization with scheduling is discussed. Next, the application of smart antennas in mobile ad hoc networks is analyzed. The next chapter shows how smart antennas can be used to achieve unconditional security in generating secret keys for encryption of communications. Finally, the use of smart antennas in radio frequency identification readers is shown to have the potential to improve dramatically reader performance.

The last section describes the implementation of smart antenna testbeds and new experimentally-implemented techniques. The first chapter provides an overview of existing testbeds and then describes the implementation of a testbed using commercially available components, including a field programmable gate array. A testbed for ad hoc networks with smart antennas is also presented. A new technique for a wideband spatial beamformer that does not use frequency filters or tapped delay lines is then described and demonstrated. Finally, the implementation of a compact array as a single-port electronically steerable parasitic array radiator is described.

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