Topics for the MSCSP

Advanced Research Projects

Summer Semester 2015
Selection of topics and submission of topic sheets until April 16, 2015.
Department of Electrical Engineering and Information Technology

Institute for Information Technology

Division of Communication Networks

Head: Prof. Dr. rer. nat. habil. Jochen Seitz
Recently, VANETs (Vehicular Ad Hoc Networks) and their applications have become increasingly popular. A VANET consists of vehicles acting as wireless mobile devices. These are distributed, dynamic, and do not use any predefined infrastructure or centralized administration.

- Theoretical research of VANET routing protocols.
- Generate a file for mobility traces based on NS3 highway mobility model or SUMO.
- Compare two VANET routing protocols with regard to QoS based on simulation runs.

- NS3 Highway mobility: [https://code.google.com/p/ns-3-highway-mobility/](https://code.google.com/p/ns-3-highway-mobility/)

Focus

- 1 student
- theory / programming / hardware / simulation / measurements
Description
Communication in Intelligent Transport Systems known as Internet of Vehicles (IoV) demands a different perspective in the decentralized routing process which are not offered currently by traditional routing techniques. This research is focused in the problem of routing, in the context of Internet of Vehicles (IoV), using Social Networking Strategies specially in the Neighbor Discovery, Situational Awareness and Service Recovery Management components with emphasis in the Self-Organization of the routing process. The goal of this project is to carry out a comparison of Social Strategies and selection of the two best routing solutions. For the simulations of the selected routing solutions will be used SUMO and OMNeT++. The conclusions of this project should propose improvements in the routing process.

Tasks
- Literature survey of Self-Organized IoV routing approaches based on Social-Driven Strategies
- Theoretical comparison of strategies and selection of the best routing solutions
- Implementation and simulative comparison of the two best solutions in SUMO and OMNeT++
- Conclusions and scheme of improvements

References

Focus
2 student theory / programming / hardware / measurements
Network Information Management in Heterogeneous Environment

Responsible Professor: Prof. Jochen Seitz
Supervisor: Atheer Al-Rubaye

• **Description:**
Collection and exchange of information related to network resources and users experience between entities in heterogeneous environments play a major role in handover decision.

• **Tasks**
  – Literature study on network management protocols.
  – Hands on the OmneT++ network simulator.
  – Implementing the proposed approach in the simulator.

• **References**

• **Focus**
  1 student  theory / programming / hardware / measurements
Vehicular Ad-hoc Networks (VANETs) are considered as the first deployed large-scale mobile ad-hoc networks, in which each vehicle is considered as a mobile node. It provides the ability for the vehicles to communicate with each other and exchange information (called Vehicle-To-Vehicle (V2V)). The target of this project is to evaluate the performance of standard MAC protocol in VANETs in terms of collisions, delay and throughput in a realistic scenario.

**Tasks**
- Literature survey on existing MAC protocols for VANETs
- Implementation and Simulation of standard MAC protocol
- Concept for further enhancements

**References**


**Focus**
1 student  
theory / programming / hardware / measurements
Multi-criteria decision framework for OmneT++

Responsible Professor: Prof. Jochen Seitz
Supervisor: Atheer Al-Rubayye

- **Description:**
  Decision algorithms that consider multiple parameters are significant for network selection in heterogeneous networks environment to provide seamless handover.

- **Tasks**
  - Literature study on multi-criteria algorithms.
  - Hands on the OmneT++ network simulator.
  - Implementing the AHP algorithm as a framework in the simulator.

- **References**

- **Focus**
  1 student theory / programming / hardware / measurements
Evaluating Terrain Aware 3D Propagation for MANETs

Description:
Common simulation environments consider 2D propagation only. However, if Mobile Ad Hoc Networks (MANETs) are applied to an outdoor use case, the terrain and other obstacles have an impact on the signal strength and thus the resulting topology. The goal of this project is to implement one approach presented by Filiposka et. al [1] in ns3 and to evaluate the impact on default MANETs with respect to connectivity and routing protocol performance.

Tasks
- Literature survey on 3D propagation models and comparison with [1]
- Implementation of the approach in [1] in ns3
- Evaluation of the impact on MANET scenarios

References

Focus
1 student theory / programming / hardware / simulation
Description

Wireless communication protocols have to adapt to varying environmental conditions due to mobility, shadowing etc. This condition imposes a requirement, during design phase of the protocol, that it must be evaluated against environmental conditions as accurately as possible. This can be achieved by using an appropriate path loss model that reflects these conditions, during simulation. Goal of this project is to implement such a path loss model for hilly terrains. This path loss model then shall be evaluated and compared against existing Two-ray Interference model, using a scenario that simulates ad-hoc networks in hilly terrains. The results should validate the new model.

Tasks

– Literature survey on existing path loss models for hilly terrains.
– Implementation of appropriate path loss model in Omnet++ & Veins.
– Compare the new model with existing Two-Ray Interference model using Omnet++ & Veins.
– Concept to import DTED / SRTM files to simulate real-life scenarios for hilly terrains.

References


Focus

2 students theory / programming / simulation
Mobile Ad-hoc networks (MANETs) need efficient routing algorithms due to their changing topology. Depending on the mobility situations, the appropriate type of routing protocol (proactive, reactive etc.) must be chosen for the network. Goal of this project is to compare the performance of different MANET routing algorithms under a given scenario. A large-area, sparse-density, multi-hop MANET shall be simulated with reactive & proactive protocols and routing performance shall be evaluated against a given metric.

Tasks
- Literature survey on adaptive and reactive routing protocols.
- Design and simulate MANET multi-hop scenarios with different routing protocols (at least three) using Omnet++ & Veins.
- Evaluate the performance of simulated routing protocols and make appropriate recommendation.

References

Focus
1 student  theory / programming / simulation
Delay Tolerant Networks (DTNs) are an approach to deal with intermittent connectivity and are especially useful to bridge partitioned Mobile Ad hoc Networks (MANTEs). Multicast approaches are suitable for group communication. In DTN the challenge is to identify all group members in time. Therefore, multicast protocols have to provide the replication of messages to intended receivers. The goal of this project is to implement and compare 2 existing protocols OS-Multicast and MIDTONE in the Opportunistic Network Simulator (ONE).

Tasks
- Literature survey on DTN multicast routing protocols
- Implementation of OS-Multicast and MIDTONE in ONE
- Comparison of the OS-Multicast and MIDTONE with focus on delay and delivery rate

References

Focus
2 students theory/programming/evaluation
Filter bank based multi-carrier with offset quadrature amplitude modulation (FBMC/OQAM) systems have the potential of enabling an effective utilization of the available fragmented spectrum in heterogeneous radio environments. The use of OQAM gives rise to the potential of exploiting widely-linear processing in FBMC/OQAM systems. After some preliminary investigations, open issues remain.

Tasks

- Study the concept of FBMC/OQAM and get to know its superiority over orthogonal frequency-division multiplexing (OFDM)
- Investigate existing widely-linear processing schemes via a thorough literature study as well as extensive MATLAB simulations
- Work on extensions of the current algorithm for MIMO FBMC/OQAM systems

References


Focus

1 or 2 students    theory / programming / hardware / measurements
3D Beamforming for 5G Cellular Networks

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

• **Description:**
MIMO techniques are becoming mature, and incorporated into emerging mobile broadband standard like LTE. To further exploit the potential of MIMO techniques in 5G systems, massive MIMO becomes one of the new research fields in wireless communications. Moreover, 3D beamforming which takes the advantage of the vertical antenna pattern is a popular task in current LTE standard.

• **Tasks**
  – Literature study of massive MIMO techniques and 3D beamforming techniques
  – Demonstrate the advantage of 3D beamforming
  – Study the remaining issues in the current work

• **References**

• **Focus**
  1 student, theory / programming / hardware / measurements / protocols
Tensor-Based Robust PCA in Video Surveillance

Responsible Professor: Prof. Dr. -Ing. Martin Haardt
Research Adviser: Dr.-Ing. Jianshu Zhang
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• Description:
Robust principle component analysis (PCA) solved via Principal Component Pursuit (PCP) is a promising technique for detecting moving object in video surveillance. The existing PCP methods are based on vector-matrix representation. Since the video sequence has a multi-dimensional structure, it is natural to model it using a tensor model.

• Tasks
– Literature study of the state of the art robust PCA methods and tensor based signal processing
– Extending the existing method using tensor based signal processing
– Define performance metrics and test cases to evaluate the performance of the proposed methods

• References

• Focus
1 students, theory / programming / hardware / measurements / protocols
Decomposition of a low-rank tensor with missing entries

Responsible Professor: Prof. Martin Haardt
Supervisor: Kristina Naskovska

• Description:
More and more often we deal with massive amounts of heterogeneous data, for that reason we would like to analyse the so called big data using tensor algebra. Moreover, some of this data is either missing or it is corrupted and needs to be estimated. This can be achieved via decomposition of a low-rank tensor with mission entries. An implementation of the state of the algorithms as well as appropriate modifications should be achieved.

• Tasks
  – Literature study on tensor algebra and tensor decompositions.
  – Literature study on decomposition of low-rank tensor
  – Implementation of the state of the art algorithms

• References

Focus
1 student theory / programming / hardware / measurements
More and more often we deal with massive amounts of heterogeneous data, for that reason we would like to analyse the so called big data using tensor algebra. Since the big data requires a lot of memory space a first and obvious solution is to perform a compression of the data. For that reason an implementation of the state of the algorithms as well as appropriate modifications should be achieved.

**Tasks**
- Literature study on tensor algebra and tensor decompositions.
- Literature study on big data compression
- Implementation of the state of the art algorithms

**References**

**Focus**
1 student  
theory / programming / hardware / measurements
The CP decomposition is unique up to permutation and scaling, if certain constraints are fulfilled. An investigation and comparison of these constraints should be performed, for different algorithms such as ALS, SECSI, PARACOMP.

Tasks

- Literature study on tensor algebra and tensor decompositions.
- Implementation of the state of the art algorithms
- Convergences and uniqueness comparison.

References


Focus

1 student theory / programming / hardware / measurements
Description:
More and more often we deal with massive amounts of heterogeneous data, for that reason we would like to analyse the so called big data using tensor algebra. An example of a big data is a social network data. We would like to investigate how can we efficiently decompose a tensor into sparse factors, producing sparse approximations.

Tasks
- Literature study on tensor algebra and tensor decompositions.
- Implementation of the state of the art algorithms

References

Focus
1 student theory / programming / hardware / measurements
Performance Comparison of 5G Modulation Schemes

Supervisor: Sher Ali Cheema, Dr. Bilal Zafar

• **Description:**
  5th Generation Non-Orthogonal Waveforms (5GNOW) is an explorative research proposal challenging the obedience of LTE and LTE-Advanced to strict synchronism and orthogonality with respect to future applications. The idea is to abandon synchronism and orthogonality altogether, thereby admitting some crosstalk or interference, and to control these impairments by a suitable transceiver structure and transmission technique. Current research addresses these design goals by various filter bank based signal design techniques. Currently four waveforms such as Generalized Frequency Division Multiplexing (GFDM), Universal Filtered Multicarrier (UFMC), Filter Bank Multicarrier (FBMC) and Biorthogonal Frequency Division Multiplexing (BFDM) are considered. In this work, a performance comparison of these waveforms will be done.

• **Requirements:** Programming skills in MATLAB.

• **Tasks**
  - Review of the literature
  - Performance comparison of these waveforms

• **Literature:**
  [1]. "5G Waveform Candidate Selection" 5GNOW D3.1 version 1.0 document.

• **Focus** 2/3 students theory / programming
Unique Word OFDM for LTE-A Downlink

Supervisor: Sher Ali Cheema

**Description:**
In OFDM based systems, the symbols are separated by guard intervals which are usually implemented by cyclic prefixes (CP). CP is a random sequence and is solely created in time domain by copying the last part of the output of IDFT. Instead of using a random sequence as CP, a known deterministic sequence called as unique word (UW) can be used which, in result, can be very helpful for channel estimation and synchronization. Therefore, such UW systems does not require dedicated pilot carriers as compared to systems using CP. In [1], two different methods are introduced to construct UW-OFDM. In this project, we will compare the performance of UW-OFDM against the CP-OFDM for the LTE-A downlink scenario.

**Requirements:** Programming skills in MATLAB.

**Tasks**
- Review of the literature
- Implementation of UW-OFDM in Matlab
- Performance comparison of UW-OFDM and CP-OFDM for LTE-A downlink

**Literature:**


**Focus** 1/2 students theory / programming
Channel Estimation Techniques for UW-OFDM

Supervisor: Sher Ali Cheema

• Description:
  In OFDM based systems, the symbols are separated by guard intervals which are usually implemented by cyclic prefixes (CP). CP is a random sequence and is solely created in time domain by copying the last part of the output of IDFT. Instead of using a random sequence as CP, a known deterministic sequence called as unique word (UW) can be used which, in result, can be very helpful for channel estimation and synchronization. Therefore, such UW systems does not require dedicated pilot carriers as compared to systems using CP. In this project, we will investigate the channel estimation techniques for UW-OFDM.

• Requirements: Programming skills in MATLAB.

• Tasks
  - Review of the literature
  - Channel estimation using UW

• Literature:

• Focus 1 students theory / programming
Unique Word based DMT Schemes

Supervisor: Sher Ali Cheema

• Description:
OFDM and its real-valued version DMT are popular schemes used to compensate the channel dispersion in direct detection optical systems. DMT schemes also take advantage of the CP, as in CP-OFDM, to mitigate the effect of channel dispersion. CP is a random sequence and is solely created in time domain by copying the last part of the output of IDFT. Instead of using a random sequence as CP, a known deterministic sequence called as unique word (UW) can be used which, in result, can be very helpful for channel estimation and synchronization. In this work, we will investigate the UW-OFDM structure for the DMT schemes and, based on this, propose new UW based DMT schemes for optical communication systems.

• Requirements: Programming skills in MATLAB.

• Tasks
  □ Review of the literature
  □ Implementation of these schemes in Matlab

• Literature:

• Focus 1 students theory / programming
Peak to Average Power Ratio Reduction for DMT Schemes

Supervisor: Sher Ali Cheema

- **Description:**
  OFDM and its real-valued version DMT are popular schemes used to compensate channel dispersion in direct detection optical systems. One of the major drawbacks of OFDM is its high peak to average power ratio (PAPR) of the output signal which seriously limits the power efficiency of transmitter’s high power amplifier. Transmitting a signal with high PAPR requires highly linear power amplifiers with a large back-off to avoid adjacent channel interference due to nonlinear effects. In this work, we will investigate the different PAPR reduction algorithms for DMT schemes such as AC-DMT and DC-biased DMT.

- **Requirements:** Programming skills in MATLAB.

- **Tasks**
  - Review of the literature
  - Implementation of different PAPR reduction algorithms in Matlab

- **Literature:**

- **Focus** 1 students theory / programming
Device to Device (D2D) communications

Supervisor: Bilal Zafar, Sher Ali Cheema

• Description:
In conventional cellular networks, users communicate via base stations (BS) however close range users may gain if they communicate directly between each other. Device-to-device (D2D) networking allows direct communication between cellular users and provide the following benefits:
  ➢ Offload traffic from the core network
  ➢ Higher data rates and power efficiency for both users and networks
  ➢ Optimized spectrum reuse if sharing is allowed (underlay case)
  ➢ Better coverage
  ➢ Improved energy efficiency and reduced backhaul demand

• Requirements: Strong programming skills in MATLAB and good knowledge about wireless systems.

• Tasks
  ❑ When one should use direct D2D communication instead of cellular?
  ❑ Comparison between in-band (overlay and underlay) and out-of-band modes
  ❑ Use of MIMO to provide additional degrees of freedom
  ❑ How to implement D2D on new generation systems where the transceivers for uplink and downlink are different
  ❑ (please contact the supervisors for more details)

• Focus 1 students theory / programming
RF and Microwave Research Laboratory

Head: Prof. Dr. rer. nat. habil. Matthias Hein
Wireless links are a convenient and effective solution for data exchange in many applications. The ISM band at 868 MHz is well suited for compact transceivers. More and more low-cost applications motivate the trend towards simple truly planar printed circuit board (PCB) solutions. This project considers a planar inverted F-antenna (PIFA) with an additional conductive plane from a metallic housing in the near field of the antenna. The radiation properties shall be analyzed and the optimum placement of the antenna PCB relative to the metal body identified.

**Tasks**
- Qualitative design of a suitable PIFA structure
- Numerical simulation of the 3D antenna structure
- Analysis and optimization of the radiation properties

**References (basic literature)**


**Focus**
1 student theory / programming / simulation / hardware / measurements / protocols
Investigation of the RF electromagnetic spectrum

Responsible Professor: Prof. Matthias Hein
Research Assistant: Dr. Christian Bornkessel, christian.bornkessel@tu-ilmenau.de

• Description
For the design and test of new RF technologies it is necessary to characterize the existing electromagnetic environment and to identify available frequency resources. This problem can be solved by “over-the-air” measurements of the RF electromagnetic spectrum. Therefore, the task of this project is to perform electric field measurements outside the area of the Helmholtzbau at TU Ilmenau. The measurements shall be performed with a handheld spectrum analyzer and suitable antennas. The measured emissions shall be mapped to the respective radio service using the German national frequency plan.

• Tasks
– Become familiar with the operation of the spectrum analyzer R&S FSH-8
– Measure the RF electromagnetic spectrum in the range from 20 MHz to 6 GHz
– Map the measured signals to the German national frequency plan

• References (basic literature)
1. German Federal Network Agency, frequency plan (Frequenznutzungsplan)

• Focus
1 student theory / programming / simulation / hardware / measurements / protocols
Circularly polarized microstrip patch antenna array

Responsible Professor: Prof. Matthias Hein
Research Assistant: Dipl.-Ing. Alexander Krauß, alexander.krauss@tu-ilmenau.de

• Description
Circular polarization (CP) of patch antennas can be obtained by different feed arrangements or by mode distortions. The resulting polarization purity can be judged by the axial ratio. In the context of satellite communications, the dis/advantages of CP patch antenna arrays shall be analyzed, supported by electromagnetic field simulations. The analysis addresses antenna and array parameters such as resonant frequency, impedance and radiation bandwidths, return loss, radiation pattern, and gain.

• Tasks
– Focused literature research
– EM field simulation (Ansys HFSS) and selection of suitable designs
– Comparative analysis of the different designs
– Discussion of advantages and disadvantages

• References

• Focus
1 student theory / programming / simulation / hardware / measurements / protocols
Single layer dual-band antenna for satellite navigation systems

Responsible Professor: Prof. Matthias Hein
Research Assistant: M.Sc. Maysam Ibraheam, maysam.ibraheam@tu-ilmenau.de

• Description
This project considers dual-band antennas for global navigation satellite system (GNSS) receivers. In contrast to multi-layer antennas, where two stacked resonators enable dual-band operation, in a single-layer antenna the two resonators are located in the same conducting layer. The single-layer approach is followed here due to the ease of manufacturing as printed circuit boards. Special attention shall be devoted to the design improvement of single-layer dual-band antennas with prescribed radiation patterns and polarization purity while the antenna efficiency is optimised.

• Tasks
– Understanding the multi-layer and single-layer concepts
– Designing a dual-band single-layer antenna using numerical simulations (CST or HFSS)
– Optimizing the antenna properties of a predesigned version in terms of radiation efficiency

• References (basic literature)

• Focus
1 student theory / programming / simulation / hardware / measurements / protocols
Electronic Measurement Research Lab

Head: Prof. Dr.-Ing. habil. Reiner S. Thomä
Random Beamforming Methods for Compressive Sensing Based Direction of Arrival Estimation

Responsible Professor: Prof. Reiner Thomä  
Supervisor: M.Sc. Sergii Skoblikov

• Description:  
In terms of a doctoral thesis a novel measurement architecture for Compressive Sensing based Direction of Arrival (DoA) estimation has been developed. The DoA estimation method involves random beamforming. A student is expected to find random beamforming methods suitable (optimal) for the developed measurement architecture.

• Tasks
  – Acquaintance with the Compressive Sensing
  – Literature study on pseudo-random complex-valued sequence generation methods
  – Simulation-based study of the methods’ performance
  – Introduction of the metric for assessment of the methods’ suitability (optional)

• References

• Focus
  1 student  theory / programming / hardware / measurements
Department of Computer Science and Automation

Institute of Computer Engineering

Integrated Communication Systems Group

Head: Prof. Dr.-Ing. habil. Andreas Mitschele-Thiel
Applied Media Systems

Head: Prof. Dr.-Ing. Gerald Schuller
Filter Bank Multi Carrier with Low Delay Filter Banks

Responsible Professor: Prof. Prof. G. Schuller
Research Advisor: M.Sc. Michael Sturm

• Description
Implement an FBMC transmission scheme with Low Delay Filter Banks

• Tasks
- Implement an FBMC transmission scheme with Low Delay Filter Banks
- Simulate in Matlab and Python
- Compare to the State-of-the Art

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