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Research results of the ComGreen project

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Project summary

Project title:	ComGreen – Communicate Green
BMWi code:	01 ME11012, 01 ME11008A, 01 ME11010, 01 ME11011, 01 ME11009
Term:	01/01/2011 to 31/12/2014
Consortium:	Deutsche Telekom AG / Telekom Innovation Laboratories Ericsson Fraunhofer Gesellschaft Technical University of Berlin University of Paderborn
Project director:	Steffen Bretzke, Ericsson GmbH
Website:	www.communicate-green.de

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Research topics

In the ComGreen project, solutions were developed for saving energy in modern mobile networks:

- Load-adaptive power management supported by context manager or neighbouring BS relations
- Wireless backhaul energy management
- Single-RAT sleep mode for co-located cells
- Single-RAT pico sleep mode in heterogeneous networks
- Coverage extension
- Bandwidth expansion mode, BEM
- Prediction and caching in the core
- Energy-efficient connectivity management

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Energy models for four usage scenarios

Energy models were developed for four typical usage scenarios:

- Standard scenario: Regular city scenario
- Alternative scenarios: Rural Area, Business Area, Stadium Area scenario

Data for parameterisation of the energy models included:

- Mobile networks (including type, configuration, and power consumption of the network elements and cell types, cell density, and coverage area)
- Terminals (including the type of services used and mobile wireless technologies, signal strength, user location, and user movement, etc.)
- Network context (including current and average loads, load profiles, network or cell configuration, antenna orientation, etc.)

For ease of calculations, traffic models derived from actual traffic measurements were approximated analytically by trigonometric formulas

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App for detection of network parameters

In the project, the RRCLogger app for Android 2.3 was developed for the measurement and statistical recording of usage and network parameters.

- The app collects information on the base station, the supported mobile wireless technologies (2G/3G) and the position of the user
- Test rides with specially equipped bicycles for data acquisition
- Visualization of the measurement results was performed using OpenStreetMap

Measurement results:

- Many mobile networks have a very high coverage capacity, since all four network providers often provide full coverage in urban areas in Germany
- This means that depending on traffic, individual network elements can be put into sleep mode to conserve energy without network quality being adversely affected

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Mobile wireless and core network simulator

Development of a simulator for a complete heterogeneous mobile wireless and core network based on 22,000 systems in Hesse (incl. base stations, core and transport network components)

- Focus on transport networks (switches, routers and their connections to base stations – mobile backhaul) – large quantities and high share of total energy demand
- Provision of precise data on data transmission and energy consumption
- Dynamic comparison of many products, strategies and solutions, as well as their combinations
- Simultaneous observation of data traffic demand per km², corresponding network energy consumption and end-user performance at a particular time for various network configurations.
- Modelling of variation in network performance indicators during the day with the time bar to identify the most energy-efficient time ranges

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OpenMobileNetwork

OpenMobileNetwork – Semantic modelling and linking of mobile wireless network data

OpenMobileNetwork: open platform which makes available approximate and semantically enriched data on mobile networks and WiFi access point topologies (RDF format)

- Measurement clients on mobile devices of users have been collecting global data since 2012 (crowdsourcing) → topology modelling for mobile networks and WiFi access points
- Data structuring by means of a comprehensive ontology: Locations of base stations and WiFi access points, network coverage, neighbour cell relations and dynamic data such as data traffic, service usage and number of users
- The OpenMobileNetwork Demo for ComGreen and the Forecast Visualiser demonstrate the applicability of the OpenMobileNetwork for establishing power management for mobile networks.

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Energy requirements of a BTS in load-adaptive operation

In the project, the electrical power of a base station (BTS) and the energy conservation in low-power mode were measured:

- Power consumption of the base station is allocated to the radio unit, signal processing, cooling unit and power supply unit
- When using the bandwidth expansion modes (BEM), the transmission power of the base station is controlled by adjustment of the power amplifier according to the requirements
- If the power amplifier is switched off, the transmission power and resultant power consumption is reduced by about 25%

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Dynamic on/off control of network elements

- Dynamic on/off control of network elements is crucial for adapting the capacity to meet demand (load adaptivity)
- This means an increase in energy consumption through concentration of the radio networks under control
- The Hetnet demonstrator clearly demonstrated that adding small cells with sleep mode can improve service quality and energy consumption
- To allow the systems to be turned off more often, future radio access technologies will need to be able to operate with a minimum of signalling traffic (a big challenge)
- The 'Green LTE carrier' demonstrator shows that reasonable energy savings are possible by dispensing with the regular 'pilot signals' in LTE
- Forecasting of user movement and user behaviour supports dynamic operation of network elements

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Green LTE carrier operation

Energy-efficient operation of the LTE carrier:

- Only required transmissions are made
- Signalling and pilot signals are not transmitted when no data is present
- Reduces network interference, thereby increasing transmission rates
- Assessment in combination with a further improvement:
“Dual Connectivity” (LTE Rel-12 feature to improve user performance and extend sleep mode at base stations)
- Visualisation via demonstrator with day/night profile

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Load-adaptive provision of services

Virtualisation: Flexible deployment, migration and consolidation of services with cloud computing

- Distribution over thousands of geographically isolated cloud locations
- ComGreen: Adaptation of the principle of mobile networks – in this case, cloud sites are base stations, access routers or backhaul routers
- Compared to the current situation of permanently active infrastructure for service provisioning, adaptation of the sites and user allocation taking into account regional load situations enables additional energy savings (less active hardware for ensuring operational functionalities)
- Consolidation of services enables shutdown of unused hardware
- Development of a plugin for distribution algorithms tested in the project's own testbed

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Patents and publications

3 European patent applications:

- Andreas Roos, Dmitry Sivchenko, Nico Bayer. “Method and system for network-centric control of network connectivity for mobile terminals in IEEE 802.11 based networks”. European patent application.
- Nico Bayer, Andreas Roos, Dmitry Sivchenko. “Method and system for network-centric discovering of points of attachment to the network for mobile devices within networks having plural access points”. European patent application.
- Nico Bayer, Hans Einsiedler, Christoph Peylo, Peter Dely, Andreas Kassler. “Method and system for the distribution of the control and data plane in Wireless Local Area Network Access Points”. European patent application.

34 national and international scientific publications