Topics for the MSCSP
Student Research Projects
Advanced Research Projects
Winter Semester 2012 / 2013

Selection of topics until
October 5, 2012.
Robust Widely-Linear Adaptive Beamforming

Description:
In many beamforming applications, the received signals are second-order noncircular and widely-linear processing is applied to exploit the noncircularity to improve the performance of the conventional beamformers. However, the direction of the desired user and its noncircularity coefficient need to be known a priori. In this research project, a robust approach to widely-linear beamforming is to be developed that can deal with the uncertainties in the array steering vector and the noncircularity coefficient.

Tasks:
- Understanding the concept of adaptive beamforming
- Study of widely-linear processing and robustness against signal mismatch
- Simulating the performance of the robust widely-linear beamformer

References:

Focus:
theory & programming - 1 student
Large-Scale Tensor Decompositions on Sparse Data

Responsible Professor: Prof. Martin Haardt, Prof. Gerald Schuller

Supervisor: Yao Cheng, Jianshu Zhang

• Description:
Tensor decompositions are powerful tools to analyze multidimensional data. They take advantage of the R-D structure in the data with particularly large gains for data that possesses a low-rank structure in multiple dimensions. An example are sparsely interconnected graphs, which appear in data mining applications, such as social network analysis or web search. The goal of the project is to review tensor decompositions that apply to large-scale sparse data and perform MATLAB simulations to demonstrate their effectiveness.

• Tasks
- review state of the art in large-scale tensor decompositions, including but not limited to Streaming Tensor Analysis [1], greedy PARAFAC [2], Memory-Efficient Tucker [3], etc. (there are a lot more)
- survey related data-mining applications, such as web search [2], social networks [4], and others [5]
- perform own MATLAB simulations based on existing or own implementations

• References

• Focus: 1-2 students theory / programming / hardware / measurements / protocols

Very Large MIMO Systems for Relay Networks

Responsible Professor: Prof. Martin Haardt

Research Adviser: M. Sc. Jianshu Zhang, Yao Cheng

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• 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 relay networks

• References

• Focus: 1 student, theory / programming / hardware / measurements / protocols
Channel Estimation and Tracking for Bi-directional Relaying in a MIMO-OFDM System

Responsible Professor: Prof. Martin Haardt
Research Adviser: M. Sc. Jianshu Zhang, Yao Cheng
E-Mail: {jianshu.zhang, y.cheng}@tu-ilmenau.de

• Description:
In standard cellular systems, e.g., LTE, reference symbols (pilots) are used to perform the channel estimation and thus facilitate the coherent detection. As pilots consume bandwidth and power, the attainable accuracy of pilot-aided channel estimation (PACE) schemes needs to be traded off with the incurred degradation in spectral efficiency.

• Tasks
– Understand and implement LS and MMSE type PACE techniques for bi-directional relaying in a SISO-OFDM system
– Derive novel channel tracking algorithms and tracking performance analysis
– Extend the framework to MIMO-OFDM system

• References

• Focus
1 student, theory / programming / hardware / measurements / protocols

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, Yao Cheng
E-Mail: {jianshu.zhang, y.cheng}@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
Convex optimization is one advanced linear algebra which is intensively used in the research of electrical engineering. The common convex optimization solvers are SeduMi, SDPT3, Mosek. However, none of the above solvers is specified for large-scale SDP problems with complex variables.

- **Tasks**
  - Understanding semidefinite programming (SDP) problems
  - Develop a common framework for solving the SDP problem using the aforementioned solvers
  - Apply the framework to wireless communication problems

- **References**

- **Focus**
  1 student, theory / programming / hardware / measurements / protocols
Acknowledgment handling in a message oriented middleware

**Responsible Professor:** Prof. Jochen Seitz  
**Supervisor:** Dipl.-Ing. Karsten Renhak

**Description:**  
If a client (consumer) receives a message from an AMQP-message oriented middleware (MOM) it has to send an acknowledgment to the server. How is it possible to inform the sender (producer) about positive and negative acknowledgments?

**Tasks:**  
- Familiarization with the topic  
- Investigate about ack-handling in rabbitMQ MOM  
- Develop a scenario to inform the producer about ack status, discuss possible error cases  
- Create a testbed with at least one message producer and one consumer to perform positive and negative ack’s and further imitate possible error scenarios.

**References**  
Please ask the supervisor

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

Implementation of a quality of service mechanism for wireless ad hoc networks

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

**Description**  
QoS refers to a set of parameters/metrics to be met on a network so that it can support a desired service, mostly multimedia and real time services. These metrics are mainly: bandwidth, delay, jitter, and packet loss rate. However, ensuring a minimum bandwidth or/bounded end to end delays remains very challenging in wireless ad hoc networks where resources are limited and time dependent.

**Tasks**  
- Define a layer to work on, e.g., MAC layer  
- Survey existing QoS protocols, approaches or mechanisms for that layer  
- Investigate and implement an agreed QoS mechanism

**References**  

**Focus**  
1 student  
theory / programming / hardware / measurements
Investigation of distributed clock synchronization methods for wireless ad hoc networks

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

• Description:
Synchronization is often assumed in many mechanisms and applications of communication networks. It also plays an important role in the MAC layer for access scheduling, quality of service support and power conservation. The aim of this work is to investigate distributed synchronization methods that can be found in literature for wireless ad hoc networks.

• Tasks
– Write a survey on distributed synchronization methods for wireless ad hoc networks
– Implementation

• References
please ask the supervisor

• Focus
  1 student  theory / programming / hardware / measurements

Reliable Multicast in Delay Tolerant Networks (DTN)

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

• Description:
Reliable multicast in delay tolerant networks (DTN) giant significance. Many different approaches exists. List and compare the existing 30 bases. Consider the group management.

• Tasks
– Search for useable approaches
– Compare the found solutions on critical
– Evaluate 3 protocols in ns3

• References
– IEEE Xplore.
– google

Focus
  1 student  theory / evaluation
Reliable Multicast in Mobile Ad-hoc Network (MANET)

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 3 protocols in ns3

References:
- IEEE Xplore.
- google

Focus: 1 student theory / evaluation

Evaluation of Data Center Bridging

Description: 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
The Simulations of P2P-Pastry Algorithm: Research and explore

**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 examining 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://peerfact.kom.e-technik.tu-darmstadt.de)  
  [http://www.freepastry.org/FreePastry](http://www.freepastry.org/FreePastry)  
  [https://sites.google.com/site/peerfactsimkom/news](https://sites.google.com/site/peerfactsimkom/news)  

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

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Implementation and Simulation of the Low Latency Ad hoc On-Demand Distance Vector Routing Protocol

**Responsible Professor:** Prof. Jochen Seitz  
**Supervisor:** M.Sc. Sebastian Schellenberg  
**Supervisor:** Dipl.-Ing. (FH) Thomas Finke

- **Description:**
  In the Communication Networks Group, a low latency extension for the well known AODV routing protocol was developed. In the scope of this work, the extension should be implemented based on an existing AODV implementation in the Click Modular Router (C++ based). The programmed protocol should be simulated and validated in the discrete event simulator network simulator 3 (C++ based).

- **Tasks**
  - Understanding the LLAODV protocol based on a paper
  - Implementation of the low latency extension in Click
  - Simulation and validation of the protocol in ns3

- **References**

- **Focus**
  1 student  theory / programming / hardware / measurements
Ant Colony Optimization Based Routing for Mobile Ad Hoc networks

Responsible Professor: Prof. Jochen Seitz  
Research Advisor: M.Sc. Aymen Al-Ani  
E-Mail: Aymen-dawood.al-ani@tu-ilmenau.de

- **Description:**
  Due to the dynamic nature of MANETs, the primary challenge of these networks is the design of an effective routing algorithm that can adapt to frequent and rapid changes in MANETs. Ant Colony algorithms (ACO) tend to provide properties such as adaptivity and robustness, which are essential to deal with the challenges of MANETs. The Ant Colony based solution for wireless ad hoc routing is more appealing because it easily fits into the dynamic nature of MANET. It provides adaptivity, flexibility, robustness and even efficiency to the applied system to make them prime requisites in such environment.

- **Tasks:**
  Designing algorithms using ACO and apply it using NS3.

- **References:**

- **Focus:**
  theory / programming / hardware / measurements / protocols, 1 students

Usage of Hash Functions for Traffic Reduction in Name Resolution Mechanisms

Responsible Professor: Prof. Jochen Seitz  
Supervisor: M.Sc. Sebastian Schellenberg  
Dipl.-Ing. (FH) Thomas Finke

- **Description:**
  To reduce traffic during name resolution, known names could be transmitted in a hashed form to have less traffic. In the scope of this work, a hashing extension to a name resolution mechanism should be implemented based on existing AODV and OLSR implementation in the Click Modular Router (C++ based). The programmed mechanism should be simulated and validated in the discrete event simulator Network Simulator 3 (C++ based).

- **Tasks:**
  – Literature survey on hashing and name resolution
  – Implementation of hashing module based on existing routing protocols in Click
  – Simulation and validation of the new mechanism in Network Simulator 3 (ns3)

- **References:**

- **Focus:**
  theory / programming / hardware / measurements
Merging Optimization and Game Theory for Cognitive Radios Networks

Responsible Professor: Prof. Andreas Mitschele-Thiel
Supervisor: Ali Haider Mahdi

• Description:
  Unstable radio environment is one of the main problems facing the communication systems, especially Cognitive Radios (CRs), where each CR node tries to access the network and consume more resources, which has a negative effect on other nodes. Our idea is to merge optimization with Game theory to develop a mechanism that defines the best network behaviour.

• Task:
  - Literature study on Game theory and Particle swarm optimization
  - Define a mechanism to merge mentioned algorithms in one algorithm
  - Simulate the algorithm on different network scenarios
  - Compare the results with previous works

• Requirements:
  - Knowledge of MATLAB simulator

• Focus: 1 student theory / programming
Analysis of ARQ schemes in high-delay networks

Responsible Professor: Prof. Andreas Mitschele-Thiel
Research Advisor: André Puschmann
E-Mail: andre.puschmann@tu-ilmenau.de

- **Description:**
  Simple Stop-and-Wait automatic repeat request (ARQ) schemes are known to only provide low performance, especially in networks with high communication delay and packet loss. More advanced schemes such as selected repeat or Go-back-N promise higher performance under these circumstances.

- **Tasks:**
  Find, select and study appropriate algorithms. Evaluate and discuss their performance analytically. Implement them in C++ either using network simulator (OMNeT++ or SDR framework) and study performance of implementation.

- **References**

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

 Evaluation of blind rendezvous algorithms for CRNs

Responsible Professor: Prof. Andreas Mitschele-Thiel
Research Advisor: André Puschmann
E-Mail: andre.puschmann@tu-ilmenau.de

- **Description:**
  Blind rendezvous in the field of Cognitive Radio networks describes how two or more nodes initially set up a network in order to start communicating with each other without the help of a centralized controller or control channel. In the literature, multiple algorithms have been proposed which aim at guaranteeing rendezvous or minimizing the time to rendezvous (TTR).

- **Tasks:**
  Find, select and study appropriate algorithms. Evaluate and discuss their performance analytically. Implement and simulate them in your preferred programming language, such as C++, Python or Matlab.

- **References**

- **Focus** theory / programming / measurements / protocols, 1 student
Study the using of Tabu search algorithm, Multi-armed bandit and Ant Colony in Cognitive Radios Networks

Description:
Link configuration is still one of the main issues in wireless communication systems, especially Cognitive Radios (CRs), where each CR node has to keep communication under dynamic environment and unstable Primary Users (PUs) activities. Our issue is to study the link configuration and decision making by each algorithm.

Task:
- Literature study on Tabu search, Multi-armed bandit and Ant colony
- Define a mechanism to implement mentioned algorithms in CR
- Simulate the algorithms on different network scenarios
- Compare the results with previous works

Requirements:
- Knowledge of MATLAB simulator

Focus
1 student
theory / programming
Active Compensation Techniques for Accurate Sound Field Reproduction Systems

Description:
A fundamental signal processing problem in acoustics is to control the sound field within a given region. Its origin is in three-dimensional (3-D) audio or surround sound systems, which have become increasingly popular over the past few decades. The ultimate goal of such systems is to manipulate and render a fully 3-D aural environment in real time that gives the listener the impression of being immersed in a realistic, yet virtual sound environment. Most of the works performed on this integral rely on three-dimensional Kirchhoff-Helmholtz for source of errors in the approximation of the integral. Simplifying assumptions are and will degrade the performance of a practical system by

Tasks:
- Literature survey on state-of-the-art of 3D spatial sound capturing and reproduction techniques
- Literature survey on deficiency of the available methods
- Literature survey on signal processing techniques used to compensate the resulting artifacts
- Establishing a simple simulation framework showing the effect of different parameters on the accuracy of the designed sound field

References:

Focus: theory / programming / hardware / measurements / protocols, 1 student
Statistical Analysis of Large Scale Parameters from RIMAX Estimation Results

Responsible Professor: Prof. Reiner Thomä
Supervisor: C. Schneider & M. Käske

- **Description:**
  To develop suitable channel models such as WINNER I+II so called large scale parameters (LSP) like the delay spread (DS), the transmission loss (TL), shadow fading (SF), XPR and the narrowband K-factor as well as statistics from the angular domain as azimuth of arrival (AoA), elevation of arrival (EoA) and departure (AoD) are needed. The LSP’s have a fundamental role, because they are scenario dependent parameters they control the behaviour of the modelled channel. The research work is based on results of the high resolution multipath parameter estimator RIMAX.

- **Tasks:**
  - Read and understand the concept of large scale parameter (LSP) and their auto- and cross-correlations
  - Investigate calculation of Shadow Fading (SF), K-factor as well as spreads from AoA, EoA, AoD, DS and XPR, (equations and text) from RIMAX data sets.
  - Implement the algorithms in Matlab
  - Compare your results with given performances and reliability of real measurement

- **References**

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

Influence of Considering AGC on Noise and Dynamic Estimation of MIMO Snapshots

Responsible Professor: Prof. Reiner Thomä
Supervisor: C. Schneider & M. Käske

- **Description:**
  The RUSK MIMO channel sounder, available at TU Ilmenau, is equipped with an automatic gain control (AGC) for each of the individual MIMO subchannels. Using the AGC can result in varying noise levels of the different subchannels. Different approaches are possible to reduce the impact of the noise, e.g. temporal gating (windowing). The aim of this work is to investigate different noise estimation approaches and how they can be extended to AGC dependent measurements. Furthermore, the impact of different noise levels and reduction procedures to the overall statistics of the MIMO channel, e.g. noise variance, Rayleigh and Rice distributions is to be investigated.

- **Tasks:**
  - Study the AGC concept and noise estimation algorithm available in literature
  - Understand and use available noise level estimation algorithm available at the lab
  - Develop, discuss and implement at least 2 different approaches of noise and dynamic estimation considering AGC feature of the MIMO sub channel measurement
  - Compare performances and reliability with real measurement

- **References**

- **Focus**
  1 students theory / programming / hardware / measurements
RF and Microwave Research Laboratory

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