Tutorial 1:

Short-packet communications – fundamentals and practical coding schemes by Giuseppe Durisi (Chalmers) and Fabian Steiner (TU Munich)

Abstract:
The design of block codes for short information blocks (e.g., a thousand or less information bits) is an open research problem that is gaining increasing relevance because of emerging applications in the area of low latency wireless communication. In this tutorial, we shall review the fundamental tradeoff between throughput and reliability when transmitting short packets, using recently-developed tools in finite-blocklength information theory. We will then describe the state-of-the-art code constructions (involving binary/nonbinary LDPC and turbo codes, polar codes, and tailbiting convolutional codes) for the short-block regime, and compare their performance with nonasymptotic information-theoretic limits.

Specifically, we will illustrate how to achieve performance close to the theoretical bounds with different performance vs. decoding complexity trade-offs. A special emphasis will be given to the LDPC and polar code solutions selected within 3GPP for eMBB data and control channel signaling.

Biographies:
Giuseppe Durisi received the Laurea degree summa cum laude and the Doctor degree both from Politecnico di Torino, Italy, in 2001 and 2006, respectively. From 2006 to 2010 he was a postdoctoral researcher at ETH Zurich, Zurich, Switzerland. In 2010, he joined Chalmers University of Technology, Gothenburg, Sweden, where he is now professor with the Communication Systems Group and co-director of Chalmers ICT Area of Advance and of Chalmers AI research centre.
Dr. Durisi is a senior member of the IEEE. He is the recipient of the 2013 IEEE ComSoc Best Young Researcher Award for the Europe, Middle East, and Africa Region, and is co-author of a paper that won a “student paper award” at the 2012 International Symposium on Information Theory, and of a paper that won the 2013 IEEE Sweden VTCOM-IT joint chapter best student conference paper award. In 2015, he joined the editorial board of the IEEE Transactions on Communications as associate editor. From 2011 to 2014, he served as publications editor for the IEEE Transactions on Information Theory. His research interests are in the areas of communication and information theory and machine learning.

Fabian Steiner was born in Prien am Chiemsee, Germany. He received the B.Sc. degree and M.Sc. degree (with high distinction) in electrical engineering from the Technical University of Munich (TUM), Germany, in 2011 and 2014, respectively. He is now working toward the Ph.D. degree at the Institute for Communications Engineering, TUM. He is supervised by Prof. Gerhard Kramer. His current research interest include coding, modulation and multi-user massive MIMO systems. He received the Prof. Dr. Ralf Kötter memorial award for his master’s thesis and won the third prize of the 2015 Bell Labs Prize with his proposal on probabilistic shaping for capacity achieving and rate adaptive communication.

Tutorial 2:

5G Cellular-V2X by Tommy Svensson (Chalmers), Mikael Fallgren (Ericsson), Antonio Eduardo Fernandez Barciela (PSA), Zexian Li (Nokia), Laurent Gallo (Orange Labs), Toktam Mahmoodi (KCL), Bastian Cellarius (Ericsson)

Abstract: This tutorial will give an introduction to 5G cellular V2X (Vehicle-to-Everything), and elaborate on key use cases, requirements and technical enablers with a special focus on the research outcomes from the EU H2020 5GPPP 5GCAR project (https://5gcar.eu/). The main objectives within the 5GCAR project has been to develop an overall 5G system architecture providing optimized end-to-end V2X network connectivity for highly reliable and low-latency V2X services, which supports security and privacy, manages quality-of-service and provides traffic flow management in a multi-RAT and multi-link V2X communication system; Interworking of multi-RATs that allows embedding existing communication solutions and novel 5G V2X solutions; Develop an efficient, secure and scalable sidelink interface for low-latency, high-reliability V2X communications; Propose 5G radio-assisted positioning techniques for both vulnerable road users and vehicles to increase the availability of very accurate localization; Identify business models and spectrum usage alternatives that support a wide range of 5G V2X services; and Demonstrate and validate the developed concepts and evaluate the quantitative benefits of 5G V2X solutions using automated driving scenarios in test sites. In this tutorial we will also highlight recent academic research results for beyond 5G in the area of network assisted vehicular communications.

Biographies:

Tommy Svensson is Full Professor in Communication Systems at Chalmers University of Technology in Gothenburg, Sweden, where he is leading the Wireless Systems research on air interface and wireless backhaul networking technologies for future wireless systems. He received a Ph.D. in Information theory from Chalmers in 2003, and he has worked at Ericsson AB with core networks, radio access networks, and microwave transmission products. He was involved in the European WINNER and ARTIST4G projects that made important contributions to the 3GPP LTE standards, the EU FP7 METIS and the EU H2020 5GPPP mmMAGIC 5G projects, and currently in the EU H2020 5GPPP 5GCar project, as well as in the Chase On antenna systems excellence center at Chalmers targeting mm-wave solutions for 5G access, backhaul and V2X scenarios. His research interests include design and analysis of physical layer algorithms, multiple access, resource allocation, cooperative systems, moving networks, and satellite networks. He has co-authored 4 books, 80 journal papers, 121 conference papers and 52 public EU projects deliverables. He is Chairman of the IEEE Sweden joint Vehicular Technology/ Communications/ Information Theory Societies chapter and editor of IEEE Transactions on Wireless Communications, and has been editor of IEEE Wireless Communications Letters, Guest Editor of several top journals, organized several tutorials and workshops at top IEEE conferences, and served as coordinator of the Communication Engineering Master's Program at Chalmers.

Mikael Fallgren is a Senior Researcher at Ericsson Research, Stockholm, Sweden. He has received a M.Sc. degree in engineering physics and a Ph.D. degree in applied and computational mathematics from KTH (the Royal Institute of Technology), Stockholm, and a B.Sc. degree in business administration from Stockholm University. His research interests include V2X and wireless access networks. In the METIS project he led the work on scenarios and requirements as well as on dissemination and standardization. He was editor for two chapters of the book: 5G Mobile and wireless communications technology. Dr. Fallgren is the 5GCAR project coordinator (https://5gcar.eu/).

Tutorial 3:

Part I: 5G NR positioning by Basuki Priyanto (Sony)
Part II: low power MTC/NR by Nafiseh Mazloum (Sony)

Abstract Part I:
We will present an overview of positioning in 5G NR. NR positioning poses many challenges than the predecessor (e.g. LTE). It includes the need to be operated in both FR1 and FR2, supporting many deployment scenarios (outdoor, indoor, etc), and to support both regulatory and demanding commercial positioning requirements. First, the potential NR positioning use-cases and its requirements will be presented. NR radio access has many new features, such as wider bandwidth, and beam management operation. In addition, some potential NR positioning techniques have been identified. We will present the details of those techniques and also how to utilize NR new features to improve positioning accuracy.

Abstract Part II:
To support IoT applications through cellular connectivity, several enhancements have been introduced to LTE, by adding new features to reduce the device cost and complexity, and also enabling connectivity for large number of devices covering all types of communication between machines. In this presentation, we will give an overview of massive Machine Type Communication (mMTC) features. Energy efficiency is one of the key requirement for mMTC/IoT devices. We discuss in more detail power savings schemes for mMTC and potential future NR IoT devices which allow low power operation.

Biographies:
Basuki Priyanto received the M.Eng degree in electrical and electronic engineering from Nanyang Technological University, Singapore in 2002 and the Ph.D. degree in wireless communications from Aalborg University, Denmark in 2008. From 2005 to 2008 he was an external researcher at Nokia Networks. From 2008 to 2012 he worked with baseband algorithm unit at Ericsson Mobile Platform. From 2012 to 2014 he was a Senior specialist at Huawei Technologies Sweden. He is currently with research and standardization at Sony Research Center Lund as Master Engineer. His research interests include positioning techniques in cellular network and optimization of machine type communications (MTC), in particular related to low power consumption, and radio access protocol.

Nafiseh Mazloum received the M.Sc. degree in Digital Communication Systems and Technology from Chalmers University in 2008 and the Ph.D. degree in Radio Systems from Lund University in 2016. From 2000 to 2006, she worked as a hardware design engineer at Catalyst Enterprises Inc (acquired by LeCroy), in Tehran, Iran. From 2007 to 2008 she was with the Distributed Sensor Systems Department at Philips Research Eindhoven, the Netherlands. Since 2017, she works as a researcher at the Radio Access Lab., Sony Research Center Lund, Sweden. Her main research focus is on low-power wireless communication systems.

Tutorial 4:

NR Physical Layer
by Robert Baldemair and Claes Tidestav (Ericsson)

Abstract:
In this presentation we will give an overview over the NR physical layer. Compared to earlier mobile communication standards, NR has a much wider operating range stretching from sub-1 GHz to several 10 GHz, operates over much wider bandwidth, provides lower latencies, and has a very lean design enabling energy efficient operation. We will present NR design choices such as frame structure, modulation and numerology, control channels, reference signals, coding, and multi-antennas techniques enabling these extended operating characteristic. Operations in mmW bands require high-gain beamforming and as a consequence communication will often be beam-based, beam management becomes therefore an essential part of NR mmW operations. Fundamentals on NR beam management will discussed.

Biographies:
Robert Baldemair received his Dipl. Ing. and Dr. degree from the Vienna University of Technology in 1996 and 2001, respectively. From 1996 to 2000 he was a research assistant at the Vienna University of Technology. In 2000 Robert joined Ericsson where he initially was engaged in research and standardization of digital subscriber line technologies ADSL and VDSL. Since 2004 Robert has been working with research and development of radio access technologies for LTE and since 2011 with wireless access for 5G. Currently he holds a Master Researcher position at Ericsson.
Robert received the Ericsson Inventor of the Year 2010 award, an award Ericsson awards to employees with substantial contributions to Ericsson's patent portfolio. In 2014 he and colleagues at Ericsson were nominated for the European Inventor Award, the most prestigious inventor award in Europe, for their contribution to LTE.
Robert's research interests include signal processing and communication theory for wireless communications systems.

Claes Tidestav received his M.Sc. and PhD degrees from Uppsala university in 1994 and 1999, respectively. Between 1999 and 2003, he worked with Systems management for early 3G development with Ericsson, before joining Ericsson research. Between 2003 and 2008, he worked with radio network algorithms for 3G systems, and between 2008 and 2014 he led the research on radio network algorithms at Ericsson Research. Since 2015, Claes has worked with radio network algorithms, in particular related to the advanced antenna aspects. In recent years, Claes has worked with advanced antenna solutions for 5G, with particular focus on mmW systems. Currently, he holds a Principle Researcher position at Ericsson.

Claes' research interests include radio network algorithms, in particular related to advanced antenna systems and the interaction with higher layer protocols.

Decentralized Equalizer Construction for Large Intelligent Surfaces

Juan Vidal Alegría, Jesús Rodríguez Sánchez, Fredrik Rusek, Liang Liu, and Ove Edfors

Department of Electrical and Information Technology, Lund University

E-mail: {juan.vidal_alegria, jesus.rodriguez_sanchez, fredrik.rusek, liang.liu, ove.edfors}@eit.lth.se

Abstract: In this poster we present fully decentralized methods for calculating an approximate zero-forzing (ZF) equalizer in a large intelligent surface (LIS). A LIS is intended for wireless communication and facilitates unprecedented MU-MIMO performance, far superior to that of Massive MIMO. Antenna modules in the grid connect to their neighbors to exchange messages of information needed for interference cancellation in a fully de-centralized fashion, making the system scalable. By a careful design of how the messages are routed, we show that the proposed method is able to cancel inter-user interference sufficiently well without any centralized coordination, opening the door for the realization of this type of structures.

Improving Short-Length LDPC Codes with a CRC and Iterative Ordered Statistic Decoding

Wei Zhou, Michael Lentmaier

Department of Electrical and Information Technology, Lund University, Sweden

E-mail: wei.zhou@eit.lth.se, michael.lentmaier@eit.lth.se

Abstract: We present a CRC-aided LDPC coding scheme that can outperform the underlying LDPC code under ordered statistic decoding (OSD). In this scheme, the CRC is used jointly with the LDPC code to construct a candidate list, instead of conventionally being regarded as a detection code to prune the list generated by the LDPC code alone. As an example we consider a (128, 64) 5G LDPC code with BP decoding, which we can outperform by 2 dB using a (128, 72) LDPC code in combination with a 8-bit CRC under OSD of order $t = 3$. The proposed decoding scheme for CRC-aided LDPC codes also achieves a better performance than the conventional scheme where the CRC is used to prune the list. A manageable complexity can be achieved with iterative reliability based OSD, which is demonstrated to perform well with a small OSD order.

On LSB Data Hiding in High-Definition Images Using Morphological Operations

Dang Ninh Tran, Hans-Jürgen Zepernick, and Thi My Chinh Chu

Sweden Blekinge Institute of Technology, SE-371 79 Karlskrona, Sweden

E-mail: dnt@bth.se, hjz@bth.se, cch@bth.se

Abstract: The aim of steganography is to conceal the presence of communication by way of hiding secret data in perceptually irrelevant parts of a cover object. In this paper, we propose a method for hiding secret images in edge regions of high-definition (HD) images because the human visual system is less sensitive to intensity changes in these regions. In particular, least significant bit substitution is used to embed a secret image in the edge regions of a HD cover image. The edge regions are obtained using a Canny edge detector followed by morphological operations which are used to control the hiding capacity. A performance assessment of the proposed method reveals the trade-off between capacity, detectability, and perceptibility of the hidden data.

Reference: This paper has been submitted to IEEE International Symposium on Communications and Information Technologies, 25-27 March 2019, Ho Chi Minh City, Vietnam.

Objective Perceptual Video Quality Prediction Using Spatial and Temporal Information Differences

Majed Elwardy, Hans-Jürgen Zepernick, Thi My Chinh Chu, and Veronica Sundstedt

Blekinge Institute of Technology, SE-371 79 Karlskrona, Sweden

E-mail: mew@bth.se, hjz@bth.se, cch@bth.se, vsu@bth.se

Abstract: In this paper, objective perceptual video quality models are proposed that use spatial and temporal perceptual information differences for predicting video quality as perceived by human observers. Spatial perceptual information characterizes the complexity and temporal perceptual information quantifies the motion contained in a video. As such, differences in the spatial and temporal perceptual information of a reference video (original) and test video (processed) may be used to predict the quality of videos that have undergone encoding, transmission, or other processing. In particular, several video quality prediction functions are derived using curve fitting along with training and validation on data from a publicly available annotated database. The obtained functions provide predicted mean opinion scores as a measure of perceptual quality subject to spatial and temporal perceptual information differences. The analysis of the video quality prediction performance of the proposed models shows that differences in spatial and temporal perceptual information can be used for objective video quality prediction.

Reference: This paper has been submitted to the IEEE International Symposium on Communications and Information Technologies, 25-27 September 2019, Ho Chi Minh City, Vietnam.

Sum Spectral Efficiency Maximization in Massive MIMO Systems: Benefits from Deep Learning

Trinh Van Chien, Emil Björnson, and Erik G. Larsson

Department of Electrical Engineering (ISY), Linkoping University, SE-581 83 Linköping, Sweden

Abstract: This paper investigates the joint data and pilot power optimization for maximum sum spectral efficiency (SE) in multi-cell Massive MIMO systems, which is a non-convex problem. We first propose a new optimization algorithm, inspired by the weighted minimum mean square error (MMSE) approach, to obtain a stationary point in polynomial time. We then use this algorithm together with deep learning to train a convolutional neural network to perform the joint data and pilot power control in sub-millisecond runtime, making it suitable for online optimization in real multi-cell Massive MIMO systems. The numerical result demonstrates that the solution obtained by the neural network is 1% less than the stationary point for four-cell systems, while the sum SE loss is 2% in a nine-cell system.

Reference: This paper has been accepted for oral presentation at 2019 IEEE International Conference on Communications (ICC).

Scalability Aspects of Cell-Free Massive MIMO

Giovanni Interdonato[1], Pål Frenger[2] and Erik G. Larsson[1]

[1]Department of Electrical Engineering (ISY), Linköping University, 581 83 Linköping, Sweden,

[2]Ericsson Research, 581 12 Linköping, Sweden

Abstract: Ubiquitous cell-free massive MIMO (multiple-input multiple-output) combines massive MIMO technology and user-centric transmission in a distributed architecture. All the access points (APs) in the network cooperate to jointly and coherently serve a smaller number of users in the same time-frequency resource. However, this coordination needs significant amounts of control signalling which introduces additional overhead, while data co-processing increases the back/front-haul requirements. Hence, the notion that the "whole world" could constitute one network, and that all APs would act as a single base station, is not scalable. In this study, we address some system scalability aspects of cell-free massive MIMO that have been neglected in literature until now. In particular, we propose and evaluate a solution related to data processing, network topology and power control. Results indicate that our proposed framework achieves full scalability at the cost of a modest performance loss compared to the canonical form of cell-free massive MIMO.

Reference: Accepted for publication in Proceedings of IEEE International Conference on Communications (ICC) 2019, 20-24 May 2019. Link: https://arxiv.org/abs/1902.11275.

Rate Adaptation in Predictor Antenna Systems

Hao Guo, Behrooz Makki and Tommy Svensson

Chalmers University of Technology, Sweden

Abstract: Predictor antenna (PA) system is referred to as a system with two sets of antennas on roof of a vehicle, where the PAs positioned in the front of the vehicle are used to predict the channel state observed by the receive antennas (RAs) that are aligned behind the PAs. This letter studies the performance of PA systems in the presence of the miss-matching problem, i.e., when the channel observed by the PA is not exactly the same as the channel experienced by the RA. Particularly, we study the effect of spatial miss-matching on the accuracy of channel state information estimation and rate adaption. We derive closed-form expressions for instantaneous throughput, outage probability, and the throughput-optimized rate adaptation. Also, we take the temporal evolution of the channel into account and evaluate the system performance in temporally-correlated conditions. The simulation and analytical results show that, while PA-assisted adaptive rate adaptation leads to considerable performance improvement, the throughput and the outage probability are remarkably affected by the spatial miss-match and temporal correlations.

Reference: H. Guo, B. Makki and T. Svensson, "Rate Adaptation in Predictor Antenna Systems," submitted to IEEE Wireless Communications Letters, April. 2019.

Full Downlink Channel Reconstruction using Incomplete Uplink Channel Measurements in Massive MIMO Networks

Aleksei Fedorov[1], Haibo Zhang[2], Galina Sidorenko[2], and Bo Yang[3]

[1]Department of Electrical and Information Technology, Lund University,

[2]Department of Computer Science, University of Otago

[3]Shang Hai Jiao Tong University

Abstract: The continuously increasing demand on high throughput wireless communication has forced the communication technology to integrate more antennas at both base station and user equipment sides to exploit the advantages of Multi-Input Multi-Output systems to increase the capacity of the wireless channel. From the BS side, Massive MIMO, as one of the key technologies for 5G networks, tends to integrate even hundreds of antennas at one base station. From the UE side, the existing flagman smartphones such as Samsung S8, Note9, and Sony XZ already have four antennas. In 2018, Qualcomm unveils the first mmWave 5G antennas for smartphones, which can support up to 16 antennas in one smartphone. While more and more antennas are integrated into single mobile user equipment to increase communication quality and throughput, the number of antennas used for transmission is commonly restricted due to the concerns on hardware complexity and energy consumption, making it impossible to achieve the maximum channel capacity.

The project investigates the problem of reconstructing the full downlink channel from incomplete uplink channel measurements in Massive MIMO systems. We present ARDI, a scheme that builds a bridge between the radio channel and physical signal propagation environment to link spatial information about the non-transmitting antennas with their radio channels. By inferring locations and orientations of the non-transmitting antennas from an incomplete set of uplink channels, ARDI can reconstruct the downlink channels for non-transmitting antennas. We derive a closed-form solution to reconstruct antenna orientation in both single-path and multi-path propagation environments. The performance of ARDI is evaluated using simulations with realistic human movement. The results demonstrate that ARDI is capable of accurately reconstructing full downlink channels when the signal-to-noise ratio is higher than 15dB, thereby expanding the channel capacity of Massive MIMO networks.

Reference: This paper has been recently accepted for publication in IFIP Networking 2019.

Codes on Graphs with Trellis Constraints

Muhammad Umar Farooq, Saeedeh Moloudi, and Michael Lentmaier

Department of Electrical and Information Technology, Lund University, Sweden

E-mail: muhammad.umar_farooq@eit.lth.se, michael.lentmaier@eit.lth.se

Abstract: It is established in [1] that with braided convolutional codes (BCC), a class of spatially coupled turbo-like codes (TCs) defined by a (2,3) regular graph, it is possible to achieve very competitive thresholds due to the threshold saturation phenomenon. BCCs have better maximum a-posteriori probability (MAP) thresholds than the classical TCs, such as serially concatenated codes (SCCs) and parallel concatenated codes (PCCs), which are defined on irregular graphs. For low-density parity-check (LDPC) codes with regular graphs, it is known that the MAP threshold achieves capacity as the variable node degree of the graph increases. The aim of this work is to investigate the trade-off between variable node degree and component code memory for TCs. In particular, we define a family of Tcs with regular graphs, which generalize the original BCC ensemble. We analyze BP thresholds, MAP thresholds and minimum distance for (2,3), (4,6), (6,9) TC ensembles of rate 1/3 and (2,4), (3,6), (4,8) TC ensembles of rate ½ and compare them to the corresponding LDPC code ensembles.

[1] S. Moloudi, M. Lentmaier and A.G. i Amat, “Spatially Coupled Turbo-Like Codes,” *IEEE Trans. on Inform. Theory*, vol. 63, no. 10, Oct. 2017.

Ultra-Reliable and Low-Latency Wireless Communication for Control

Christian Nelson[1], Paul Rigge[2], and Fredrik Tufvesson[1]

[1]Department of Electrical and Information Technology, Lund University, Sweden,

[2]Department of Electrical Engineering and Computer Sciences, UC Berkeley, USA

Abstract: Industry 4.0 and autonomous vehicles are two fields which are rapidly advancing. Both areas have in common that they will rely on low-latency and ultra-reliable wireless communication to optimize performance. To put the controller on the cloud, or for safety-critical systems, the round-trip latency must be less than 2 ms, and the bit error rate (BER) must not exceed 10^{-9}. The wireless communication protocols used today cannot meet both these requirements at the same time. They are designed for other purposes than control, e.g., high throughput or low energy consumption. There exist work to tweak some of these standards, but to really solve the issue at its core a new communications protocol is needed. We are assuming that the network is fixed and connected in a star or in a daisy chain topology with the controller at the center. The requirements can be achieved by greatly simplifying or combining the network layer with the MAC layer and eliminating higher levels of the protocol. With smart network coding and using channel prediction, to use the best relays, will reduce the latency and improve the BER. At a nominal SNR of 5 dB, simulations achieve a latency < 2 ms with a BER of 10^{-9} using only 3 relays. In the current work, channel measurements are being performed to verify the theory.

On Emptying a Wireless Network with Minimum-Energy under Age Constraints

Qing He, Gyorgy Dan and Viktoria Fodor

Division of Network and Systems Engineering, School of Electrical Engineering and Computer Science,

KTH Royal Institute of Technology, Stockholm, Sweden

Abstract: Timely information delivery and low energy consumption are of critical importance for a variety of wireless applications. In this paper, we address the link scheduling problem of emptying a network with minimum energy, subject to a maximum peak age constraint for each information source. We formulate the minimum-energy scheduling with age constraints (MESA) problem in its general form and prove that it is NP-hard. We derive fundamental results, such as lower and upper bounds of the minimum energy consumption, and the conditions when a TDMA schedule is optimal. We propose the deadline-first- with-revision (DFR) algorithm for constructing a scheduling solution, and evaluate its performance under two rate functions. Numerical results show that DFR achieves a significant energy reduction compared to a minimum age scheduling solution.

Reference: The paper has been recently presented at the AoI workshop in Infocom 2019.

Phase Calibration for Massive MIMO Directional Estimation

Guoda Tian, Fredrik Rusek, Harsh Tataria, Fredrik Tufvesson

Department of Electrical and Information Technology, Lund University

Abstract: Positioning is an interesting application that can benefit from the many antennas used in massive MIMO systems. However, in order to efficiently access the information in the angular domain, it is necessary to estimate the amplitude gains and the phase shifts introduced by the individual receive antennas and the corresponding RF chains. In this work we formulate the mathematical model for accurate receiver calibration, calculate the Cramer-Rao lower bound and derive the corresponding estimator.

A Fair and Scalable Power Control Scheme in Multi-Cell Massive MIMO

Amin Ghazanfari, Hei Victor Cheng, Emil Björnson, and Erik G. Larsson

Department of Electrical Engineering (ISY), Linkoping University, SE-581 83 Linköping, Sweden,

Xuhong Li, Erik Leitinger, Magnus Oskarsson, Kalle Åström, Fredrik Tufvesson

Abstract: This paper studies the transmit power optimization in a multi-cell massive multiple-input multiple-output (MIMO) system. To overcome the scalability issue of network-wide max-min fairness (NW-MMF), we propose a novel power control (PC) scheme. This scheme maximizes the geometric mean (GM) of the per-cell max-min spectral efficiency (SE). To solve this new optimization problem, we prove that it can be rewritten in a convex form and then solved using standard tools. To provide a fair comparison with the available utility functions in the literature, we solve the network-wide proportional fairness (NW-PF) PC as well. The NW-PF focuses on maximizing the sum SE, thereby ignoring fairness, but gives some extra attention to the weakest users. The simulation results highlight the benefits of our model which is balancing between NW-PF and NW-MMF.

Reference: This paper is accepted for ICASSP2019.

Massive MIMO-based Localization and Mapping Exploiting Phase Information of Multipath Components

Xuhong Li[1], Erik Leitinger[1,2], Magnus Oskarsson[3], Kalle Åström[3], Fredrik Tufvesson[1]

[1]Department of Electrical and Information Technology, Lund University, Sweden,

Email:{xuhong.li, fredrik.tufvessong@eit.lth.se}

[2]Signal Processing and Speech Communication Laboratory, Graz University of Technology, Austria,

Email:erik.leitinger@tugraz.at

[3]Mathematical Sciences, Lund University, Lund University, Sweden,

Email:{magnuso, kalleg@maths.lth.se}

In this work, we present a multipath-based localization and mapping framework that exploits the phases of specular multipath components (MPCs) using a massive multiple-input multiple output (MIMO) array at the base station. Utilizing the phase information related to the propagation distances of the MPCs enables the possibility of localization with extraordinary accuracy even with limited bandwidth. The specular MPC parameters along with the parameters of the noise and the dense multipath component (DMC) are tracked using an extended Kalman filter (EKF), which enables to preserve the distance-related phase changes of the MPC complex amplitudes. The DMC comprises all non-resolvable MPCs, which occur due to finite measurement aperture. The estimation of the DMC parameters enhances the estimation quality of the specular MPCs and therefore also the quality of localization and mapping. The estimated MPC propagation distances are subsequently used as input to a distance-based localization and mapping algorithm. This algorithm does not need prior knowledge about the surrounding environment and base station position. The performance is demonstrated with real radio-channel measurements using an antenna array with 128 ports at the base station side and a standard cellular signal bandwidth of 40 MHz. The results show that high accuracy localization is possible even with such a low bandwidth.

A 28 GHz Channel Sounder for Dynamic Propagation Measurements

Erik Bengtsson[1,2], Harsh Tataria[2], Peter Karlsson[1], Fredrik Tufvesson[2], and Ove Edfors[2]

[1]Radio Access Lab, Sony Research Center Lund, Sweden,

[2]Department of Electrical and Information Technology, Lund University, Sweden

A pre-requisite for the design and performance assessment of future wireless systems is the understanding of the involved propagation processes, and derivation of insightful channel models. In this paper, we present a novel 28 GHz multiple-input multiple-output (MIMO) channel sounder for characterizing the dynamic propagation behavior. Based on the switched array principle, our design is capable of measuring 256x128, dual polarized, directionally resolved channels with a switching rate of approximately us. Unlike previous systems, this extraordinary angular resolution is complemented with a 1 GHz measurement bandwidth enabling nanosecond delay resolution. To this end, a complete MIMO snapshot can be acquired in real time with 380 ms, in sharp contrast to tens of minutes with rotating horn antenna sounders. The short measurement time combined with the high phase stability of radio frequency up/down-conversion chains facilitates phase-coherent measurements. This allows for tracking of multipath components over time to investigate the temporal dependencies of channel parameters. With this high resolution look at the channel, we recalibrate the conventional beliefs around channel sparsity at 28 GHz. Overall, the paper discusses the most important aspects of sounder design, as well as sample results from directional channel measurements performed at Lund University, Sweden.