Research

- Our research spans the areas of
  - communications engineering
  - signal processing
  - information theory
  - numerical linear and multi-linear algebra
  - antennas and propagation
- A major focus is on
  - array signal processing
  - wireless communications
    - new concepts and further enhancements for future wireless communication systems (4G, 5G, etc.)
    - that take into account multi-carrier transmission, ultra-wideband (UWB) techniques, infra-red transmission, multiple antenna systems, and the sharing of physical resources (like spectrum and infrastructure)
      - coordination of Ilmenau University of Technology's membership in the WWRF
  - multi-linear algebra and its applications in communications and signal processing (biomedical engineering, media technology, etc.)

Current Research Highlights

- Multi-user MIMO-systems (and smart antennas) with antenna arrays at the base station and (optionally) also at the terminals
  - efficient transmit processing (depending on the available CSI at the TX)
  - efficient receive processing, e.g., channel estimation and equalization
  - efficient feedback signaling from the terminals to the base station
- Scheduling algorithms for SDMA (space division multiple access)
- Realistic channel modeling for multi-user MIMO systems
- Space-time-frequency coding
- Cross layer designs
- Multi-hop systems
- Multiple access schemes
  - multi carrier systems, CDMA, SDMA, UWB, infra red, etc.
- High-resolution parameter estimation
  - multidimensional parameter estimation techniques
    - with applications in radar, mobile communications, sonar, seismology, and biomedicine
  - array calibration algorithms
  - realisic channel modeling based on estimated channel parameters
  - algorithms for time and frequency synchronization
  - prediction of time-varying mobile radio channels
- MIMO channel sounding for wireless systems
  - joint acquisition of a channel sounder with the University of Erlangen-Nuremberg (Prof. Wolfgang Koch)

The Communications Research Laboratory (CRL) emphasizes activities that give its research a strong international profile. Academic staff members serve on the editorial boards of prestigious international journals and international conference committees. It plays a central role in several strategic European research projects such as WINNER and OMEGA. Moreover, the CRL coordinates Ilmenau University of Technology's membership in the Wireless World Research Forum (WWRF) . Research students are encouraged to report their work at leading international conferences and publish in highest impact journals.

Selected Research Projects

We have intensive co-operations with international and national partners from industry (manufacturers, operators, etc.), research institutes, and academia within the following research projects:

- DFG Projects
- GIF (German-Israeli Foundation for Scientific Research and Development)

- UKOLOS

    - Project Abstract

- WWRF (Wireless World Research Forum)

- COST 273 (COoperation européenne dans le domaine de la recherche Scientifique et Technique)
  Towards Mobile Broadband Multimedia Networks

- TakeOFDM (Techniken, Algorithmen und Konzepte für zukünftige COFDM Systeme)
  DFG Focus Program
    - Project Abstract

- Focus Program Mobile Communications at Ilmenau University of Technology

- Bilateral exchange with Helsinki University of Technology
    - Kick-Off-Meeting
    - Second-Meeting
- International Graduate School on Mobile Communications

EU Projects

- EMPhAtiC (Enhanced Multicarrier Techniques for Professional Ad-Hoc and Cell-Based Communications)
  The goal of EMPhAtiC is to develop, evaluate and demonstrate the capability of enhanced multicarrier techniques to make better use of the existing radio frequency bands in providing broadband data services in coexistence with narrowband legacy services. The project will address the Professional Mobile Radio (PMR) application, and in particular the evolution of the Public Protection & Disaster Relief (PPDR) service currently using TETRA or other legacy systems for voice and low-speed data services. Both cell-based and ad-hoc networking solutions are needed for PPDR and will be developed. Our main emphasis is on filterbank based multicarrier (FB-MC) and single-carrier (FB-SC) waveforms for utilizing effectively the available fragmented spectrum in such heterogeneous environments. The core idea is to develop a multi-mode radio platform, based on variable filter-bank processing, which is able to perform modulation/detection functions simultaneously for different signal formats with adjustable centre frequencies, bandwidths and subchannel spacings. SC-FDMA waveforms are included in the study in order to relax the transmitter power amplifier requirements of mobile terminals. Enhanced OFDM solutions are also considered as alternatives aiming at minimal modifications to the 3GPP LTE standard, which serves as the reference system in the studies. In addition to physical layer functionalities, the project also develops MIMO and MAC-layer techniques, as well as relay networking solutions which are compatible and maximize the benefits of the waveform level solutions.
  The EMPhAtiC consortium has a strong expertise in the design of practical TETRA and ETSI BRAN systems and a very good track record in the development of FB-MC and FB-SC data transmission systems. We believe that the design of FB-MC schemes facilitating flexible and efficient multi-access spectrum usage, along with a proof of concept implementation, form the necessary basis for proposing better next generation broadband data solutions for the PMR evolution and other applications, including the 3GPP LTE evolution.

- OMEGA, (www.ict-omega.eu)

- WINNER, (Wireless World Initiative New Radio)
  Integrated Project within the 6-th Framework Programme of the European Union
    - Press release
    - WP 5 Meeting, 14. - 15. March 2005 (photos)
    - MATLAB implementation of the 3GPP SCM channel model
    - project summary winner II
  The key objective of the WINNER (Wireless World Initiative New Radio) project is to develop an innovative radio access concept in order to address high flexibility and scalability with respect to data rates and radio environments. Based on a detailed analysis of future user requirements the technology evaluation is being performed and a system concept definition is being developed.

- WINNER+, (Wireless World Initiative New Radio+)
    - EUREKA SUCCESS STORY > CELTIC WINNER+
    - Celtic-Plus Innovation Award 2012

- NEWCOM (Network of Excellence in Wireless COMmunications)
  Network of Excellence within the 6-th Framework Programme of the European Union

- SAPHYRE (Sharing Physical Resources - Mechanisms and Implementations for Wireless Networks)
  The SAPHYRE (Sharing Physical Resources - Mechanisms and Implementations for Wireless Networks) project has stared in January 2010 and is a STREP funded by the European Union within framework program seven (FP7-ICT-248001).
  In current wireless communications, radio spectrum and infrastructure are typically used such that interference is avoided by exclusive allocation of frequency bands and employment of base stations. SAPHYRE will demonstrate how equal-priority resource sharing in wireless networks improves spectral efficiency, enhances coverage, increases user satisfaction, leads to increased revenue for operators, and decreases capital and operating expenditures.

SAPHYRE represents a consortium that spans the entire chain from spectrum regulatory aspects, networking, physical layer to hardware implementation. The vision of SAPHYRE is to:

- show how voluntary sharing of physical and infrastructure resources enables a fundamental, order-of-magnitude-gain in the efficiency of spectrum utilisation;
- develop the enabling technology that facilitates such voluntary sharing;
- determine the key features of a regulatory framework that underpins and promotes such voluntary sharing.

SAPHYRE s main objectives are conceptually described as:

- SAPHYRE analyses and develops new self-organising physical layer resource (spectrum, spatial coexistence) sharing models by a generalised cross-layer and cross-disciplinary approach.
- SAPHYRE proposes and analyses efficient co-ordination mechanisms which require only small intervention (to counteract selfish, malicious users). In particular in sharing scenarios, incentive based design is applied in order to reduce regulatory complexity.
- SAPHYRE develops a framework for infrastructure sharing to support quality of service with sufficiently wide carrier bandwidths and competition between different operators.

Software

- Demo implementation for the SEmi-algebraic framework for the approximate CP decompositions via SImultaneous Matrix Diagonalizations (SECSI) on Github Github project

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