Topics for the MSCSP
Student Research Projects
Advanced Research Projects
Summer Semester 2013

Selection of topics until
April 12, 2013.
RF and Microwave Research Laboratory

Head: Prof. Dr. rer. nat. habil. Matthias Hein

RF transistors for low-loss electronically tunable circuits

Responsible Professor: Prof. Matthias Hein
Research Assistant: MSc. Stefanie Kühn
stefanie.kuehn@tu-ilmenau.de

• Description
The RF design of transistors is common use. However, they usually differ strongly in their figure-of-merits like noise figure, power gain, efficiency, depending on transistor technology and bias configuration. This project focuses on a study of transistors optimally suited for low-loss electronically tuneable metamaterial circuits.

• Tasks
– Literature study of hetero-bipolar and field-effect transistors for high-frequency applications
– Numerical simulation of selected transistors with Agilent ADS
– Simulation of a representative class of transistor circuits in ADS

• References
2. Anholt, R.: “Electrical and thermal characterization of MESFETs, HEMTs and HBTs”; Artech House; 1995

Focus
1 student theory / programming / simulation / hardware / measurements / protocols
Active RF metamaterial transmission lines

Responsible Professor: Prof. Matthias Hein
Research Assistant: MSc. Stefanie Kühn
stefanie.kuehn@tu-ilmenau.de

• Description
At RF frequencies, the so-called metamaterials represent quasi-homogeneous lumped-element circuits with exciting properties, that can beneficially be used for the composition of ultra-wideband or multi-band tuneable devices. This project focuses on the investigation of the key properties of elementary cells of such circuits.

• Tasks
– Literature study on metamaterials, with a focus on recent results of our research partner at Electrotechnical University St. Petersburg
– Numerical circuit simulation and optimisation of circuits like the one shown in the figure, and discussion of the results

• References (basic literature)

Focus
1 student                    theory / programming / simulation / hardware / measurements / protocols

Design of longitudinal-mode RF-MEMS resonators
(already assigned)

Responsible Professor: Prof. Matthias Hein
Research Assistant: MSc. Dmitry Podoskin
dmitry.podoskin@tu-ilmenau.de

• Description
The efficiency of novel piezoelectric RF-MEMS resonators for stable and programmable oscillator circuits is determined by the quality factor Q and the electromechanical coupling factor κ. These quantities themselves result from the geometrical dimensions and mechanical and electrical properties of the resonator materials. This project aims at elementary design contributions to RF-MEMS oscillators in the framework of an interdisciplinary DFG research unit (Forscherguppe).

• Tasks
– Analytical approach to estimate Q-factor and electromechanical coupling factor κ as a function of geometric and material parameters
– Numerical simulation of electrical transmission behaviour
– Identification of useful geometries providing high Q and high κ

• References (basic literature)

Focus
1 student                    theory / programming / simulation / hardware / measurements / protocols
Data center Bridging (DCB) defines several standards for Ethernet network to enhance the functionality of the network with regard to the use case of data centers. The main goal is to integrate an adequate quality of service support to the Ethernet network. The strategy for this typically consists of several aspects like congestion notification, flow signaling and a distributed management.

Tasks:
- Summarize the functionality of DCB and evaluate it theoretically
- Create a small OMNeT++ simulation to verify some of these assumptions (basic programming knowledge is recommended)

References:
- corresponding IEEE standards (802.1Qbb, 802.1Qau, …)

Focus
- theory / programming / hardware / measurements / protocols, 1 student
Simulation of a Management-Middleware
(already assigned)

Responsible Professor: Prof. Jochen Seitz
Research Advisor: M.Sc. Markus Hager
E-Mail: markus.hager@tu-ilmenau.de

- **Description:** Many networks are based on simple protocols to keep it predictable and reliable. Nevertheless, in several use-cases a more complex behavior is required, e.g. to support some quality of service features. One common way to enhance networks with regard to these requirements is, instead of changing the networks protocols, to use a middleware. The advantage is, that it could be applied to many networks and offers a more flexible interface as compared to typical network protocols but introduces additional overhead as well. The task of this project is to evaluate typical functionalities of such a middleware approach with a special focus on the overhead introduced by such a solution.

- **Tasks:**
  - Define two different strategies for a network management realized by a middleware
  - Implement these scenarios using OMNeT++ and check the overhead caused by the middleware management (basic programming knowledge is recommended)

- **References:**

- **Focus** theory / programming / hardware / simulation / protocols, 1 student

Reliable Multicast in Mobile Ad-hoc Network (MANET) (already assigned)

Responsible Professor: Prof. Jochen Seitz
Supervisor: Dipl.-Inf. (FH) Peggy Begerow

- **Description:** Reliable multicast in mobile ad-hoc network (MANET) giant significance. Many different approaches exists. List and compare the existing protocols. Consider the group management.

- **Tasks**
  - Search for useable approaches
  - Compare the found solutions (theoretical).
  - Evaluate 1 protocol in ns3.

- **References**
  - IEEE Xplore.
  - google

- **Focus** theory/evaluation, 1 student
**Reliable Multicast in Delay Tolerant Networks (DTN)**
(already assigned)

**Responsible Professor:**  Prof. Jochen Seitz

**Supervisor:**  Dipl.-Inf. (FH) Peggy Begerow

- **Description:**
  Reliable multicast in delay tolerant networks (DTN) giant significance. Many different approaches exist. List and compare the existing protocols. Consider the group management.

- **Tasks**
  - Search for useable approaches
  - Compare the found solutions (theoretical).
  - Evaluate 3 protocols in ns3.

- **References**
  - IEEE Xplore.
  - google

**Focus**

1 student  theory/evaluation

---

**Resource management in Mobile Ad Hoc Networks (MANETs) using SNMP**
(already assigned)

**Responsible Professor:**  Prof. Jochen Seitz

**Research Advisor:**  M.Sc. Aymen Al-Ani

**E-Mail:**  Aymen-dawood.al-ani@tu-ilmenau.de

- **Description:**
  Management applications in MANETs include network monitoring, configuration and control of network and node resources (like battery life and bandwidth). The resource management plays the major role in the QoS provisioning and efficient utilization of network resources. In MANETs monitoring of radio parameters and nod activity is essential for effective transmission, optimal route calculation and QoS support. To achieve optimum end to end transmission it is necessary to take into account following information: (topology change, link characteristics, node activity, and node resources).

- **Tasks**
  - Theoretical research of the SNMP (Sample Network Management Protocol).
  - Implementation of SNMP using AODV router.
  - Simulation and validation of the protocol using NS3.

- **References**
  - SNMP/ click: https://github.com/kohler/click-packages
  - NS3: http://www.nsnam.org/
  - AODV/ click: https://github.com/patsqi

- **Focus**
  - theory / programming , 1 students
Investigating Ad Hoc MAC Protocols using OMNET++ (already assigned)

Responsible Professor: Prof. Jochen Seitz
Supervisor: M.Sc. Amina Arkoub

• **Description:** Real time application require QoS aware protocols. The aim here is to investigate the possible ways to achieve QoS at the MAC layer for wireless ad hoc networks.

• **Tasks**
  - Literature study on current QoS aware MAC protocols for wireless ad hoc networks
  - Implementation of such a protocol in Omnet++
  - Compare to the 802.11/802.11e protocol

• **References**

• **Focus**
  1 student  theory / programming / hardware / measurements

---

The Simulations of P2P-Pastry Algorithm: Research and explore (already assigned)

Responsible Professor: Prof. Jochen Seitz
Supervisor: Dipl.-Ing. Mais Hasan

• **Description:** A simulation is an attempt to model a system in order to study it scientifically. Simulations are the most popular tool for examine P2P applications. Pastry is one of the DHT-algorithms which is usually simulated with different Simulators like PeerfactSim.KOM, FreePastry and PeerSim.

• **Tasks**
  - Theoretical research of the Pastry Algorithm and its available Simulations
  - Researching the Applications which use these Simulations
  - Comparison between these Simulations (from the perspective of development opportunity)

• **References**
  http://peerfact.kom.e-technik.tu-darmstadt.de
  http://www.freepastry.org/Freepastry/
  https://sites.google.com/site/peerfactsimkom/news
  http://peersim.sourceforge.net/

• **Focus**
  1 student  theory / programming / hardware / measurements
To address nodes via their location, some work has been spent in the development of Geocast addressing and routing. With such mechanisms, it is possible to send a packet to all the nodes in a defined region. In this project, a mechanism for location-based packet delivery should be developed based on a routing-based name resolution mechanism. The developed concept should be implemented and validated using the C++-based Network Simulator 3 (ns3).

**Tasks**
- Literature survey on Geocast name resolution
- Geocast concept using an existing name resolution mechanism (under queries with the supervisor)
- Implementation and simulation of the algorithm in ns3

**References**
1. Thomas Finke, Sebastian Schellenberg: Name Resolution in MANETs using Adaptive Routing
2. Imielinski et al. – GPS-Based Addressing and Routing (IETF RFC 2009)

**Focus**
- 2 student
- theory / programming / hardware / measurements
**Interacting multiple models for multiple target tracking**

**Responsible Professor:** Prof. Reiner Thomä  
**Supervisor:** Snezhana Jovanoska  

- **Description:** The aim of this project is to incorporate and analyze the effect of IMM for multiple target tracking. IMM estimator is a suboptimal hybrid filter able to estimate the state of a dynamic system with several behaviour modes which can switch from one to another.

- **Tasks:**
  - Literature review
  - Algorithm implementation
  - Measurements
  - Result analysis

- **References:**

- **Focus**
  1 student theory / programming / hardware / measurements

---

**Doppler and micro-doppler effects for target characterization and tracking**

**Responsible Professor:** Prof. Reiner Thomä  
**Supervisor:** Snezhana Jovanoska  

- **Description:** The idea of this project is to examine the feasibility of using Doppler processing to detect and track human motion in indoor environment by multistatic UWB radar. Micro-doppler characteristics of humans should also be investigated.

- **Tasks:**
  - Literature review
  - Perform measurements
  - Result analysis – algorithm implementation

- **References:**
  - Y. He et al. 'Range-Doppler processing for indoor human tracking by multistatic ultra-wideband radar', IRS 2012
  - S. S. Ram et al. 'Doppler-based detection and tracking of humans in indoor environments', Journal of the Franklin Institute, 2008
  - T. Thayaparan et al. 'Micro-Doppler based target detection and feature extraction in indoor and outdoor environments', Journal of the Franklin Institute, 2008

- **Focus**
  2 students theory / programming / hardware / measurements
A Comprehensive Study on Leakage Based Precoding (SLR) and Regularized Block Diagonalization (RBD)

**Responsible Professor:** Prof. Dr.-Ing. Martin Haardt  
**Supervisor:** M. Sc. Jianshu Zhang  
**E-Mail:** {jianshu.zhang}@tu-ilmenau.de

**Description:**  
Multi-user MIMO precoding techniques are key solutions to the future cellular network. Among them leakage based precoding (SLR) and regularized block diagonalization (RBD) algorithm have many similarities.

**Tasks**  
- Understanding RBD and SLR  
- Implement and compare the algorithms under various MIMO system setups  
- Understanding analytically the connection between these two algorithms

**References**  

**Focus**  
1 student, theory / programming / hardware / measurements / protocols
Massive MIMO Techniques for Relay Broadcast Channel

Responsible Professor: Prof. Dr.-Ing. Martin Haardt
Research Adviser: M. Sc. Jianshu Zhang
E-Mail: {jianshu.zhang}@tu-ilmenau.de

- **Description:**
  MIMO techniques are becoming mature, and incorporated into emerging mobile broadband standard like LTE. Very large MIMO systems, or massive MIMO is a new research field in wireless communications. The ultimate vision is that the antenna array consists of extremely low power elements facilitates inexpensive fabrication of the antennas and the robust performance of the system.

- **Tasks**
  - Literature study of massive MIMO techniques
  - Study random matrix theory and its application to MIMO
  - Apply massive MIMO concept to the relay broadcast channel

- **References**

- **Focus**
  1 student, theory / programming / hardware / measurements / protocols

---

Coordinated beamforming for two-users MIMO broadcast channels with limited feedback

Responsible Professor: Prof. Martin Haardt
Supervisor: Bin Song

- **Description:**
The system employs limited feedback strategy to provide the channel state information (CSI) to the base station. Two quantization schemes are studied. One performs vector quantization scheme to quantize the channel directly. Another exploits the structure of the coordinated beamforming to avoid full channel quantization.

- **Tasks**
  - Literature study on coordinated beamforming and quantization schemes.
  - Investigate the sum rate performance with quantized CSI.
  - Evaluate the performance comparison in terms of achieved sum rate and overhead.

- **References**

- **Focus**
  1 student, theory / programming / hardware / measurements
Coordinated Beamforming (FlexCoBF) in time-variant correlated broadcast channels

Description:
A coordinated beamforming algorithm (FlexCoBF) is studied in the presence of a time-variant correlated multi-user MIMO channels.

Tasks
- Literature study on coordinated beamforming (FlexCoBF) and basic concepts in limprop.
- Investigate the achievable sum rate in realistic limprop scenario.
- Evaluate the effect of the long-term CSI on the achievable sum rate.

References

Focus
1 student                  theory / programming / hardware / measurements

On the Performance of Linear Precoding-based Geometric Mean Decomposition (LP-GMD) in Critical Scenarios

Description:
Endowed with the potential of combining the benefits of both MIMO processing and the space-division multiple access (SDMA), multi-user MIMO downlink has received great research attention. Among various linear precoding algorithms designed for multi-user MIMO downlink transmissions, linear precoding-based geometric mean decomposition (LP-GMD) is able to mitigate the multi-user interference and to allow an effective equal modulation and coding scheme (MCS) implementation on all the spatial streams of each user. Yet the performance of LP-GMD in critical scenarios (e.g., with bad-conditioned channels) has not been investigated.

Tasks
- Study linear precoding techniques developed for multi-user MIMO downlink with SDMA
- Investigate the performances of LP-GMD in different channel conditions
- Work on the solutions of possible performance degradation of LP-GMD in a certain channel condition

References

Focus
1 student                  theory / programming / hardware / measurements
Survey on MIMO techniques for Filter Bank Multicarrier (FBMC) systems

Description:
Filter bank multicarrier (FBMC) systems have the potential of enabling an effective utilization of the available fragmented spectrum in heterogeneous radio environments. Until recently, new space diversity and multiplexing algorithms have been developed to exploit the particularities of FBMC.

Tasks
- Study the concept of FBMC and get to know its superiority over orthogonal frequency-division multiplexing (OFDM)
- Investigate the state-of-the-art MIMO techniques developed for FBMC systems via a thorough literature study as well as extensive MATLAB simulations
- Work on extensions of the current algorithms

References

Focus
1 student theory/programming/hardware/measurements

Cluster based Cooperative MIMO-Simulations in SONIR
Supervisor: Bilal Zafar

Description:
We have built a software SONIR (Self-Organizing Network with Intelligent Relaying), in MATLAB, which implements an end-to-end multi-hop, virtual MIMO system, capable of dealing with mobility of nodes in a Rayleigh fading environment. Different methods for clustering, mobility management, routing, virtual MIMO, etc. have been implemented. These methods work on different OSI layers. Our main goal is to be able to visualize such a system as a whole in order to see the end-to-end performance as well as solve the possible issues that arise with it.

Tasks
- Work with the existing programmers to understand and improve the already implemented algorithms.
- Be able to integrate work by other students working on cluster based cooperative MIMO systems into the simulator
- Expand the existing environment to be able to include more scenarios, fixed infrastructure such as base stations and tailoring schemes to fit some industry standard like WiFi, Wimax, 802.11s etc.

Focus
1 student theory/programming

Contact the supervisor, Room 3502 Helmhotzbau for more details.
Investigation of FBMC with Cooperative MIMO in SONIR

Supervisor: Tilahun Melkamu, Bilal Zafar

• Description: The main idea of co-operative MIMO is the recruitment of nearby idle nodes to assist transmitting and receiving data thus transmitting nodes use idle nodes as relays to reduce multi-path fading effect in wireless channels. This creates a "Virtual MIMO" system in which we can achieve MIMO gains even with one antenna per-node. We would like to investigate cooperative MIMO with FBMC (Filter-bank Multi-carrier) modulation technique and perform this implementation in our matlab-based network simulator SONIR (Self-Organized Network with Intelligent Relaying).

• Requirements: Very strong programming skills in MATLAB and strong concepts of mobile communications.

• Tasks
  - Investigate the performance of FBMC in cooperative MIMO scenarios
  - Comparison with OFDM
  - Implementation/integration in SONIR
  - (please contact the supervisors, Room 3502 Helmhotzbau, for more details)

• Focus 1 student theory / programming

Performance comparison of FBMC/OQAM based and CP-OFDM based two-way relaying

Supervisors: Tilahun Melkamu Getu and Jianshu Zhang

• Description: In this advanced research project, we would like to investigate the bit error rate (BER) performance of FBMC/OQAM and CP-OFDM for temporal-synchronous and asynchronous two-way relaying scenarios with single antenna at the two transmitters and a relay over a frequency selective channel between the relay and transmitters. For simplicity, the composite global channel state information (CG-CSI) will be assumed available at the transmitters.

• Requirements: Basic knowledge of cooperative and multicarrier communications, good knowledge of Matlab programming, and simulation of communications systems using Matlab

• Tasks: BER performance curves for FBMC/OQAM versus CP-OFDM over a frequency selective channel for temporal synchronous and asynchronous two-way relaying scenario having a single antenna at both transmitters and a relay
  - (please contact the supervisors, Room 3502 Helmhotzbau, for more details)

• Focus 1 student theory / simulation
Widely-Linear Distributed Beamforming Based on the Relay Power Minimization (already assigned)

Responsible Professor: Prof. Martin Haardt
Research Advisor: M.Sc. Jens Steinwandt
E-Mail: jens.steinwandt@tu-ilmenau.de

- **Description:**
  In many distributed beamforming applications, the transmitted signals are second-order noncircular and widely-linear processing can be applied to exploit the noncircularity to improve the performance of the conventional distributed beamforming algorithms. In this research project, a new approach to widely-linear distributed beamforming is to be developed that minimizes the consumed relay power subject to quality of service constraints.

- **Tasks:**
  - Understanding the concept of distributed beamforming
  - Study of widely-linear processing and its application to distributed beamforming
  - Simulating the performance of the distributed widely-linear beamformer

- **References:**

- **Focus:**
  1 student
  theory & programming

Compressive Sensing Based DOA Estimation (already assigned)

Responsible Professor: Prof. Martin Haardt
Research Advisor: M.Sc. Jens Steinwandt
E-Mail: jens.steinwandt@tu-ilmenau.de

- **Description:**
  In recent studies, it was shown that parameter estimation methods based on a sparse representation of the sensor measurements with an overcomplete basis composed of samples from the array manifold is an effective approach that allows for high resolution capabilities. The sparsity is enforced by imposing penalties based on the 1-norm. However, the estimation errors can be further reduced through a weighted regularization, which will be investigated in this research project.

- **Tasks:**
  - Understanding the concept of direction of arrival estimation
  - Study of sparsity-aware processing through regularization
  - Verification and comparison of the results presented in the given reference with conventional DOA estimation techniques

- **References:**

- **Focus:**
  1 student
  theory & programming
Constant Envelope Modulation

Responsible Professor: Prof. Martin Haardt
Research Advisor: Dr. Mike Wolf
E-Mail: mike.wolf@tu-ilmenau.de

- Description:
RF identification in medical environments demands for transmission techniques which ensure a very low electromagnetic interference. For that reason, various constant envelope modulation schemes shall be investigated and compared.

- Tasks:
  - Energy and bandwidth efficiency of various constant envelope modulation schemes in AWGN
  - Coherent detection vs. non-coherent detection
  - Implementation issues
  - Effect of transmitted signal on transistor/diode operation points

- References:

- Focus: 1 student theory & programming