Introduction to Space-Time Wireless Communications

This practically-oriented, all-inclusive guide covers all the major enabling techniques for current and next-generation cellular communications and wireless networking systems. Technologies covered include CDMA, OFDM, UWB, turbo and LDPC coding, smart antennas, wireless ad hoc and sensor networks, MIMO, and cognitive radios, providing readers with everything they need to master wireless systems design in a single volume. Uniquely, a detailed introduction to the properties, design, and selection of RF subsystems and antennas is provided, giving readers a clear overview of the whole wireless system. It is also the first textbook to include a complete introduction to speech coders and video coders used in wireless systems. Richly illustrated with over 400 figures, and with a unique emphasis on practical and state-of-the-art techniques in system design, rather than on the mathematical foundations, this book is ideal for graduate students and researchers in wireless communications, as well as for wireless and telecom engineers.

Wireless-Powered Communication Networks

The Definitive, Comprehensive Guide to Cutting-Edge Millimeter Wave Wireless Design “This is a great book on mmWave systems that covers many aspects of the technology targeted for beginners all the way to the advanced users. The authors are some of the most credible scholars I know of who are well respected by the industry. I highly recommend studying this book in detail.” —Ali Sadri, Ph.D., Sr. Director, Intel Corporation, MCG mmWave Standards and Advanced Technologies Millimeter wave (mmWave) is today's breakthrough frontier for emerging wireless mobile cellular networks, wireless local area networks, personal area networks, and vehicular communications. In the near future, mmWave products, systems, theories, and devices will come together to deliver mobile data rates thousands of times faster than today’s existing cellular and WiFi networks. In Millimeter Wave Wireless Communications, four of the field's pioneers draw on their immense experience as researchers, entrepreneurs, inventors,
and consultants, empowering engineers at all levels to succeed with mmWave. They deliver exceptionally clear and useful guidance for newcomers, as well as the first complete desk reference for design experts. The authors explain mmWave signal propagation, mmWave circuit design, antenna designs, communication theory, and current standards (including IEEE 802.15.3c, Wireless HD, and ECMA/WiMedia). They cover comprehensive mmWave wireless design issues, for 60 GHz and other mmWave bands, from channel to antenna to receiver, introducing emerging design techniques that will be invaluable for research engineers in both industry and academia. Topics include Fundamentals: communication theory, channel propagation, circuits, antennas, architectures, capabilities, and applications Digital communication: baseband signal/channel models, modulation, equalization, error control coding, multiple input multiple output (MIMO) principles, and hardware architectures Radio wave propagation characteristics: indoor and outdoor applications Antennas/antenna arrays, including on-chip and in-package antennas, fabrication, and packaging Analog circuit design: mmWave transistors, fabrication, and transceiver design approaches Baseband circuit design: multi–gigabit-per-second, high-fidelity DAC and ADC converters Physical layer: algorithmic choices, design considerations, and impairment solutions; and how to overcome clipping, quantization, and nonlinearity Higher-layer design: beam adaptation protocols, relaying, multimedia transmission, and multiband considerations 60 GHz standardization: IEEE 802.15.3c for WPAN, Wireless HD, ECMA-387, IEEE 802.11ad, Wireless Gigabit Alliance (WiGig)

Thermodynamics, Diffusion and the Kirkendall Effect in Solids

This book reviews the state of the art of big data analysis and smart city. It includes issues which pertain to signal processing, probability models, machine learning, data mining, database, data engineering, pattern recognition, visualisation, predictive analytics, data warehousing, data compression, computer programming, smart city, etc. Data is becoming an increasingly decisive resource in modern societies, economies, and governmental organizations. Data science inspires novel techniques and theories drawn from mathematics, statistics, information theory, computer science, and social science. Papers in this book were the outcome of research conducted in this field of study. The latter makes use of applications and techniques related to data analysis in general and big data and smart city in particular. The book appeals to advanced undergraduate and graduate students, postdoctoral researchers, lecturers and industrial researchers, as well as anyone interested in big data analysis and smart city.

5G Wireless Systems

Do you need to design efficient wireless communications systems? This unique text provides detailed coverage of radio resource allocation problems in wireless networks and the techniques that can be used to solve them. Covering basic principles and mathematical algorithms, and with a particular focus on power control and channel allocation, you will learn how to model, analyze, and optimize the allocation of resources in both physical and data link layers, and for a range of different network types. Both established and emerging networks are considered, including CDMA and OFDMA wireless networks, relay-based wireless networks, and cognitive radio networks. Numerous exercises help you put knowledge into practice, and provide the tools needed to address some of the current research problems in the field. This is an essential reference whether you are a graduate student, researcher or industry professional working in the field of wireless communication networks.

Complex-Valued Matrix Derivatives

The book is a collection of high-quality peer-reviewed research papers presented in International Conference on Soft Computing Systems (ICSCS 2015) held at Noorul Islam Centre for Higher Education, Chennai, India. These research papers provide the latest developments in the emerging areas of Soft Computing in Engineering and Technology. The book is organized in two volumes and discusses a wide variety of industrial, engineering and scientific applications of the emerging techniques. It presents invited papers from the inventors/originators of new applications and advanced technologies.
Optical Wireless Communications

In this book basic and some more advanced thermodynamics and phase as well as stability diagrams relevant for diffusion studies are introduced. Following, Fick’s laws of diffusion, atomic mechanisms, interdiffusion, intrinsic diffusion, tracer diffusion and the Kirkendall effect are discussed. Short circuit diffusion is explained in detail with an emphasis on grain boundary diffusion. Recent advances in the area of interdiffusion will be introduced. Interdiffusion in multi-component systems is also explained. Many practical examples will be given, such that researches working in this area can learn the practical evaluation of various diffusion parameters from experimental results. Large number of illustrations and experimental results are used to explain the subject. This book will be appealing for students, academicians, engineers and researchers in academic institutions, industry research and development laboratories.

Software Defined Mobile Networks (SDMN)

Mobile Broadband Multimedia Networks: Techniques, Models and Tools for 4G provides the main results of the prestigious and well known European COST 273 research project on the development of next generation mobile and wireless communication systems. Based on the applied research of over 350 participants in academia and industry, this book focuses on the radio aspects of mobile and wireless broadband multimedia communications, by exploring and developing new methods, models, techniques, strategies and tools towards the implementation of 4th generation mobile and wireless communication systems. This complete reference includes topics ranging from transmission and signal processing techniques to antennas and diversity, ultra wide band, MIMO and reference scenarios for radio network simulation and evaluation. This book will be an ideal source of the latest developments in mobile multimedia broadband technologies for researchers, R&D engineers, graduates and engineers in industry implementing simulation models and conducting measurements. Based on the well known and respected research of the COST 273 project 'Towards Mobile Broadband Multimedia Networks', whose previous models have been adopted by standardisation bodies such as ITU, ETSI and 3GPP Gives methods, techniques, models and tools for developing 4th generation mobile and wireless communication systems. Includes the latest development of key technologies and methods such as MIMO systems, ultra wide-band and OFDM

Full-Duplex Communications for Future Wireless Networks

With the full cooperation of the Alvar Aalto Foundation, Goran Schildt has explored its archives, and some 20,000 letters, memoranda and contemporary newspaper cuttings as well as many building models, to ensure that every work is included in this volume.

Radio Resource Management in Wireless Networks

This book features high-quality papers presented at the International Conference on Computational Intelligence and Communication Technology (CICT 2019) organized by ABES Engineering College, Ghaziabad, India, and held from February 22 to 23, 2019. It includes the latest advances and research findings in fields of computational science and communication such as communication & networking, web & informatics, hardware and software designs, distributed & parallel processing, advanced software engineering, advanced database management systems and bioinformatics. As such, it is of interest to research scholars, students, and engineers around the globe.

Millimeter Wave Wireless Communications
In this complete introduction to the theory of finding derivatives of scalar-, vector- and matrix-valued functions with respect to complex matrix variables, Hjørungnes describes an essential set of mathematical tools for solving research problems where unknown parameters are contained in complex-valued matrices. The first book examining complex-valued matrix derivatives from an engineering perspective, it uses numerous practical examples from signal processing and communications to demonstrate how these tools can be used to analyze and optimize the performance of engineering systems. Covering un-patterned and certain patterned matrices, this self-contained and easy-to-follow reference deals with applications in a range of areas including wireless communications, control theory, adaptive filtering, resource management and digital signal processing. Over 80 end-of-chapter exercises are provided, with a complete solutions manual available online.

Millimeter Wave Communication Systems

The latest research and developments in robust adaptivebeamforming Recent work has made great strides toward devising robust adaptivebeamformers that vastly improve signal strength against backgroundnoise and directional interference. This dynamic technology has diverse applications, including radar, sonar, acoustics, astronomy, seismology, communications, and medical imaging. There are also exciting emerging applications such as smart antennas for wirelesscommunications, handheld ultrasound imaging systems, and directional hearing aids. Robust Adaptive Beamforming compiles the theories and work of leading researchers investigating various approaches in one comprehensive volume. Unlike previous efforts, these pioneering studies are based on theories that use an uncertainty set of the array steering vector. The researchers define their theories, explain their methodologies, and present their conclusions. Methods presented include: * Coupling the standard Capon beamformers with a spherical or ellipsoidal uncertainty set of the array steering vector * Diagonal loading for finite sample size beamforming * Mean-squared error beamforming for signal estimation * Constant modulus beamforming * Robust wideband beamforming using a steered adaptive beamformer to adapt the weight vector within a generalized sidelobe canceller formulation. Robust Adaptive Beamforming provides a truly up-to-date resource and reference for engineers, researchers, and graduate students in this promising, rapidly expanding field.

Massive MIMO

Pervasive Mobile and Ambient Wireless Communications reports the findings of COST 2100, a project of the European intergovernmental COST framework addressing various topics currently emerging in mobile and wireless communications. Drawing on experience developed in this and earlier COST projects, the text represents the final outcome of collaborative work involving more than 500 researchers in 140 institutions and 30 countries (including outside Europe). The book’s subject matter includes: • transmission techniques; • signal processing; • radio channel modelling and measurement; • radio network issues; and • recent paradigms including ultra-wideband, cooperative, vehicle-to-vehicle and body communications. The research reported comes from a variety of backgrounds: academic, equipment-manufacturing and operational. The information contained in this book will bring the study reported to a wider audience from all those spheres of work. Pervasive Mobile and Ambient Wireless Communications will be of interest to researchers for its cutting-edge analysis and to practitioners for its functional usability.

Pervasive Mobile and Ambient Wireless Communications

Full-Duplex Communications and Networks

This book presents comprehensive coverage of current and emerging multiple access, random access, and waveform design techniques for 5G wireless networks and beyond. A definitive reference for researchers in these fields, the book describes recent research from academia, industry,
and standardization bodies. The book is an all-encompassing treatment of these areas addressing orthogonal multiple access and waveform design, non-orthogonal multiple access (NOMA) via power, code, and other domains, and orthogonal, non-orthogonal, and grant-free random access. The book builds its foundations on state of the art research papers, measurements, and experimental results from a variety of sources.

Wireless Communication Systems

This book focuses on key simulation and evaluation technologies for 5G systems. Based on the most recent research results from academia and industry, it describes the evaluation methodologies in depth for network and physical layer technologies. The evaluation methods are discussed in depth. It also covers the analysis of the 5G candidate technologies and the testing challenges, the evolution of the testing technologies, fading channel measurement and modeling, software simulations, software hardware cosimulation, field testing and other novel evaluation methods. The fifth-generation (5G) mobile communications system targets highly improved network performances in terms of the network capacity and the number of connections. Testing and evaluation technologies is widely recognized and plays important roles in the wireless technology developments, along with the research on basic theory and key technologies. The investigation and developments on the multi-level and comprehensive evaluations for 5G new technologies, provides important performance references for the 5G technology filtering and future standardizations. Students focused on telecommunications, electronic engineering, computer science or other related disciplines will find this book useful as a secondary text. Researchers and professionals working within these related fields will also find this book useful as a reference.

5G Mobile and Wireless Communications Technology

The book focuses on the integration of intelligent communication systems, control systems, and devices related to all aspects of engineering and sciences. It includes high-quality research papers from the 3rd international conference, ICICCD 2018, organized by the Department of Electronics, Instrumentation and Control Engineering at the University of Petroleum and Energy Studies, Dehradun on 21-22 December 2018. Covering a range of recent advances in intelligent communication, intelligent control and intelligent devices., the book presents original research and findings as well as researchers’ and industrial practitioners’ practical development experiences of.

Journal of Forest Science

This book describes the concept of a Software Defined Mobile Network (SDMN), which will impact the network architecture of current LTE (3GPP) networks. SDN will also open up new opportunities for traffic, resource and mobility management, as well as impose new challenges on network security. Therefore, the book addresses the main affected areas such as traffic, resource and mobility management, virtualized traffics transportation, network management, network security and techno economic concepts. Moreover, a complete introduction to SDN and SDMN concepts. Furthermore, the reader will be introduced to cutting-edge knowledge in areas such as network virtualization, as well as SDN concepts related to next generation mobile networks. Finally, by the end of the book the reader will be familiar with the feasibility and opportunities of SDMN concepts, and will be able to evaluate the limits of performance and scalability of these new technologies while applying them to mobile broadband networks.

Proceedings of the International Conference on Soft Computing Systems

This book provides an overview of the latest research and development of new technologies for cognitive radio, mobile communications, and wireless networks. The contributors discuss the research and requirement analysis and initial standardization work towards 5G cellular systems and
the capacity problems it presents. They show how cognitive radio, with the capability to flexibly adapt its parameters, has been proposed as the enabling technology for unlicensed secondary users to dynamically access the licensed spectrum owned by legacy primary users on a negotiated or an opportunistic basis. They go on to show how cognitive radio is now perceived in a much broader paradigm that will contribute to solve the resource allocation problem that 5G requirements raise. The chapters represent hand-selected expanded papers from EAI sponsored and hosted conferences such as the 12th EAI International Conference on Mobile and Ubiquitous Systems, the 11th EAI International Conference on Heterogeneous Networking for Quality, Reliability, Security and Robustness, the 10th International Conference on Cognitive Radio Oriented Wireless Networks, the 8th International Conference on Mobile Multimedia Communications, and the EAI International Conference on Software Defined Wireless Networks and Cognitive Technologies for IoT.

**Signal Processing for 5G: Algorithms and Implementations**

Get up to speed with the protocols, network architectures and techniques for 5G wireless networks with this comprehensive guide.

**Smartphone Energy Consumption**

"Professor Andreas F. Molisch, renowned researcher and educator, has put together the comprehensive book, Wireless Communications. The second edition, which includes a wealth of new material on important topics, ensures the role of the text as the key resource for every student, researcher, and practitioner in the field." —Professor Moe Win, MIT, USA Wireless communications has grown rapidly over the past decade from a niche market into one of the most important, fast moving industries. Fully updated to incorporate the latest research and developments, Wireless Communications, Second Edition provides an authoritative overview of the principles and applications of mobile communication technology. The author provides an in-depth analysis of current treatment of the area, addressing both the traditional elements, such as Rayleigh fading, BER in flat fading channels, and equalisation, and more recently emerging topics such as multi-user detection in CDMA systems, MIMO systems, and cognitive radio. The dominant wireless standards; including cellular, cordless and wireless LANs; are discussed. Topics featured include: wireless propagation channels, transceivers and signal processing, multiple access and advanced transceiver schemes, and standardised wireless systems. Combines mathematical descriptions with intuitive explanations of the physical facts, enabling readers to acquire a deep understanding of the subject. Includes new chapters on cognitive radio, cooperative communications and relaying, video coding, 3GPP Long Term Evolution, and WiMax; plus significant new sections on multi-user MIMO, 802.11n, and information theory. Companion website featuring: supplementary material on ‘DECT’, solutions manual and presentation slides for instructors, appendices, list of abbreviations and other useful resources.

**Big Data and Smart Digital Environment**

The aim of this book is to present the modern design and analysis principles of millimeter-wave communication system for wireless devices and to give postgraduates and system professionals the design insights and challenges when integrating millimeter wave personal communication system. Millimeter wave communication system are going to play key roles in modern gigabit wireless communication area as millimeter-wave industrial standards from IEEE, European Computer Manufacturing Association (ECMA) and Wireless High Definition (Wireless HD) Group, are on their way to the market. The book will review up-to-date research results and utilize numerous design and analysis for the whole system covering from Millimeter wave frontend to digital signal processing in order to address major topics in a high speed wireless system. This book emphasizes the importance and the requirements of high-gain antennas, low power transceiver, adaptive equalizer/modulation, channeling coding and adaptive multi-user detection for gigabit wireless communications. In addition, the book will include the updated research literature and patents in the topics of transceivers, antennas, MIMO, channel capacity, coding, equalizer, Modem and multi-user detection. Finally the application of these antennas will be
Advances in Computational Intelligence and Communication Technology

A comprehensive and invaluable guide to 5G technology, implementation and practice in one single volume. For all things 5G, this book is a must-read. Signal processing techniques have played the most important role in wireless communications since the second generation of cellular systems. It is anticipated that new techniques employed in 5G wireless networks will not only improve peak service rates significantly, but also enhance capacity, coverage, reliability, low-latency, efficiency, flexibility, compatibility and convergence to meet the increasing demands imposed by applications such as big data, cloud service, machine-to-machine (M2M) and mission-critical communications. This book is a comprehensive and detailed guide to all signal processing techniques employed in 5G wireless networks. Uniquely organized into four categories, New Modulation and Coding, New Spatial Processing, New Spectrum Opportunities and New System-level Enabling Technologies, it covers everything from network architecture, physical-layer (down-link and up-link), protocols and air interface, to cell acquisition, scheduling and rate adaption, access procedures and relaying to spectrum allocations. All technology aspects and major roadmaps of global 5G standard development and deployments are included in the book. Key Features: Offers step-by-step guidance on bringing 5G technology into practice, by applying algorithms and design methodology to real-time circuit implementation, taking into account rapidly growing applications that have multi-standards and multi-systems. Addresses spatial signal processing for 5G, in particular massive multiple-input multiple-output (massive-MIMO), FD-MIMO and 3D-MIMO along with orbital angular momentum multiplexing, 3D beamforming and diversity. Provides detailed algorithms and implementations, and compares all multicarrier modulation and multiple access schemes that offer superior data transmission performance including FBMC, GFDM, F-OFDM, UFMC, SEFDM, FTN, MUSA, SCMA and NOMA. Demonstrates the translation of signal processing theories into practical solutions for new spectrum opportunities in terms of millimeter wave, full-duplex transmission and license assisted access. Presents well-designed implementation examples, from individual function block to system level for effective and accurate learning. Covers signal processing aspects of emerging system and network architectures, including ultra-dense networks (UDN), software-defined networks (SDN), device-to-device (D2D) communications and cloud radio access network (C-RAN).

Multiple Access Techniques for 5G Wireless Networks and Beyond

This book focuses on optical wireless communications (OWC), an emerging technology with huge potential for the provision of pervasive and reliable next-generation communications networks. It shows how the development of novel and efficient wireless technologies can contribute to a range of transmission links essential for the heterogeneous networks of the future to support various communications services and traffic patterns with ever-increasing demands for higher data-transfer rates. The book starts with a chapter reviewing the OWC field, which explains different sub-technologies (visible-light, ultraviolet (UV) and infrared (IR) communications) and introduces the spectrum of application areas (indoor, vehicular, terrestrial, underwater, intersatellite, deep space, etc.). This provides readers with the necessary background information to understand the specialist material in the main body of the book, which is in four parts. The first of these deals with propagation modelling and channel characterization of OWC channels at different spectral bands and with different applications. The second starts by providing a unified information-theoretic treatment of OWC and then discusses advanced physical-layer methodologies (including, but not limited to: advanced coding, modulation diversity, cooperation and multi-carrier techniques) and the ultimate limitations imposed by practical constraints. On top of the physical layer come the upper-layer protocols and cross-layer designs that are the subject of the third part of the book. The last part of the book features a chapter-by-chapter assessment of selected OWC applications. Optical Wireless Communications is a valuable reference guide for academic researchers and practitioners concerned with the future development of the world’s communication networks. It succinctly but comprehensively presents the latest advances in the field.

Cognitive Radio, Mobile Communications and Wireless Networks
Femtocell is currently the most promising technology for supporting the increasing demand of data traffic in wireless networks. Femtocells provide an opportunity for enabling innovative mobile applications and services in home and office environments. Femtocell Communications and Technologies: Business Opportunities and Deployment Challenges is an extensive and thoroughly revised version of a collection of review and research based chapters on femtocell technology. This work focuses on mobility and security in femtocell, cognitive femtocell, and standardization and deployment scenarios. Several crucial topics addressed in this book are interference mitigation techniques, network integration option, cognitive optimization, and economic incentives to install femtocells that may have a larger impact on their ultimate success. The book is optimized for use by graduate researchers who are familiar with the fundamentals of wireless communication and cellular concepts.

**LTE-Advanced and Next Generation Wireless Networks**

Multi-antenna techniques are widely considered to be the most promising avenue for significantly increasing the bandwidth efficiency of wireless data transmission systems. In so called MIMO (multiple input multiple output) systems, multiple antennas are deployed both at the transmitter and the receiver. In MISO (multiple input single output) systems, the receiver has only one antenna, and the multiple transmit antennas are used for transmit diversity. The key aspects of multiple antenna transceiver techniques for evolving 3G systems and beyond are presented. MIMO and MISO (transmit diversity) techniques are explained in a common setting. In particular, the book covers linear processing transmit diversity methods with and without side information at the transmitter (feedback), including the current transmit diversity concepts in the WCDMA standards, as well as promising MIMO concepts, crucial for future high data rate systems. As an example, MIMO and MISO aspects of 3GPP HSDPA (high speed downlink packet access) will be considered. Furthermore, examples of high throughput, low complexity space-time codes will be provided, when signalling without side information (open loop concepts). The theory of linear space-time block codes will be developed, and optimal non-orthogonal high throughput codes will be constructed, both for MIMO and MISO systems. Performance may be further improved by feedback from receiver to transmitter. The corresponding closed loop modes in the current 3GPP specifications will be discussed, along with their extensions for more than two transmit antennas. In addition, feedback signalling for MIMO channels will be addressed. Optimal quantisation methods of the feedback messages will be discussed. Finally, hybrid schemes are constructed, where the amount of feedback is reduced using partly open, partly closed loop signalling.

* Provides a concise and up-to-date description of perhaps the most active area of research in wireless communications
* Unique in presenting recent developments in both WCDMA and MIMO

**Smart Grids and Their Communication Systems**

Learn about the key technologies and understand the state of the art in research for full-duplex communication networks and systems with this comprehensive and interdisciplinary guide. Incorporating physical, MAC, network, and application layer perspectives, it explains the fundamental theories on which full-duplex communications are built, and lays out the techniques needed for network design, analysis and optimization. Techniques covered in detail include self-interference cancellation and signal processing algorithms, physical layer algorithms, methods for efficient resource allocation, and game theory. Potential applications and networking schemes are discussed, including full-duplex cognitive radio networks, cooperative networks, and heterogeneous networks. The first book to focus exclusively on full-duplex communications, this is an indispensable reference for both researchers and practitioners designing the next generation of wireless networks.

**Multi-antenna Transceiver Techniques for 3G and Beyond**
This exclusive coverage of the opportunities, technological challenges, solutions, and state of the art of large MIMO systems provides an in-depth discussion of algorithms for large MIMO signal processing, suited for large MIMO signal detection, precoding and LDPC code designs. An ideal resource for researchers, designers, developers and practitioners in wireless communications.

**Key Technologies for 5G Wireless Systems**

**Large MIMO Systems**

A comprehensive overview of the 5G landscape covering technology options, most likely use cases and potential system architectures.

**Fundamentals of Massive MIMO**

To build wireless systems that deliver maximum performance and reliability, engineers need a detailed understanding of radio propagation. Drawing on over 15 years of experience, leading wireless communications researcher Henry Bertoni presents the most complete discussion of techniques for predicting radio propagation ever published. From its insightful introduction on spectrum reuse to its state-of-the-art real-world models for buildings, terrain, and foliage, Radio Propagation for Modern Wireless Systems delivers invaluable information for every wireless system designer. Coverage provides: A door to the understanding of radio wave propagation for the wireless channel. In-depth study of the effects on path loss of buildings, terrain, and foliage. A unified view of key propagation effects in narrowband and wideband systems, including spatial variation, angle of arrival, and delay spread. Readable account of diffraction at building corners, with worked out examples. Never-before-published coverage of mobile-to-mobile path loss in cities. Effective new ray-based models for site-specific predictions and simulation of channel statistics. Simulations of fast fading and shadow loss. From start to finish, Radio Propagation for Modern Wireless Systems presents sophisticated models—and compares their results with actual field measurements. With thorough coverage and extensive examples from both narrowband and wideband systems, it can help any wireless designer deliver more powerful, cost-effective services.

**Robust Adaptive Beamforming**

Written by pioneers of the concept, this is the first complete guide to the physical and engineering principles of Massive MIMO. Assuming only a basic background in communications and statistical signal processing, it will guide readers through key topics in multi-cell systems such as propagation modeling, multiplexing and de-multiplexing, channel estimation, power control, and performance evaluation. The authors' unique capacity-bounding approach will enable readers to carry out effective system performance analyses and develop advanced Massive MIMO techniques and algorithms. Numerous case studies, as well as problem sets and solutions accompanying the book online, will help readers put knowledge into practice and acquire the skill set needed to design and analyze complex wireless communication systems. Whether you are a graduate student, researcher, or industry professional working in the field of wireless communications, this will be an indispensable guide for years to come.

**Number Theory Meets Wireless Communications**

This book constitutes the joint refereed proceedings of the 12 International Conference on Next Generation Teletraffic and Wired/Wireless Advanced
Online Library Overview Of Mimo Systems Aalto Networking, NEW2AN, and the 5th Conference on Internet of Things and Smart Spaces, ruSMART 2012, held in St. Petersburg, Russia, in August 2012. The total of 42 papers was carefully reviewed and selected for inclusion in this book. The 14 papers selected from ruSMART are organized in topical sections named: defining an internet-of-things ecosystem; future services; and smart space governing through service mashups. The 28 papers from NEW2AN deal with the following topics: wireless cellular networks; ad-hoc, mesh, and delay-tolerant networks; scalability, cognition, and self-organization; traffic and internet applications; and wireless sensor networks. They also contain 4 selected papers from the NEW2AN 2012 winter session.

**Internet of Things, Smart Spaces, and Next Generation Networking**

The book presents a broad overview of emerging smart grid technologies and communication systems, offering a helpful guide for future research in the field of electrical engineering and communication engineering. It explores recent advances in several computing technologies and their performance evaluation, and addresses a wide range of topics, such as the essentials of smart grids for fifth generation (5G) communication systems. It also elaborates the role of emerging communication systems such as 5G, internet of things (IoT), IEEE 802.15.4 and cognitive radio networks in smart grids. The book includes detailed surveys and case studies on current trends in smart grid systems and communications for smart metering and monitoring, smart grid energy storage systems, modulations and waveforms for 5G networks. As such, it will be of interest to practitioners and researchers in the field of smart grid and communication infrastructures alike.

**Mobile Broadband Multimedia Networks**

LTE- A and Next Generation Wireless Networks: ChannelModeling and Performance describes recent advances in propagation and channel modeling necessary for simulating nextgeneration wireless systems. Due to the radio spectrum scarcity, two fundamental changes are anticipated compared to the current status. Firstly, the strict reservation of a specific band for a unique standard could evolve toward a priority policy allowing the existence of secondary users in a band allocated to a primary system. Secondly, a huge increase of the number of cells is expected by combining outdoor base stations with smaller cells such as pico/femto cells and relays. This evolution is accompanied with the emergence of cognitive radio that becomes a reality in terminals together with the development of self-organization capabilities and distributed cooperative behaviors. The book is divided into three parts: Part I addresses the fundamentals (e.g. technologies, channel modeling principles etc.) Part II addresses propagation and modeling discussing topics such as indoor propagation, outdoor propagation, etc. Part III explores system performance and applications (e.g. MIMO Over-the-air testing, electromagnetic safety, etc).

**Radio Propagation for Modern Wireless Systems**

Get the key measurement, modeling, and analytical tools for developing energy-aware and efficient systems and applications with this practical guide.

**Intelligent Communication, Control and Devices**

Foreword from Arogyaswami Paulraj, Professor (Emeritus), Stanford University (USA) The first book to show how MIMO principles can be implemented in today's mobile broadband networks and components Explains and solves some of the practical difficulties that arise in designing and implementing MIMO systems Both theory and implementation sections are written in the context of the most recent standards: IEEE 802.11n (WiFi); IEEE 802.16 (WIMAX); 4G networks (3GPP/3GPP2, LTE)
**Femtocell Communications and Technologies: Business Opportunities and Deployment Challenges**

An accessible introduction to the theory of space-time wireless communications.

**MIMO**

This book focuses on the multidisciplinary state-of-the-art of full-duplex wireless communications and applications. Moreover, this book contributes with an overview of the fundamentals of full-duplex communications, and introduces the most recent advances in self-interference cancellation from antenna design to digital domain. Moreover, the reader will discover analytical and empirical models to deal with residual self-interference and to assess its effects in various scenarios and applications. Therefore, this is a highly informative and carefully presented book by the leading scientists in the area, providing a comprehensive overview of full-duplex technology from the perspective of various researchers, and research groups worldwide. This book is designed for researchers and professionals working in wireless communications and engineers willing to understand the challenges and solutions full-duplex communication so to implement a full-duplex system.

**Alvar Aalto**

The last ten years have seen a massive growth in the number of connected wireless devices. Billions of devices are connected and managed by wireless networks. At the same time, each device needs a high throughput to support applications such as voice, real-time video, movies, and games. Demands for wireless throughput and the number of wireless devices will always increase. In addition, there is a growing concern about energy consumption of wireless communication systems. Thus, future wireless systems have to satisfy three main requirements: i) having a high throughput; ii) simultaneously serving many users; and iii) having less energy consumption. Massive multiple-input multiple-output (MIMO) technology, where a base station (BS) equipped with very large number of antennas (collocated or distributed) serves many users in the same time-frequency resource, can meet the above requirements, and hence, it is a promising candidate technology for next generations of wireless systems. With massive antenna arrays at the BS, for most propagation environments, the channels become favorable, i.e., the channel vectors between the users and the BS are (nearly) pairwise orthogonal, and hence, linear processing is nearly optimal. A huge throughput and energy efficiency can be achieved due to the multiplexing gain and the array gain. In particular, with a simple power control scheme, Massive MIMO can offer uniformly good service for all users. In this dissertation, we focus on the performance of Massive MIMO. The dissertation consists of two main parts: fundamentals and system designs of Massive MIMO. In the first part, we focus on fundamental limits of the system performance under practical constraints such as low complexity processing, limited length of each coherence interval, intercell interference, and finite-dimensional channels. We first study the potential for power savings of the Massive MIMO uplink with maximum-ratio combining (MRC), zero-forcing, and minimum mean-square error receivers, under perfect and imperfect channels. The energy and spectral efficiency tradeoff is investigated. Secondly, we consider a physical channel model where the angular domain is divided into a finite number of distinct directions. A lower bound on the capacity is derived, and the effect of pilot contamination in this finite-dimensional channel model is analyzed. Finally, some aspects of favorable propagation in Massive MIMO under Rayleigh fading and line-of-sight (LoS) channels are investigated. We show that both Rayleigh fading and LoS environments offer favorable propagation. In the second part, based on the fundamental analysis in the first part, we propose some system designs for Massive MIMO. The acquisition of channel state information (CSI) is very important in Massive MIMO. Typically, the channels are estimated at the BS through uplink training. Owing to the limited length of the coherence interval, the system performance is limited by pilot contamination. To reduce the pilot contamination effect, we propose an eigenvalue-decomposition-based scheme to estimate the channel directly from the received data. The proposed scheme results in better performance compared with the conventional training schemes due to the reduced pilot contamination. Another important issue of CSI acquisition in Massive MIMO is how to acquire CSI at the users. To address this issue, we propose two channel estimation
schemes at the users: i) a downlink "beamforming training" scheme, and ii) a method for blind estimation of the effective downlink channel gains. In both schemes, the channel estimation overhead is independent of the number of BS antennas. We also derive the optimal pilot and data powers as well as the training duration allocation to maximize the sum spectral efficiency of the Massive MIMO uplink with MRC receivers, for a given total energy budget spent in a coherence interval. Finally, applications of Massive MIMO in relay channels are proposed and analyzed. Specifically, we consider multipair relaying systems where many sources simultaneously communicate with many destinations in the same time-frequency resource with the help of a massive MIMO relay. A massive MIMO relay is equipped with many collocated or distributed antennas. We consider different duplexing modes (full-duplex and half-duplex) and different relaying protocols (amplify-and-forward, decode-and-forward, two-way relaying, and one-way relaying) at the relay. The potential benefits of massive MIMO technology in these relaying systems are explored in terms of spectral efficiency and power efficiency.