
Fronthaul Design For Radio Access Networks Using Multicore

Fiber-Wireless Convergence in Next-Generation
Communication Networks

Open RAN Explained

Information Theory for Data Communications and
Processing

Open Radio Access Network (O-RAN) Systems
Architecture and Design

Key Technologies for 5G Wireless Systems

Joint Design of Access and Fronthaul Uplinks in
Cloud Radio Access Networks

Design Principles of 5G NR RoF-Based Fiber-
Wireless Access Network

5G Verticals

NextGen Network Synchronization

5G System Design

Radio Access Network Slicing and Virtualization
for 5G Vertical Industries

Ultra-Dense Networks

Cell-Free Massive MIMO

Joint Design of Wireless Fronthaul and Access
Links in Massive MIMO CRANs

Cloud Radio Access Networks

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Optical Network Design and Modeling
Optical and Wireless Convergence for 5G

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Fiber- Wireless Convergence in Next- Generation Communicati on Networks

John Wiley &
Sons

Presents the components, challenges, and solutions of wireless automation as enablers for industry 4.0 This timely book introduces the state of the art in industrial automation

techniques, concentrating on wireless methods for a variety of applications, ranging from simple smart homes to heavy-duty complex industrial setting with robotics accessibility. It covers a wide range of topics including the industrial revolution enablers, applications, challenges, their possible solutions, and future directions. Wireless Automation as

an Enabler for the Next Industrial Revolution opens with an introduction to wireless sensor networks and their applications in various domains, emphasizing industrial wireless networks and their future uses. It then takes a look at life-span extension for sensor networks in the industry, followed by a chapter on multiple access and resource

<p>sharing for low latency critical industrial networks. Industrial automation is covered next, as is the subject of ultra reliable low latency communications. Other topics include: self healing in wireless networks; cost efficiency optimization for industrial automation; a non event-based approach for non-intrusive load monitoring; wireless networked control; and caching at the edge in low</p>	<p>latency wireless networks. The book finishes with a chapter on the application of terahertz sensing at nano-scale for precision agriculture. Introduces the future evolving dimension in industrial automation and discusses the enablers of the industrial revolution Places particular emphasis on wireless communication techniques which make industrial automation</p>	<p>reliable, efficient, and cost-effective Covers many of the associated topics and concepts like robotics, AI, internet-of-things, telesurgery, and remote manufacturing Of great interest to researchers from academia and industry who are looking at the industrial development from various perspectives Wireless Automation as an Enabler for the Next Industrial Revolution is an excellent</p>
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book for telecom engineers, IoT experts, and industry professionals. It would also greatly benefit researchers, professors, and doctorate and postgraduate students involved in automation and industry 4.0.

Open RAN Explained John Wiley & Sons
This book constitutes the refereed proceedings of the 23rd International IFIP conference on Optical Network Design and

Modeling, ONDM 2019, held in Athens, Greece, in May 2019. The 39 revised full papers were carefully reviewed and selected from 87 submissions. The papers focus on cutting-edge research in established areas of optical networking as well as their adoption in support of a wide variety of new services and applications. This involves the most recent trends in networking

including 5G and beyond, big data and network data analytics, cloud/edge computing, autonomic networking, artificial intelligence assisted networks, secure and resilient networks, that drive the need for increased capacity, efficiency, exibility and adaptability in the functions that the network can perform. In this context new disaggregated optical network architectures

were discussed, exploiting and integrating novel multidimensional photonic technology solutions as well as adopting open hardware and software platforms relying on software defined networking (SDN), and network function virtualization (NFV) to allow support of new business models and opportunities. *Information Theory for Data Communications and*

Processing
Academic Press
This book provides a comprehensive overview of the emerging technologies for next-generation 5G mobile communications, with insights into the long-term future of 5G. Written by international leading experts on the subject, this contributed volume covers a wide range of technologies, research results, and networking methods. Key enabling

technologies for 5G systems include, but are not limited to, millimeter-wave communications, massive MIMO technology and non-orthogonal multiple access. 5G will herald an even greater rise in the prominence of mobile access based upon both human-centric and machine-centric networks. Compared with existing 4G communications systems, unprecedented

d numbers of smart and heterogeneous wireless devices will be accessing future 5G mobile systems. As a result, a new paradigm shift is required to deal with challenges on explosively growing requirements in mobile data traffic volume (1000x), number of connected devices (10–100x), typical end-user data rate (10–100x), and device/network lifetime (10x). Achieving

these ambitious goals calls for revolutionary candidate technologies in future 5G mobile systems. Designed for researchers and professionals involved with networks and communication systems, 5G Mobile Communications is a straightforward, easy-to-read analysis of the possibilities of 5G systems. *Open Radio Access Network (O-RAN) Systems Architecture and Design*

Cambridge University Press
For today, much attention in the upcoming 5G New Radio (NR) mobile networks is paid to radically expanding the available spectral bands up to millimeter wavelengths (MMW). Following this tendency, currently, the local telecommunication commissions of various countries are proposing and harmonizing the plans of frequency

allocation in MMW band, which will be reviewed this year at the World Radio Conference (WRC-2019). Another milestone of great importance is the development of access networks. Here, well-known radio-over-fiber (RoF) technology is considered as the most promising approach, which is implemented based on fiber-wireless (FiWi) architecture. Elaborating

the direction, in this chapter we review the worldwide progress of RoF-architected 5G NR access networks and highlight our last simulation results on design and optimization of millimeter-phonic-based FiWi interface. All schemes are modeled using VPIphotonics Design Suite software tool. In the result of simulation experiments, optimal design principles of optical distribution network (ODN), fiber-

wireless interface (Fwi), and fiber-wireless fronthaul network (FWFN) as a whole have been proposed, described, and validated. *Key Technologies for 5G Wireless Systems* Academic Press This book tackles the 6G odyssey, providing a concerted technology roadmap towards the 6G vision focused on the interoperability between the wireless and

optical domain, including the benefits that are introduced through virtualization and software defined radio. The authors aim to be at the forefront of beyond 5G technologies by reflecting the integrated works of several major European collaborative projects (H2020-ETN-SECRET, 5GSTEPFWD, and SPOTLIGHT). The book is structured so as to provide insights towards the 6G horizon,

reporting on the most recent developments on the international 6G research effort. The authors address a variety of telecom stakeholders, which includes practicing engineers on the field developing commercial solutions for 5G and beyond products; postgraduate researchers that require a basis on which to build their research by highlighting the current challenges on

radio, optical and cloud-based networking for ultra-dense networks, including novel approaches; and project managers that could use the principles and applications for shaping new research proposals on this highly dynamic field. *Joint Design of Access and Fronthaul Uplinks in Cloud Radio Access Networks* John Wiley & Sons This book provides a comprehensive overview of the latest

research and standardization progress towards the 5th generation (5G) of mobile communications technology and beyond. It covers a wide range of topics from 5G use cases and their requirements, to spectrum, 5G end-to-end (E2E) system architecture including core network (CN), transport network (TN) and radio access network (RAN) architecture, network slicing, security and network management.

It further dives into the detailed functional design and the evaluation of different 5G concepts, and provides details on planned trials and pre-commercial deployments across the globe. While the book naturally captures the latest agreements in 3rd Generation Partnership Project (3GPP) New Radio (NR) Release 15, it goes beyond this by describing the likely

developments towards the final 5G system that will ultimately utilize a wide range of spectrum bands, address all envisioned 5G use cases, and meet or exceed the International Telecommunications (IMT) requirements for the year 2020 and beyond (IMT-2020). 5G System Design: Architectural and Functional Considerations and Long Term Research is based on the

knowledge and consensus from 158 leading researchers and standardization experts from 54 companies or institutes around the globe, representing key mobile network operators, network vendors, academic institutions and regional bodies for 5G. Different from earlier books on 5G, it does not focus on single 5G technology components, but describes the full 5G system design

from E2E architecture to detailed functional design, including details on 5G performance, implementation and roll-out. **Design Principles of 5G NR RoF-Based Fiber-Wireless Access Network** John Wiley & Sons This book provides a comprehensive introduction of Fog Radio Access Networks (F-RANs), from both academic and industry perspectives. The authors first introduce the network

architecture and the frameworks of network management and resource allocation for F-RANs. They then discuss the recent academic research achievements of F-RANs, such as the analytical results of theoretical performance limits and optimization theory-based resource allocation techniques. Meanwhile, they discuss the application and implementations of F-RANs,

including the latest standardization procedure, and the prototype and test bed design. The book is concluded by summarizing the existing open issues and future trends of F-RANs. Includes the latest theoretical and technological research achievements of F-RANs, also discussing existing open issues and future trends of F-RANs toward 6G from an interdisciplinary

y perspective; Provides commonly-used tools for research and development of F-RANs such as open resource projects for implementing prototypes and test beds; Includes examples of prototype and test bed design and gives tools to evaluate the performance of F-RANs in simulations and experimental circumstances .
5G Verticals
Artech House
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

NextGen Network Synchronization

John Wiley & Sons
Open RAN EXPLAINED A pioneering outline of the concepts that enhance 5G capabilities to revolutionize the telecommunications industry. Open radio-access network, or Open RAN, is a type of network

architecture in which baseband and radio unit components from different suppliers can operate seamlessly in concert.

Advances in network communication were, until recently, hampered by the proprietary network operations of each mobile operator; the advent of 5G, however, with its service-based architecture model, has finally opened the door to the expansion of connectivity

on the Open RAN model. This transformation promises to define the future of mobile network architecture. Open RAN Explained is among the first books dedicated to this groundbreaking technology. Its comprehensive but accessible summary of current and future developments in Open RAN promises to facilitate network deployment and device

design, as well as to provide a handy reference for network professionals in a range of different fields. The result is a must-read volume for anyone looking to understand the future of wireless communication. Open RAN Explained readers will also find: In-depth description of the challenges and opportunities of network modularization Analysis conversant with the latest

release specifications of the O-RAN Alliance, GSMA OP/TIP, and other key emerging technologies Authors working at the leading edge of 5G network communications Open RAN Explained is ideal for network operators, network element and device manufacturers, telecommunications researchers, and advanced students, as well as industry-adjacent figures such

as regulators, consultants, and marketing professionals. 5G System Design Springer Nature This open access book presents nine outstanding doctoral dissertations in Information Technology from the Department of Electronics, Information and Bioengineering, Politecnico di Milano, Italy. Information Technology has always been highly interdisciplinary, as many aspects have

to be considered in IT systems. The doctoral studies program in IT at Politecnico di Milano emphasizes this interdisciplinary nature, which is becoming more and more important in recent technological advances, in collaborative projects, and in the education of young researchers. Accordingly, the focus of advanced research is on pursuing a rigorous

approach to specific research topics starting from a broad background in various areas of Information Technology, especially Computer Science and Engineering, Electronics, Systems and Controls, and Telecommunications. Each year, more than 50 PhDs graduate from the program. This book gathers the outcomes of the nine best theses defended in 2018-19 and selected for the IT PhD Award. Each

of the nine authors provides a chapter summarizing his/her findings, including an introduction, description of methods, main achievements and future work on the topic. Hence, the book provides a cutting-edge overview of the latest research trends in Information Technology at Politecnico di Milano, presented in an easy-to-read format that will also appeal to non-

specialists.
*Radio Access
Network
Slicing and
Virtualization
for 5G Vertical
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Modern,
current, and
future
communication
aspects
motivate basic
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research for a
wide variety of
systems for
which we do
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Technologies
such as 5/6G
cellular
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s, Internet of
Things (IoT),
and mobile
edge
networks,
among others,
not only
require
reliable rates
of information
measured by
the relevant
capacity and
capacity

regions, but
are also
subject to
issues such as
latency vs.
reliability,
availability of
system state
information,
priority of
information,
secrecy
demands,
energy
consumption
per mobile
equipment,
sharing of
communication
resources
(time/frequenc
y/space), etc.
This book,
composed of a
collection of
papers that
have
appeared in
the Special
Issue of the
Entropy
journal

dedicated to “Information Theory for Data Communications and Processing”, reflects, in its eleven chapters, novel contributions based on the firm basic grounds of information theory. The book chapters address timely theoretical and practical aspects that constitute both interesting and relevant theoretical contributions, as well as direct implications for modern

current and future communications systems. Ultra-Dense Networks Springer Discover how the NG-RAN architecture is, and isn't, ready for the challenges introduced by 5G 5G Radio Access Network Architecture: The Dark Side of 5G explores foundational and advanced topics in Radio Access Network (RAN) architecture and why a re-thinking of that architecture is necessary to support new

5G requirements. The distinguished engineer and editor Sasha Sirotkin has included numerous works written by industry insiders with state of the art research at their disposal. The book explains the relevant standards and technologies from an academic perspective, but also explains why particular standards decisions were made and how a variety of NG-RAN architecture

options could be deployed in real-life networks. All major standards and technologies associated with the NG-RAN architecture are discussed in this book, including 3GPP, O-RAN, Small Cell Forum, IEEE, and IETF. Readers will learn about how a re-design of the RAN architecture would ensure that 5G networks can deliver their promised throughput and low latency KPIs

consistently and sustainably. The book is structured as follows: An overview of the market drivers of the NG-RAN architecture, like spectrum models, 5G-relevant regulatory considerations , and 5G radio interface technical requirements. An overview of the 5G System, from the core network, to the RAN, to the radio interface protocols and physical layer, with emphasis on how these

are different compared to 4G Release-15 RAN architectures defined in 3GPP, O-RAN, and Small Cell Forum RAN architecture evolution in Release-16 and Release-17. Enabling technologies, like virtualization, open source technologies, multi-access edge (MEC) computing, and operations, administration , and management (OAM) NG-RAN deployment considerations , objectives,

and challenges, like costs, spectrum and radio propagation considerations, and coverage. Perfect for network designers and operators who require a solid understanding of the NG-RAN architecture, 5G Radio Access Network Architecture also belongs on the bookshelves of network engineers who aim to increase their understanding of the standards and technologies relevant to the NG-RAN architecture. *Cell-Free Massive MIMO MDPI*

The fifth generation of mobile communication systems (5G) is nowadays a reality. 5G networks are being 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

<p>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</p>	<p>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</p>	<p>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</p>
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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

<p>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</p>	<p>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) è oggi una realtà. Le reti 5G si stanno diffondendo in tutto il mondo e i dispositivi 5G (ad esempio smartphones, tablets, indossabili, ecc.) sono già disponibili sul mercato. I sistemi 5G garantiscono</p>	<p>livelli di connettività e di qualità di servizio senza precedenti, per fronteggiare l'incessante crescita del numero di dispositivi connessi alla rete e della domanda di dati ad alta velocità. La tecnologia Massive MIMO (multiple-input multiple-output) riveste un ruolo fondamentale nei sistemi 5G. Il principio alla base di questa tecnologia è l'impiego di un elevato numero di antenne</p>
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collocate nella base station (stazione radio base) le quali trasmettono/ricevono segnali, in maniere coerente, a/dai più terminali utente. Questo co-processamento del segnale da parte di più antenne apporta molteplici benefici: guadagno di array, diversità spaziale e multiplexing 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, così come di ogni rete cellulare, è 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, già degradate dalle attenuazioni

del segnale dovute alla considerevole distanza dalla base station. Per superare queste limitazioni e fornire una qualità del servizio uniformemente eccellente a tutti gli utenti, è necessario un approccio più 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

<p>cambio di paradigma: ogni utente è 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 più dell'effetto</p>	<p>“bordo-cella”, gli utenti possono usufruire di qualità di servizio e velocità dati eccellenti. Sebbene attraente dal punto di vista delle performance, l'implementazione di un tale sistema distribuito è una operazione impegnativa ed è oggetto di questa tesi. Più specificatamente, questa tesi di dottorato tratta: Articolo A) L'enorme potenziale di questa promettente</p>	<p>tecnologia in scenari realistici sia indoor che outdoor, proponendo anche delle soluzioni di implementazione flessibili ed a basso costo. Articolo B) Come preservare la scalabilità 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</p>
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<p>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</p>	<p>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.</p>	<p>Articolo E) In alternativa alla soluzione precedente, uno schema di pre-codifica che è più 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</p>
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<p>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 è 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</p>	<p>massive MIMO lo è stato per il 5G. Den femte generationens mobilkommunikationssystem (5G) är numera en verklighet. 5G-nätverk är utplacerade på ett flertal platser världen över och de första 5G-kapabla terminalerna (såsom smarta telefoner, surfplattor, kroppsburna apparater, etc.) är redan kommersiellt tillgängliga. 5G-systemen kan tillhandahålla tidigare oöverträffade</p>	<p>nivåer av uppkoppling och servicekvalitet och är designade för en fortsatt oavbruten tillväxt i antalet uppkopplade apparater och ökande datataktkrav. Massiv MIMO-teknologi (eng: multiple-input multiple-output) spelar en nyckelroll i dagens 5G-system. Principen bakom denna teknik är användningen av ett stort antal samlokaliserade antenner vid basstationen,</p>
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där alla antennerna sänder och tar emot signaler faskoherent till och från flera användare. Gemensam signalbehandling av många antenssignaler ger ett flertal fördelar, såsom hög riktverkan via lobformning, vilket leder till högre dataakter samt möjliggör att flera användare utnyttjar samma radioresurser via rumslig användarmultiplexering. Eftersom en signal kan gå genom flera olika, möjligen oberoende kanaler, så utsätts den för flera olika förändringar samtidigt. Denna mångfald ökar kvaliteten på signalen vid mottagaren och förbättrar radiolänkens robusthet och tillförlitlighet. Detta gör det möjligt att uppfylla de höga kraven på servicekvalitet som fastställts för 5G-systemen. Den största begränsningen för massiva MIMO-system såväl som för alla cellulära mobilnätverk, är störningar från andra celler som påverkar användare på cellkanten väsentligt, vars prestanda redan begränsas av sträckdämpningen på radiokanalen. För att övervinna dessa begränsningar och för att kunna tillhandahålla samma utmärkta servicekvalitet till alla användare behöver vi ett mer radikalt angreppssätt: vi måste utmana

<p>cellparadigme t. I detta avseende utgör cellfri massiv-MIMO teknik ett paradigmskift e. I cellfri massive-MIMO är utgångspunkt en inte att basstationen är omgiven av användare som den betjänar, utan snarare att varje användare omges av basstationer som de betjänas av. Dessa basstationer, ofta mindre och enklare, kallas accesspunkter (AP). I ett sådan system</p>	<p>upplever varje användare att den befinner sig i centrum av systemet och ingen användare upplever några cellgränser. Därför terminologin cellfri. Som ett resultat av detta påverkas inte användarna av inter- cellstörningar och sträckdämpni- ngen reduceras kraftigt på grund av närvaron av många accesspunkter i varje användares närhet. Detta leder till</p>	<p>imponerande prestanda. Även om det är tilltalande ur ett prestandapers- pektiv så är utformningen och implementerin- gen av ett sådan distribuerat massivt MIMO- system en utmanande uppgift, och det är 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-</p>
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såväl som utomhusscener, samt hur man hanterar praktiska implementeringsproblem, såsom klocksynkronisering bland accesspunkter och kostnadseffektiva implementeringar; B) hur man ska uppnå skalbarhet i systemet genom att föreslå lösningar relaterade till databehandling, nätverkstopologi och effektkontroll; C) hur man ökar datahastighet

en i nedlänken med hjälp av två nyutvecklade distribuerade överföringsmetoder som tillhandahåller en avvägning mellan störningsundertryckning och förstärkning av önskade signaler, utan att öka mängden intern signalering till de distribuerade accesspunkterna, och som kan implementeras i accesspunkter med mycket få antenner; D) hur man kan förbättra prestandan

ytterligare genom att låta användaren estimerad nedlänkskanalen med hjälp av nedlänkspiloter, istället för att bara förlita sig på kunskap om kanalstatistik; E) en överföringsmetod för nedlänk som är mer lämpligt när endast kanalstatistiken är tillgänglig för användarna. Prestandan som uppnås genom detta schema jämförs med en utökad variant av den nedlänk-

<p>pilotbaserade metoden (beskrivet i föregående punkt); F) en metod för att uppskatta kanalstatistiken i upplänken, samt en åtföljande pilotsändnings metod, som är särskilt användbart vid direktvägsutbredning (line-of-sight) och i scenarier med resursbegränsningar. Den övergripande slutsatsen är att cellfri massiv MIMO inte är en utopi, och att ett distribuerat, skalbart, samt högpresterande</p>	<p>e system kan implementeras praktiskt. Idag representerar detta ett hett forskningsämne, men snart kan det visa sig vara en viktig möjliggörare för teknik bortom dagens system, på samma sätt som centraliserad massiv MIMO har varit för de nya 5G-systemen. <i>Joint Design of Wireless Fronthaul and Access Links in Massive MIMO CRANs</i> IET In-depth coverage of all</p>	<p>technologies required for deployment and further evolution of 5G mobile network backhaul and fronthaul In 5G Backhaul and Fronthaul, a team of communications technology experts deliver an up-to-date and technical discussion of 5G backhaul and fronthaul, preparing readers for the deployment of 5G technologies. In the book, the editors extensively cover the technologies</p>
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essential to 5G mobile network backhaul and fronthaul. They also offer views of further 5G backhaul and fronthaul evolution. 5G Backhaul and Fronthaul serves both general interest readers seeking a primer on what 5G backhaul and fronthaul can provide and advanced-level experts with senior roles in organizations who are already proficient in these

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the refereed post-conference proceedings of the 6st International Conference on IoT as a Service, IoTaaS 2020, which took place in Xi'an, China, in November 2020. Due to COVID-19 pandemic the conference was held virtually. The 69 revised full papers were carefully reviewed and selected from 136 submissions. The papers present two technical tracks and three

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