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# Power Efficient MIMO Techniques for 3GPP LTE and Beyond

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**Power Efficient Mimo Techniques For 3gpp Lte And Beyond:**

**Mobile and Wireless Communications for IMT-Advanced and Beyond** Afif Osseiran,Jose F. Monserrat,Werner Mohr,2011-08-08 A timely addition to the understanding of IMT Advanced this book places particular emphasis on the new areas which IMT Advanced technologies rely on compared with their predecessors These latest areas include Radio Resource Management Carrier Aggregation improved MIMO support and Relaying Each technique is thoroughly described and illustrated before being surveyed in context of the LTE Advanced standards The book also presents state of the art information on the different aspects of the work of standardization bodies such as 3GPP and IEEE making global links between them Explores the latest research innovations to assess the future of the LTE standard Covers the latest research techniques for beyond IMT Advanced such as Coordinated multi point systems CoMP Network Coding Device to Device and Spectrum Sharing Contains key information for researchers from academia and industry engineers regulators and decision makers working on LTE Advanced and beyond **Radio Communications** Alessandro Bazzi,2010-04-01 In the last decades the restless evolution of information and communication technologies ICT brought to a deep transformation of our habits The growth of the Internet and the advances in hardware and software implementations modified our way to communicate and to share information In this book an overview of the major issues faced today by researchers in the field of radio communications is given through 35 high quality chapters written by specialists working in universities and research centers all over the world Various aspects will be deeply discussed channel modeling beamforming multiple antennas cooperative networks opportunistic scheduling advanced admission control handover management systems performance assessment routing issues in mobility conditions localization web security Advanced techniques for the radio resource management will be discussed both in single and multiple radio technologies either in infrastructure mesh or ad hoc networks UAV Communications for 5G and Beyond Yong Zeng,Ismail Guvenc,Rui Zhang,Giovanni Geraci,David W. Matolak,2020-12-14 Explore foundational and advanced issues in UAV cellular communications with this cutting edge and timely new resource UAV Communications for 5G and Beyond delivers a comprehensive overview of the potential applications networking architectures research findings enabling technologies experimental measurement results and industry standardizations for UAV communications in cellular systems The book covers both existing LTE infrastructure as well as future 5G and beyond systems UAV Communications covers a range of topics that will be of interest to students and professionals alike Issues of UAV detection and identification are discussed as is the positioning of autonomous aerial vehicles More fundamental subjects like the necessary tradeoffs involved in UAV communication are examined in detail The distinguished editors offer readers an opportunity to improve their ability to plan and design for the near future explosive growth in the number of UAVs as well as the correspondingly demanding systems that come with them Readers will learn about a wide variety of timely and practical UAV topics like Performance measurement for aerial vehicles over cellular networks particularly with respect to existing LTE

performance Inter cell interference coordination with drones Massive multiple input and multiple output MIMO for Cellular UAV communications including beamforming null steering and the performance of forward link C C channels 3GPP standardization for cellular supported UAVs including UAV traffic requirements channel modeling and interference challenges Trajectory optimization for UAV communications Perfect for professional engineers and researchers working in the field of unmanned aerial vehicles UAV Communications for 5G and Beyond also belongs on the bookshelves of students in masters and PhD programs studying the integration of UAVs into cellular communication systems **Microwave Journal** ,2007 **MIMO Processing for 4G and Beyond** Mário Marques da Silva,Francisco A. Monteiro,2014-06-03 MIMO Processing for 4G and Beyond Fundamentals and Evolution offers a cutting edge look at multiple input multiple output MIMO signal processing namely its detection in both time and frequency domains and precoding It examines its integration with OFDM UWB and CDMA along with the impact of these combinations at the system level Massive MIMO and network coding at the physical layer are very recent topics which are also addressed and which are expected to play an important role in 5G systems The book brings together contributing authors from first class institutions who have been working in international research and development R D projects and are highly cited in the MIMO field These experts examine ongoing R D activities in the field of MIMO systems and its associated signal processing that is expected to be employed in 4G and 5G systems Covers the various wireless communication standards that make use of MIMO systems Explains the receiver processing associated with MIMO signal detection including the case of massive MIMO systems and presents the optimal precoding techniques Considers optimized MIMO schemes and processing for block transmission techniques for orthogonal frequency division multiplexing OFDM transmission techniques and for single carrier frequency domain equalization Examines MIMO processing and optimization for wideband code division multiple access WCDMA Describes the ultra wideband UWB transmission technique and the corresponding MIMO processing and optimizations Explains physical layer network coding techniques From basic receiver design to more advanced processing the book covers the spectrum of topics associated with MIMO systems and MIMO processing It provides a comprehensive description of MIMO fundamentals and theory that is ideal for anyone looking to sharpen their skills on the subject such as corporate industrial employees or graduate students The book summarizes the most important enhancements related to the processing of MIMO systems for 4G systems including its evolution and future trends It also supplies a performance analysis of the various combinations of MIMO schemes for 4G systems to help you select the combination best suited for your particular needs **Resource Allocation and MIMO for 4G and Beyond** Francisco Rodrigo Porto Cavalcanti,2013-10-23 This book will be a comprehensive collection of advanced concepts related to 4th generation wireless communication systems It will be divided into two main parts resource allocation and transceiver architectures These two research areas are at the core of the recent advances experimented by wireless communication systems Each chapter will cover a relevant timely topic with two focuses a first part which is of tutorial and

survey nature reviews the state of the art in that topic followed by a more deep treatment including current research topics case studies and performance analysis **Advanced Massive MIMO and Power Saving Techniques for 5G and Beyond** □□□,2020 **Energy-Efficient Pilot-Data Power Control in MU-MIMO Communication Systems** Ye Zhang,2018 Multiple input multiple output MIMO antenna system is considered as a core technology for wireless communication To reap the benefits of MIMO at a greater scale massive MIMO with very large antenna arrays deployed at base station BS has recently become the forefront in wireless communication research Till present the design and analysis of large scale MIMO systems is a fairly new subject On the other hand excessive power usage in MIMO networks is a crucial issue for mobile operators and the explosive growth of wireless services contributes largely to the worldwide carbon footprint As such significant efforts have been devoted to improve the spectral efficiency SE as well as energy efficiency EE of MIMO communication systems over the past decade resulting in many energy efficient techniques such as power allocation This thesis investigates novel energy efficient pilot data power control strategies which can be used in both conventional MIMO and massive MIMO communication systems The new pilot data power control algorithms are developed based ontwo optimization frameworks one aims to minimize the total transmit power while satisfying per user signal interference plus noise ratio SINR and power constraints the other aims to maximize the total EE which is defined as the ratio of the total SE to the transmit power under individual user power constraints The proposed novel pilot data power allocation schemes also take into account the maximum ratio combining MRC and zero forcing ZF detectors in the uplink together with maximum ratio transmission MRT and ZF precoder in the downlink Considering that a direct use of such SINR expressions in the power control schemeswould lead to a very difficult optimization problem which is not mathematically tractable we first investigatethe statistical SINR lower bounds for multi cell multi user MIMO MU MIMO communication systemsunder minimum mean square error MMSE channel estimation These lower bounds of the per user average SINRs are used to replace the true SINRs to simplify the power allocation optimization problems Such relaxation of the original average SINR yields a simplified problem and leads to a suboptimal solution Then based on the derived average SINR lower bounds two novel energy efficient pilot data power control problems are formulatedwithin the first optimization framework aiming to minimize the total transmit power budget subject to the per user SINR requirement and power consumption constraint in multi cell MU MIMO systems For the EE optimal power allocation problems with MRT precoder and MRC detector it is revealed that such minimization problems can be converted to a standard geometric programming GP procedure which can be further converted to a convex optimization problem For the pilot data power control scheme with ZF precoder and ZF detector geometric inequality is used to approximate the original non convex optimization to GP problem The very large number of BS station situation is also discussed by assuming infinite antennas at BS Numerical results validate the tightness of the derived SINR lower bounds and the advantages of the proposed energy efficient power allocation schemes Next two

pilot and data power control schemes are developed based on the second power allocation optimization framework to jointly maximize the total EE for both uplink and downlink transmissions in multi cell MU MIMO systems under per user and BS power constraints The original power control problems are simplified to equivalent convex problems based on the derived SINR lower bounds along with the Dinkelbach s method and the FrankWolfe FW iteration By assuming infinite antennas at BS the pilot data power control in massive MIMO case is also discussed The performance of the proposed pilot data power allocation schemes based on the two frameworks namely total transmit power minimization and total EE maximization are evaluated and compared with the SE maximization scheme Furthermore we investigate the pilot data power allocation for EE communications in single cell MU MIMO systems with circuit power consumption in consideration The pilot and data power allocation schemes are proposed to minimize the total weighted uplink and downlink transmit power as well as processing circuit power consumption while meeting the per user SINR and BS power consumption constraints In our proposed schemes both fixed and flexible numbers of BS antennas are investigated For the fixed number of BS antennas case the non convex optimization problems are converted to a general GP problem to facilitate the solution An iterative algorithm is proposed to solve the EE optimal power control problems in the flexible number of BS antennas casebased on the partial convexity of both the cost function and the constraints It is shown that the convergence of the proposed iterative algorithm is guaranteed due to the fact that each iteration follows convex optimization Massive MIMO for Future Wireless Communication Systems Webert Montlouis,Agbotiname Lucky Imoize,2024-12-30 Authoritative resource discussing the development of advanced massive multiple input multiple output MIMO techniques and algorithms for application in 6G Massive MIMO for Future Wireless Communication Systems analyzes applications and technology trends for massive multiple input multiple output MIMO in 6G and beyond presenting a unified theoretical framework for analyzing the fundamental limits of massive MIMO that considers several practical constraints In addition this book develops advanced signal processing algorithms to enable massive MIMO applications in realistic environments The book looks closer at applying techniques to massive MIMO in order to meet practical network constraints in 6G networks such as interference pathloss delay and traffic outage and provides new insights into real world deployment scenarios applications management and associated benefits of robust provably secure and efficient security and privacy schemes for massive MIMO wireless communication networks To aid in reader comprehension this book includes a glossary of terms resources for further reading via a detailed bibliography and useful figures and summary tables throughout With contributions from industry experts and researchers across the world and edited by two leaders in the field Massive MIMO for Future Wireless Communication Systems includes information on Signal processing algorithms for cell free massive MIMO systems and advanced mathematical tools to analyze multiuser dynamics in wireless channels Bit error rate BER performance comparisons of different detectors in conventional cell free massive MIMO systems Enhancement of massive MIMO using deep learning based channel estimation and cell free massive

MIMO for wireless federated learning Low complexity self organizing and energy efficient massive MIMO architectures including the prospects and challenges of Terahertz MIMO systems Massive MIMO for Future Wireless Communication Systems is an essential resource on the subject for industry and academic researchers advanced students scientists and engineers in the fields of MIMO antennas sensing and channel measurements and modeling technologies *Mimo Techniques for Utra Lte* Na Wei,2010-01 To meet the ambitious peak data rate and spectral efficiency target for the UTRA Long Term Evolution LTE Multiple Input Multiple Output MIMO is identified to be one of the most essential technologies for LTE While MIMO is a widely researched topic most studies disregard the interaction of MIMO with other essential enhancement mechanisms in the system including Link adaptation LA Hybrid ARQ HARQ L1 retransmission packet scheduling etc Therefore this PhD thesis focuses on the efficient integration of MIMO in the LTE system by making a careful design and analysis of the interoperation of different gain mechanisms at different layers rather than an evaluation of their individual performance potential only More specifically the investigation exploits new algorithms for MIMO which jointly optimize the LTE system with reasonable complexity and low signalling requirements This book is perfect for students engineers who would like to get a deeper understanding of MIMO technology and its application in next generation cellular system LTE **Optimal Power Allocation for Energy Efficient MIMO Relay Systems in 5G Wireless Communication** Md R. U. D. Rajib,2018 Wireless communication has undergone a significant growth to meet the unexpected demand of wireless data traffic over the past two decades As manifested by the revolution of the third and fourth generations and long term evolution advanced LTE A engineers and researchers have been devoted to the development of the next generation 5G wireless solutions to meet the anticipated demand of 2020 To this end cooperative relay communication has been introduced as an enabling technology to increase the throughput and extend the coverage of the broadband wireless networks Decode and forward DF has been known as an effective cooperative relaying strategy for its outstanding features On the other hand merging massive multi input multi output MIMO with cooperative DF relay is considered as a key technology for 5G wireless networks to improve the quality of service QoS in a cost effective manner The objective of this thesis is to establish and solve a power allocation optimization problem for energy efficient multi pair DF relay systems integrated with massive MIMO The first part of the thesis is focused on a constrained optimization problem to minimize the total transmit power for each transmission phase of the DF relay Due to the non convexity characteristic the objective function is approximated as a convex function by means of complementary geometric programming CGP which is then solved by a sequence of geometric programming GP A lower bound of average SINR is also introduced by adopting the MMSE channel state information CSI to relax the constraint functions in the standard GP form Finally we proposed a homotopy or continuation method based algorithm to solve the optimization problem via popular CVX optimization toolbox MATLAB simulations are conducted to validate the proposed algorithm In the second part another optimization problem is presented for the entire two hop

transmission of the DF relay to improve the global energy efficiency GEE under different channel conditions Here we estimate the channel by maximum likelihood ML criterion and investigate a closed form expression of GEE Further GEE is approximated in a convex form by applying CGP due to the difficulty arising from the non convexity and a lower bound of the average SINR expression is also derived to relax the constraint functions in the GP problem Numerical results showing a detailed comparison of GEE under ML and MMSE channel estimation conditions and the performance improvement from the proposed algorithm are provided *Massive MIMO in 5G Networks: Selected Applications* Long Zhao,Hui Zhao,Kan Zheng,Wei Xiang,2017-12-21 This SpringerBrief focuses mainly on the basic theory and applications of massive MIMO in 5G networks The significance of massive MIMO for 5G or future communications is first briefly discussed Then the basic theory of massive MIMO technology is comprehensively analyzed i e a variety of 5G scenarios and their improvements are described when massive MIMO is taken into account Art physical layer techniques and various networking techniques for interference mitigation and resource scheduling are introduced as well This SpringerBrief also examines the selected applications of massive MIMO in 5G networks i e massive MIMO aided millimeter communications and energy transfer The physical layer design multiple access control MAC mechanism and networking techniques are discussed for millimeter wave communications aided by massive MIMO technology Then massive MIMO is covered for hybrid information and energy transfer A downlink precoder and a uplink pilot scheme is proposed for single cell networks and both non cooperative and cooperative energy transfer in multi cell are presented Communication researchers in the area of MIMO technology as well as researchers and practitioners working in millimeter communications and energy transfer seeking new research topics and topic areas with communication system design centralized and distributed algorithms will find this brief useful as a reference Advanced level students studying communication engineering will also find this book useful as a secondary text

**Advances in Mobile Computing and Communications** M. Bala Krishna,Jaime Lloret Mauri,2016-08-19 By 2020 if not before mobile computing and wireless systems are expected to enter the fifth generation 5G which promises evolutionary if not revolutionary services What those advanced services will look like sound like and feel like is the theme of the book Advances in Mobile Computing and Communications Perspectives and Emerging Trends in 5G Networks The book explores futuristic and compelling ideas in latest developments of communication and networking aspects of 5G As such it serves as an excellent guide for advanced developers communication network scientists researchers academicians and graduate students The authors address computing models communication architecture and protocols based on 3G LTE LTE A 4G and beyond Topics include advances in 4G radio propagation and channel modeling aspects of 4G networks limited feedback for 4G and game theory application for power control and subcarrier allocation in OFDMA cellular networks Additionally the book covers millimeter wave technology for 5G networks multicellular heterogeneous networks and energy efficient mobile wireless network operations for 4G and beyond using HetNets Finally the authors delve into opportunistic multiconnect

networks with P2P WiFi and cellular providers and video streaming over wireless channels for 4G and beyond

**Fundamentals of Massive MIMO** Thomas L. Marzetta,Erik G. Larsson,Hong Yang,Hien Quoc Ngo,2016-11-17 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

Cell-Free Massive MIMO Giovanni Interdonato,2020-09-09 The fifth generation of mobile communication systems 5G is nowadays a reality 5G networks are been deployed all over the world and the first 5G capable devices e g smartphones tablets wearable etc are already commercially available 5G systems provide unprecedented levels of connectivity and quality of service QoS to cope with the incessant growth in the number of connected devices and the huge increase in data rate demand Massive MIMO multiple input multiple output technology plays a key role in 5G systems The underlying principle of this technology is the use of a large number of co located antennas at the base station which coherently transmit receive signals to from multiple users This signal co processing at multiple antennas leads to manifold benefits array gain spatial diversity and spatial user multiplexing These elements enable to meet the QoS requirements established for the 5G systems The major bottleneck of massive MIMO systems as well as of any cellular network is the inter cell interference which affects significantly the cell edge users whose performance is already degraded by the path attenuation To overcome these limitations and provide uniformly excellent service to all the users we need a more radical approach we need to challenge the cellular paradigm In this regard cell free massive MIMO constitutes the paradigm shift In the cell free paradigm it is not the base station surrounded by the users but rather it is each user being surrounded by smaller simpler serving base stations referred to as access points APs In such a system each user experiences being in the cell center and it does not experience any cell boundaries Hence the terminology cell free As a result users are not affected by inter cell interference and the path attenuation is significantly reduced due to the presence of many APs in their proximity This leads to impressive performance Although appealing from the performance viewpoint the designing and implementation of such a distributed massive MIMO system is a challenging task and it is the object of this thesis More specifically in this thesis we study Paper A The large potential of this promising technology in realistic indoor outdoor scenarios while also addressing practical deployment issues such as clock synchronization among APs and cost efficient implementations We provide an extensive description of a cell

free massive MIMO system emphasizing strengths and weaknesses and pointing out differences and similarities with existing distributed multiple antenna systems such as Coordinated MultiPoint CoMP Paper B How to preserve the scalability of the system by proposing a solution related to data processing network topology and power control We consider a realistic scenario where multiple central processing units serve disjoint subsets of APs and compare the spectral efficiency provided by the proposed scalable framework with the canonical cell free massive MIMO and CoMP Paper C How to improve the spectral efficiency SE in the downlink DL by devising two distributed precoding schemes referred to as local partial zero forcing ZF and local protective partial ZF that provide an adaptable trade off between interference cancelation and boosting of the desired signal with no additional front haul overhead and that are implementable by APs with very few antennas We derive closed form expressions for the achievable SE under the assumption of independent Rayleigh fading channel channel estimation error and pilot contamination These closed form expressions are then used to devise optimal max min fairness power control Paper D How to further improve the SE by letting the user estimate the DL channel from DL pilots instead of relying solely on the knowledge of the channel statistics We derive an approximate closed form expression of the DL SE for conjugate beamforming CB and assuming independent Rayleigh fading This expression accounts for beamformed DL pilots estimation errors and pilot contamination at both the AP and the user side We devise a sequential convex approximation algorithm to globally solve the max min fairness power control optimization problem and a greedy algorithm for uplink UL and DL pilot assignment The latter consists in jointly selecting the UL and DL pilot pair for each user that maximizes the smallest SE in the network Paper E A precoding scheme that is more suitable when only the channel statistics are available at the users referred to as enhanced normalized CB It consists in normalizing the precoding vector by its squared norm in order to reduce the fluctuations of the effective channel seen at the user and thereby to boost the channel hardening The performance achieved by this scheme is compared with the CB scheme with DL training described in Paper D Paper F A maximum likelihood based method to estimate the channel statistics in the UL along with an accompanying pilot transmission scheme that is particularly useful in line of sight operation and in scenarios with resource constraints Pilots are structurally phase rotated over different coherence blocks to create an effective statistical distribution of the received pilot signal that can be efficiently exploited by the AP when performing the proposed estimation method The overall conclusion is that cell free massive MIMO is not a utopia and a practical distributed scalable high performance system can be implemented Today it represents a hot research topic but tomorrow it might represent a key enabler for beyond 5G technology as massive MIMO has been for 5G La quinta generazione dei sistemi radiomobili cellulari 5G oggi una realt Le reti 5G si stanno diffondendo in tutto il mondo e i dispositivi 5G ad esempio smartphones tablets indossabili ecc sono gi disponibili sul mercato I sistemi 5G garantiscono livelli di connettivit e di qualit di servizio senza precedenti per fronteggiare l incessante crescita del numero di dispositivi connessi alla rete e della domanda di dati ad alta velocit La tecnologia Massive MIMO multiple input multiple

output riveste un ruolo fondamentale nei sistemi 5G Il principio alla base di questa tecnologia l impiego di un elevato numero di antenne collocate nella base station stazione radio base le quali trasmettono ricevono segnali in maniere coerente a da pi terminali utente Questo co processamento del segnale da parte di pi antenne apporta molteplici benefici guadagno di array diversit spaziale e multiplazione degli utenti nel dominio spaziale Questi elementi consentono di raggiungere i requisiti di servizio stabiliti per i sistemi 5G Tuttavia il limite principale dei sistemi massive MIMO cos come di ogni rete cellulare rappresentato dalla interferenza inter cella ovvero l interferenza tra aree di copertura gestite da diverse base stations la quale riduce in modo significativo le performance degli utenti a bordo cella gi degradate dalle attenuazioni del segnale dovute alla considerevole distanza dalla base station Per superare queste limitazioni e fornire una qualit del servizio uniformemente eccellente a tutti gli utenti necessario un approccio pi radicale e guardare oltre il classico paradigma cellulare che caratterizza le attuali architetture di rete A tal proposito cell free massive MIMO massive MIMO senza celle costituisce un cambio di paradigma ogni utente circondato e servito contemporaneamente da numerose semplici e di dimensioni ridotte base stations denominate access points punti di accesso alla rete Gli access points cooperano per servire tutti gli utenti nella loro area di copertura congiunta eliminando l interferenza inter cella e il concetto stesso di cella Non risentendo pi dell effetto bordo cella gli utenti possono usufruire di qualit di servizio e velocit dati eccellenti Sebbene attraente dal punto di vista delle performance l implementazione di un tale sistema distribuito una operazione impegnativa ed oggetto di questa tesi Piu specificatamente questa tesi di dottorato tratta Articolo A L enorme potenziale di questa promettente tecnologia in scenari realistici sia indoor che outdoor proponendo anche delle soluzioni di implementazione flessibili ed a basso costo Articolo B Come preservare la scalabilit del sistema proponendo soluzioni distribuite riguardanti il processamento e la condivisione dei dati l architettura di rete e l allocazione di potenza ovvero come ottimizzare i livelli di potenza trasmessa dagli access points per ridurre l interferenza tra utenti e migliorare le performance Articolo C Come migliorare l efficienza spettrale in downlink da access point verso utente proponendo due schemi di pre codifica dei dati di trasmissione denominati local partial zero forcing ZF e local protective partial ZF che forniscono un perfetto compromesso tra cancellazione dell interferenza tra utenti ed amplificazione del segnale desiderato Articolo D Come migliorare l efficienza spettrale in downlink permettendo al terminale utente di stimare le informazioni sulle condizioni istantanee del canale da sequenze pilota piuttosto che basarsi su informazioni statistiche ed a lungo termine come convenzionalmente previsto Articolo E In alternativa alla soluzione precedente uno schema di pre codifica che pi adatto al caso in cui gli utenti hanno a disposizione esclusivamente informazioni statistiche sul canale per poter effettuare la decodifica dei dati Articolo F Un metodo per permettere agli access points di stimare in maniera rapida le condizioni di canale su base statistica favorito da uno schema di trasmissione delle sequenze pilota basato su rotazione di fase Realizzare un sistema cell free massive MIMO pratico distribuito scalabile e performante non una utopia Oggi questo concept rappresenta un argomento di ricerca

interessante attraente e stimolante ma in futuro potrebbe costituire un fattore chiave per le tecnologie post 5G proprio come massive MIMO lo stato per il 5G Den femte generationens mobilkommunikationssystem 5G r numera en verklighet 5G n tverk r utplacerade p ett flertal platser v rlden ver och de f rsta 5G kapabla terminalerna s som smarta telefoner surfplattor kroppsburna apparater etc r redan kommersiellt tillg ngliga 5G systemen kan tillhandah lla tidigare o vertr ffade niv er av uppkoppling och servicekvalitet och r designade f r en fortsatt oavbruten tillv xt i antalet uppkopplade apparater och kande datataktskrav Massiv MIMO teknologi eng multiple input multiple output spelar en nyckelroll i dagens 5G system Principen bakom denna teknik r anv ndningen av ett stort antal samlokaliserade antenner vid basstationen d r alla antennerna s nder och tar emot signaler faskoherent till och fr n flera anv ndare Gemensam signalbehandling av m nga antennsignaler ger ett flertal f rdelar s som h g riktverkan via lobformning vilket leder till h gre datatakter samt m jligg r att flera anv ndare utnyttjar samma radioresurser via rumslig anv ndarmultiplexering Eftersom en signal kan g genom flera olika m jligen oberoende kanaler s uts tts den f r flera olika f r ndringar samtidigt Denna m ngfald kar kvaliteten p signalen vid mottagaren och f rb ttrar radiol nkens robusthet och tillf rlitlighet Detta g r det m jligt att uppfylla de h ga kraven p servicekvalitet som fastst llts f r 5G systemen Den st rsta begr nsningen f r massiva MIMO system s v l som f r alla cellul ra mobiln tverk r st rningar fr n andra celler som p verkar anv ndare p cellkanten v sentligt vars prestanda redan begr nsas av str ckd mpningen p radiokanalen F r att vervinna dessa begr nsningar och f r att kunna tillhandah lla samma utm rkta servicekvalitet till alla anv ndare beh ver vi ett mer radikalt angreppss tt vi m ste utmana cellparadigmet I detta avseende utg r cellfri massiv MIMO teknik ett paradigmskifte I cellfri massive MIMO r utg ngspunkten inte att basstationen r omgiven av anv ndare som den betj nar utan snarare att varje anv ndare omges av basstationer som de betj nas av Dessa basstationer ofta mindre och enklare kallas accesspunkter AP I ett s dant system upplever varje anv ndare att den befinner sig i centrum av systemet och ingen anv ndare upplever n gra cellgr nser D rav terminologin cellfri Som ett resultat av detta p verkas inte anv ndarna av inter cellst rningar och str ckd mpningen reduceras kraftigt p grund av n rvaron av m nga accesspunkter i varje anv ndares n rhet Detta leder till imponerande prestanda ven om det r tilltalande ur ett prestandaperspektiv s r utformningen och implementeringen av ett s dant distribuerat massivt MIMO system en utmanande uppgift och det r syftet med denna avhandling att studera detta Mer specifikt studerar vi i denna avhandling A den mycket stora potentialen med denna teknik i realistiska inomhus s v l som utomhusscenarier samt hur man hanterar praktiska implementeringsproblem s som klocksynkronisering bland accesspunkter och kostnadseffektiva implementeringar B hur man ska uppn skalbarhet i systemet genom att f resl l sningar relaterade till databehandling n tverkstopologi och effektkontroll C hur man kar datahastigheten i nedl nken med hj lp av tv nyutvecklade distribuerade verf ringsmetoder som tillhandah ller en avv gning mellan st rningsundertryckning och f rst rkning av nskade signaler utan att ka m ngden intern signalering till de distribuerade accesspunkterna och som kan implementeras i accesspunkter med mycket f antenner D hur man kan f rb ttra prestandan

ytterligare genom att l ta anv ndaren estimera nedl nkskanalen med hj lp av nedl nkspiloter ist llet f r att bara f rlita sig p kunskap om kanalstatistik E en verf ringsmetod f r nedl nk som r mer l mpligt n r endast kanalstatistiken r tillg nglig f r anv ndarna Prestandan som uppn s genom detta schema j mf rs med en ut kad variant av den nedl nk pilotbaserade metoden beskrivet i f reg ende punkt F en metod f r att uppskatta kanalstatistiken i uppl nken samt en tf ljande pilots ndningsmetod som r s rskilt anv ndbart vid direktv gsutbredning line of sight och i scenarier med resursbegr nsningar Den vergripande slutsatsen r att cellfri massiv MIMO inte r en utopi och att ett distribuerat skalbart samt h gpresterande system kan implementeras praktiskt Idag representerar detta ett hett forsknings mne men snart kan det visa sig vara en viktig m jligg rare f r teknik bortom dagens system p samma s tt som centraliserad massiv MIMO har varit f r de nya 5G systemen

**mmWave Massive MIMO** Shahid Mumtaz,Jonathan Rodriguez,Linglong Dai,2016-12-02 mmWave Massive MIMO A Paradigm for 5G is the first book of its kind to hinge together related discussions on mmWave and Massive MIMO under the umbrella of 5G networks New networking scenarios are identified along with fundamental design requirements for mmWave Massive MIMO networks from an architectural and practical perspective Working towards final deployment this book updates the research community on the current mmWave Massive MIMO roadmap taking into account the future emerging technologies emanating from 3GPP IEEE The book s editors draw on their vast experience in international research on the forefront of the mmWave Massive MIMO research arena and standardization This book aims to talk openly about the topic and will serve as a useful reference not only for postgraduates students to learn more on this evolving field but also as inspiration for mobile communication researchers who want to make further innovative strides in the field to mark their legacy in the 5G arena Contains tutorials on the basics of mmWave and Massive MIMO Identifies new 5G networking scenarios along with design requirements from an architectural and practical perspective Details the latest updates on the evolution of the mmWave Massive MIMO roadmap considering future emerging technologies emanating from 3GPP IEEE Includes contributions from leading experts in the field in modeling and prototype design for mmWave Massive MIMO design Presents an ideal reference that not only helps postgraduate students learn more in this evolving field but also inspires mobile communication researchers towards further innovation *MIMO Communication for Cellular Networks* Howard Huang,Constantinos B. Papadias,Sivarama Venkatesan,2011-11-19 As the theoretical foundations of multiple antenna techniques evolve and as these multiple input multiple output MIMO techniques become essential for providing high data rates in wireless systems there is a growing need to understand the performance limits of MIMO in practical networks To address this need MIMO Communication for Cellular Networks presents a systematic description of MIMO technology classes and a framework for MIMO system design that takes into account the essential physical layer features of practical cellular networks In contrast to works that focus on the theoretical performance of abstract MIMO channels MIMO Communication for Cellular Networks emphasizes the practical performance of realistic MIMO systems A unified set of

system simulation results highlights relative performance gains of different MIMO techniques and provides insights into how best to use multiple antennas in cellular networks under various conditions MIMO Communication for Cellular Networks describes single user multiuser network MIMO technologies and system level aspects of cellular networks including channel modeling resource scheduling interference mitigation and simulation methodologies The key concepts are presented with sufficient generality to be applied to a wide range of wireless systems including those based on cellular standards such as LTE LTE Advanced WiMAX and WiMAX2 The book is intended for use by graduate students researchers and practicing engineers interested in the physical layer design of state of the art wireless systems *Energy Efficient and Low Complexity Techniques for the Next Generation Millimeter Wave Hybrid MIMO Systems* Aryan Kaushik,2020 *Design and Implementation of 3GPP-LTE MIMO-OFDM Baseband Processor with Reduced-Complexity MIMO Detector and Precode Codebook Searcher* □□□,2011 **Power Control for Multi-Cell Massive MIMO** Amin Ghazanfari,2019-10-07 The cellular network operators have witnessed significant growth in data traffic in the past few decades This growth occurs due to the increases in the number of connected mobile devices and further the emerging mobile applications developed for rendering video based on demand services As the frequency bandwidth for cellular communication is limited significant effort was dedicated to improve the utilization of the available spectrum and increase the system performance via new technologies For example 3G and 4G networks were designed to facilitate high data traffic in cellular networks in past decades Nevertheless there is a necessity for new cellular network technologies to accommodate the ever growing data traffic demand 5G is behind the corner to deal with the tremendous data traffic requirements that will appear in cellular networks in the next decade Massive MIMO multiple input multi output is one of the backbone technologies in 5G networks Massive MIMO originated from the concept of multi user MIMO It consists of base stations BSs implemented with a large number of antennas to increase the signal strengths via adaptive beamforming and concurrently serving many users on the same time frequency blocks As an outcome of using Massive MIMO technology there is a notable enhancement of both sum spectral efficiency SE and energy efficiency EE in comparison with conventional MIMO based cellular networks Resource allocation is an imperative factor to exploit the specified gains of Massive MIMO It corresponds to properly allocating resources in the time frequency space and power domains for cellular communication Power control is one of the resource allocation methods to deliver high spectral and energy efficiency of Massive MIMO networks Power control refers to a scheme that allocates transmit powers to the data transmitters such that the system maximizes some desirable performance metric In the first part of this thesis we investigate reusing the resources of a Massive MIMO system for direct communication of some specific user pairs known as device to device D2D underlay communication D2D underlay can conceivably increase the SE of traditional Massive MIMO systems by enabling more simultaneous transmissions on the same frequencies Nevertheless it adds additional mutual interference to the network Consequently power control is even more essential in this scenario in

comparison with conventional Massive MIMO systems to limit the interference that is caused between the cellular network and the D2D communication thereby enabling their coexistence In this part we propose a novel pilot transmission scheme for D2D users to limit the interference to the channel estimation phase of cellular users in comparison with the case of sharing pilot sequences for cellular and D2D users We also introduce a novel pilot and data power control scheme for D2D underlaid Massive MIMO systems This method aims at assuring that D2D communication enhances the SE of the network in comparison with conventional Massive MIMO systems In the second part of this thesis we propose a novel power control approach for multi cell Massive MIMO systems The new power control approach solves the scalability issue of two well known power control schemes frequently used in the Massive MIMO literature which are based on the network wide max min and proportional fairness performance metrics We first explain the scalability issue of these existing approaches Additionally we provide mathematical proof for the scalability of our proposed method Our scheme aims at maximizing the geometric mean of the per cell max min SE To solve this optimization problem we prove that it can be rewritten in a convex form and then be solved using standard optimization solvers

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