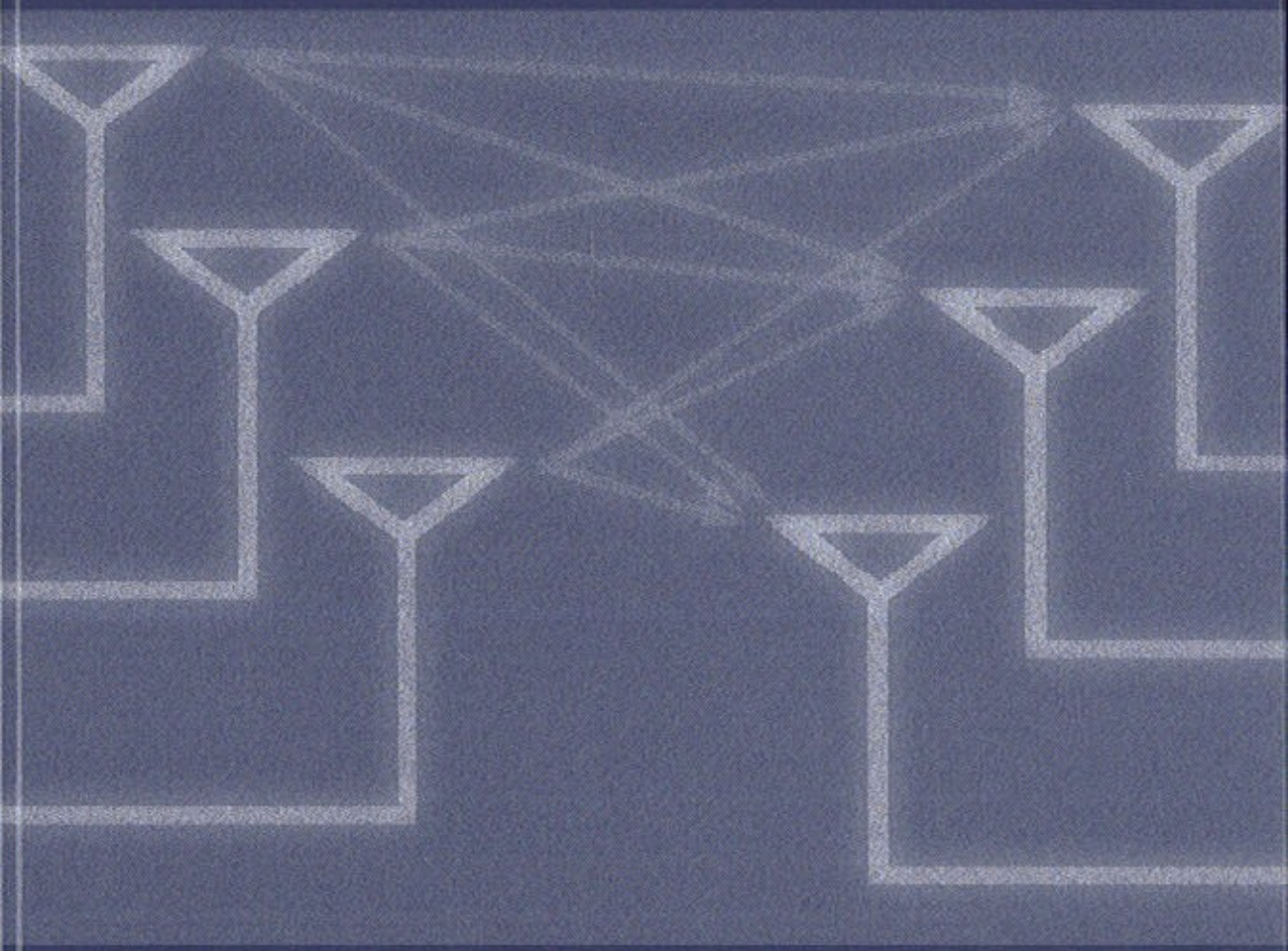
Space-Time Wireless Systems

From Array Processing to MIMO Communications



Edited by **Helmut Bölcskei, David Gesbert, Constantinos B. Papadias, and Alle-Jan van der Veen**

CAMBRIDGE

Contents

Dedication v

List of contributors xv

Acknowledgments xix

Introduction xxi

Part I

Multiantenna basics

1 Propagation aspects of MIMO channel modeling
J. Bach Andersen 3

2 Beamforming techniques
J. Winters 23

3 Diversity in wireless systems
A. F. Naguib and A. R. Calderbank 44

4 Fundamentals of MIMO channel capacity
E. Biglieri and G. Taricco 66

5 Multiantenna capacity: myths and realities
A. Lozano, A. M. Tulino, and S. Verdú 87

6 The role of feedback, CSI, and coherence in MIMO systems
G. Barriac, N. Jacobsen, and U. Madhow 108

Part II

Space-time modulation and coding

7 Introduction to space-time codes
A. R. Calderbank and A. F. Naguib 133

8 **Perspectives on the diversity-multiplexing trade-off in MIMO systems**
H. Yao, L. Zheng, and G. W. Wornell 154

9 **Linear precoding for MIMO channels**
A. Scaglione and P. Stoica 178

10 **Space-time coding for noncoherent channels**
J.-C. Belfiore and A. M. Cipriano 198

11 **Space-time coding for time- and frequency-selective MIMO channels**
X. Ma and G. B. Giannakis 218

Part III

Receiver algorithms and parameter estimation

12 **Array signal processing**
A. B. Gershman 241

13 **Optimal subspace techniques for DOA estimation**
M. Jansson, B. Ottersten, M. Viberg, and A. L. Swindlehurst 261

14 **Blind and semiblind MIMO channel estimation**
D. Slock and A. Medles 279

15 **MIMO receive algorithms**
T. Kailath, H. Vikalo, and B. Hassibi 302

16 **Space-time turbo coding**
S. ten Brink 322

17 **Training for MIMO communications**
Y. Sung, T. E. Sung, B. M. Sadler, and L. Tong 342

Part IV

System-level issues of multiantenna systems

18 **MIMO Gaussian multiple access channels**
M. Mohseni, M. Brady, and J. Cioffi 365

19 **On information-theoretic aspects of MIMO broadcast channels**
G. Caire, S. Shamai (Shitz), Y. Steinberg, and H. Weingarten 385

20 **Multiuser MIMO systems**
H. V. Poor, D. Reynolds, and X. Wang 406

21 Opportunistic communication: a system view
P. Viswanath 426

22 System level performance of MIMO systems
N. Marina, O. Tirkkonen, and P. Pasanen 443

Part V
Implementations, measurements, prototypes, and standards

23 What we can learn from multiantenna measurements
E. Bonek and W. Weichselberger 467

24 Experiments in space-time modulation and demodulation
W. Zhu, H. Lee, D. Liu, D. Browne, and M. P. Fitz 487

25 Multiple antenna techniques in 3G wireless systems
R. A. Soni and R. M. Buehrer 509

26 MIMO wireless local area networks
K. Gosse, M. de Courville, M. Muck, S. Rouquette, and S. Simoens 531

27 VLSI implementation of MIMO detection
A. Burg and D. Garrett 554

Index 575