

Summary

ComNets projects usually relate to cutting-edge designs of future mobile and wireless communication systems.

Typically, this means either the advancement of existing systems with new advanced or extended characteristics, or the design and performance evaluation of systems and contributions to the standardization of follow-up generations of existing systems.

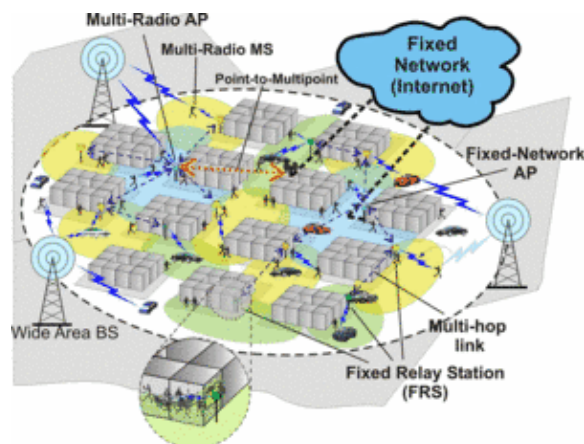
The "Quantitative Performance Analysis of Distributed Systems" is our main competence in most research projects. The methods used are Probability Theory, Queuing Theory, Theory of Scheduling, Game Theory, Stochastic Event driven Simulation. The main focus is the traffic performance of an existent or newly designed wireless/mobile communication system.

The ComNets infrastructure is a network of theories and experiments based on methods and tools and is also further developed and assessed continuously to progress the state of the art.

According to a European Commission internal ranking for funds spent for the "Wireless and Mobile" Strategic Objective in the year including 2003, RWTH Aachen (ComNets) is rank four in a list of leading European Universities and Research Centres. The reason for this is that in its domain of competence ComNets and MobNets together do not have any serious competition in Europe.

General research goals

- Designing technical solutions based on profound analyses to be included into standards for future communication systems.
- Innovative and/or disruptive contributions to system concepts of distributed wireless and mobile systems.
- Development of versatile tools for the development, prototypical implementation and quantitative mathematical and stochastic performance analysis of wireless and mobile communication systems.



Communication System

Scenario of a Relay-based Wireless Broad Band

Achievements gained so far

- The packet data service GPRS of the ETSI/GSM mobile radio system introduced in Spring 2001 follows first ComNets ideas published in 1990. The ETSI/GPRS standardization in 1996-98 made heavy use of traffic performance analysis contributions by ComNets.
- The ETSI/BRAN standard HIPERLAN/2 is to a substantial part based on contributions by ComNets, namely the design and quality of service oriented medium access control protocol. The contributions have been conveyed to ETSI/BRAN via industrial research project partners. The IEEE 802.16 (WiMax) standard very closely follows the HiperLAN2 standard.
- The CEN standard TC278 "Electronic Fee Collection" (for Road Pricing) has been designed throughout under the chairmanship of ComNets and many technical details of the standard have been contributed by ComNets.
- ComNets contributions have recently been accepted for the following standards: IEEE 802.11e, 802.11s, 802.15.3, 802.16, MBOA (mobile broadband OFDM alliance).
- The concept of Layer-2-Relay Enhanced Cell (REC) is a disruptive technology to substantially increase the range, capacity and spectral efficiency of cellular wireless/mobile broadband communication systems in both, dense urban and wide area morphostructures. This technology has been developed and introduced into the public discussion by ComNets. This concept, besides MIMO, is the one with the highest potential for increasing the capacity of existent and future wireless/mobile radio systems. Today, RECs are being researched in the labs of the main manufacturers and operators, worldwide. Even NTTDoCoMo has given-up its opposition to it.
- Application of extended finite state-machine based specification of protocols (in SDL) for implementing tools for the traffic performance evaluation of wireless/mobile radio systems based on the emulation of their protocols. The related tools allow for the traffic performance analysis of existent, further developed and future systems in multi-cellular, multiple user scenarios with user specific traffic modeling and user specific mobility behavior in various scenarios with scenario specific realistic radio propagation and interference modeling. We have detailed analysis tools ready available for all the major digital mobile and wireless systems. A public domain C++ class library CNCL for the stochastic, event driven performance evaluation of communication systems developed by ComNets is in use in research establishments worldwide and an advanced version of this, the C++ class library SPEETCL is used at the chair. The LRE (limited relative error) algorithm to determine the error masses for correlated statistical result values of stochastic simulation studies has been developed at ComNets and is used by many universities, worldwide.
- Development of a multi-hop communication based wireless broadband adhoc network (W-CHAMB) that is based on a fully decentral control, in discussion in TG IEEE 802.11s to mesh WLAN Access Points.
- The interactive fixed networks planning tool COMPOSIS is based on stochastic optimisation of existent and future fixed networks. Its performance has proven to be superior to any tool based on conventional algorithms.
- ComNets is the leading expert in Europe in trunked mobile radio systems design according to its research performed in performance of group communication and its participation in a number of field trials of ETSI/TETRA, ETSI/GSM-ASCI and TetraPol standards.
- ComNets has contributed to the scientific community by founding two scientific conferences, namely European Wireless and EPMCC, by serving in scientific engineering associations and serving as international conference chair and steering board member.

Publications

ComNets publications are downloadable from <http://www.comnets.rwth-aachen.de/?id=download> . The publications by the ComNets chair are available, separated by books, book chapters, journal papers, editorials and scientific conference publications under <http://www.comnets.rwth-aachen.de/department/personal/list/walke/publikationen.html>.

About 30 patents (granted) and patent applications can also be found there.

Two English text books have been published recently.

The download statistics shows the relevance of ComNets publications through the monthly access statistics (we know who has downloaded our papers).

Current Research Projects (Selection)

DFG projects (German Research Foundation)

- Co-existence rules for wireless communication systems competing in the frequency spectrum (Coconet).
- Related projects finished already: MultiFunk
<http://www.comnets.rwth-aachen.de/~pst/Multifunk/Multifunk.html>
- Integration of COFDM in multiple antenna systems and development of adaptive medium access control (MAC) protocols. Related projects: <http://ist-strike.org>

BMBF projects (German Ministry for Education and Research)

- The ComNets chair had initiated BMBF funding in mobile and wireless communications in 1994 and is since then scientific advisor to the BMBF, <http://www.bmbf.de>
- IP on Air: Wireless Media System based on scattered Mobile Broadband Systems. Wireless Internet to connect to the fixed telco network. Alternate Radio System Concepts (MAC- and routing protocols for wireless broadband systems, www.iponair.de
- WIGWAM: Wireless Gigabit with Advanced Multimedia Support (improving IEEE 802.15 short range wireless communication protocols, development fo IEEE 802.11 MAC protocols for multi-hop communication, CDMA based MAC protocols for IEEE 802.11, MAC protocols for OFDMA broadband systems, www.eid.dlr.de
- INVENT: Intelligent road traffic and user oriented technology (Agent based service platform for mobile Web services), www.invent-online.de

European projects (Framework Programme 5 and 6)

- **STRIKE** (SpecTRally Efficient FIxed Wireless NetworK basEd on Dual Standards): Interworking of HiperLAN2 and IEEE 802.16 (WiMax) systems and improvements of WiMax MAC protocols for use with smart antennas, <http://ist-strike.org>
- **SAILOR** (SAteellite Integrated UMTS emuLatOR): Development of a Satellite UMTS air interface and evaluation of its performance based on emulated satellite channels, www.ebanet.it Related projects finished already: VIRTUOUS <http://www.ebanet.it/Virtuous.htm> FUTURE <http://www.ebanet.it/Future.htm>
- **NEXWAY** (Network of Excellence in Wireless Applications and TechnologY): Co-operation with 38 university institutes for the exchange of information of newest developments in Beyond 3rd Generation mobile radio networks, www.nexway.net
- **ANWIRE** (Academic Network of Wireless Internet Research in Europe): Co-operation with 16 university institutes on information exchange on wireless Internet technology, www.anwire.org
- **Ambient Networks (AN)**: An integrated project (IP) in 3 Phases (each 2 years in length) co-sponsored by the European Commission under the Information Society Technology (IST) priority within the 6th Framework Programme (FP6). The project addresses the strategic objective of "Mobile and Wireless Systems Beyond 3G". The AN project works to create the network solutions for mobile and wireless systems beyond 3G. It will enable scalable and affordable wireless networking while providing rich and easy to use communication services for all. It is geared towards increasing competition and cooperation in an environment populated by a multitude of user devices, wireless technologies, network operators and business actors, www.ambient-networks.org ComNets contribution: Media point radio network architecture; caching of contents for efficient provisioning to wireless users. Mode Convergence Manager and Reference Model. Related project finished already: WSI <http://ist-wsi.org/>
- **WINNER** (Wireless World Initiative NEw Radio): An integrated project (IP) in three Phases (each 2 years in length) co-sponsored by the European Commission under the Information Society Technology (IST) priority within the 6th Framework Programme (FP6). The project addresses the strategic objective of "Mobile and Wireless Systems Beyond 3G". WINNER develops the air interface of future (beyond 3G) mobile radio systems, www.ist-winner.org ComNets contribution: Relay Enhanced Cells for cellular mobile radio systems, Mode Convergence Manager and Reference Model for scalable and re-configurable air interfaces. Spectrum estimation methodology. Multi-hop able relaying MAC protocols. WINNER has seven Work Packages (WP). ComNets is WP 3 leader (the second biggest WP in Winner). Related projects finished already: OverDrive http://www.comnets.rwth-aachen.de/~o_drive/index.html, DRIVE <http://www.ist-drive.org/index2.html>
- **MYCAREVENT** (Mobile Yield and CollAboRative work in European Vehicle Emergency NeTworks): An integrated project (IP) (3 years in length) co-sponsored by the European Commission under the Information Society Technology (IST) priority within the 6th Framework Programme (FP6). A unified middleware is developed to support vehicles under breakdown and provide telemetry based access to spare parts data bases., www.mycarevent.com. ComNets contribution: Wireless/mobile connectivity to broken down cars. Related projects finished already are DELTA www.ertico.com/activiti/projects/projects.htm,
- **SatNex** (SATellite communications Network of Excellence): The primary goal of SatNEx is to achieve long-lasting integration of the European research in satellite communication and to develop a common base of knowledge between the 21 partners, thus contributing to the realization of the

PH.D. promotions

ComNets over the last four years had an average of close to five Dr.-Ing. promotions per year.

Know-How Transfer and Start-Ups

ComNets is obliged to applicability of its research results in the highly competitive communications and IT industry.

Besides industrial contracted projects with companies assembled in the ComNets Friends and Supporters Circle (see attachment) and contracted projects with other companies throughout Europe, ComNets has actively contributed to establish start-ups in - Germany with altogether more than 70 full time equivalents employed, namely P3Solutions GmbH <http://www.p3solutions.de> and AixCom GmbH <http://www.aixcom.com/>.

ComNets with its third parties funded staff (on average 30 full time equivalents) is itself a research start-up.