LTE SON Research
1. Partnership with Fraunhofer FOKUS Institute since Jan 2010 in IMS/EPC prototyping.

2. Establishment of local IMS/EPC laboratory at MERA site

3. Participation in development and maintenance of Open EPC/IMS Core projects with Fraunhofer FOKUS group

4. MERA became a Full Member of ETSI organization in 2010.

5. MERA and Fraunhofer FOKUS demonstrated LTE extension of Open EPC at FUSECO forum in Berlin in October 2010

6. SOCRATES LTE SON research activities

7. MERA wireless research group 4G activities:
   • RF optimization simulation,
   • MIMO systems research, OFDM Simulation development,
   • LTE eNodeB Simulator development
• Unified test bed for All-IP networks
• Comprises IMS Core, EPC, LTE Access (eNB emulator), application servers and terminals
• Compliant with 3GPP Release 9/10 and ETSI TISPAN Release 2
• Used for IMS/LTE components and applications prototyping and demonstrations

Demonstrated at 1-st FUSECO Forum, Berlin, 14-15 Oct 2010
Highlights:

- Over 12 years of significant experience in the field of 2G/3G/4G Wireless technology research,
- 2 Professors and 4 Doctors of Science are among the group members
- **Achieved results**: 3 US patents, over 100 publications in an international journals, including IEEE Proceedings, EURASIP Journal on Applied Signal Processing, etc. (see appendix 1)

Research areas:

- Multi-antenna techniques (MIMO systems, Cooperative MIMO and SDMA systems in multipath environment, Super resolution algorithms),
- Coordinated multi-point (CoMP),
- Advanced interference management techniques (including adaptive antenna array, adaptive interference cancellation and in-house simulation),
- Enhanced user position location, including wireless position location for indoor and outdoor,
- RF network optimization (including signal propagation, in-house algorithm and simulation),
- OFDM-based solutions,
- Adaptive modulation and coding,
- Advanced signal processing algorithms,
- Space-time coding (including in-house simulation)

Basing on the wide experience of research projects, being carried out from initial concept via algorithms development and modeling to simulation or prototyping, MERA wireless research group brings its experience to SON domain.
Space-Time Coding and MIMO Capacity

Basing on (8:2), (4:2) and (8:4) MIMO configurations study, MIMO scheme for the Next Generation communications systems was proposed. The scheme of the coding and the data transmission is based on the OFDM technique and provides high data rates (10-40 Mbps) by means of antenna arrays and space eigenchannels forming. As the result, MIMO system provides capacity increase without increasing of the transmit power or frequency bandwidth expansion.
Fading channel prediction

In mobile cellular radio networks the delay between uplink and downlink must be taken into account for fast adaptive modulation and coding. In order to be able to select the most appropriate modulation technique, it is necessary to predict what the received signal power will be at an increment of time in the future. Advanced signal processing algorithms proposed by MERA allow fading channel prediction on 2-10ms depending upon user velocity. Four predictors (Linear (autoregressive), Fourier linear spectral, Non-linear spectral (Capon’s, MUSIC and other), Polynomial) were investigated and compared. Capon’s non-linear predictor is considered as a preferable non-linear one.

- Channel contains 4 complex sinusoids, each having unity amplitude
- Doppler frequencies are -92, 5, 85 and 100 Hz.
- Capon’s and Linear Predictors are used (LP order, m=10),
- Sample period 2ms, sample SNR=20dB
- Prediction was carried out for the 20 samples over the 40ms prediction interval
- Prediction was carried out over the whole of the 40ms prediction interval, using samples only from the (100ms) observation interval (see the diagram)

Patent US 6,993,293 B1, 31 January 2006
Indoor and Outdoor Enhanced User Position Location

Outdoor user position location

In order to locate UEs in mobile cellular radio networks in the urban environment, advanced spatial signal processing algorithms were proposed. The model of the angle spread source with the mean parameters was created basing on Low Base urban propagation trials data. The theoretical and simulation results confirm that the comparison of a sum and difference of signal amplitudes in adjacent AA beams is the most convenient bearing method to provide enhanced position location (PL) accuracy.

Position location estimation accuracy for the triangulation method (at least 2 BS) was also investigated, the theoretical formula for PDF of the PL error has been obtained.

Indoor user position location

Indoor user position location method is based on power-delay profile measurement. Power delay profile spectrum can be considered as the metric for indoor location estimation.

Patent US 7092673, 15 August 2006
Call Drop Rate Optimization in (Sub-)Urban Area

Initial state: Large area of call drops due to default set of parameters.

Power optimization, downtilt and/or beam orientation minimize call drop percentage.
In urban environment with short LN correlation distance, it is more difficult to optimize the bases.
Optimizer improves the call drop rate by varying the base antennas alignment and power levels.

Optimized state: Final settings are well matched LN fading and Base spacing.
Automated optimization simulator of a mobile network’s RF parameters (antenna pointing direction, downtilt, transmitter power and beam shaping) is based on the real calls logs and RF measurements, obtained from operational radio access network and UE. A selected set of coverage and capacity metrics and propagation models was taken into account and optimization algorithms were developed.

Models used:

- 3GPP Spatial channel model for Multiple Input Multiple Output (MIMO) simulations;

- Gaussian Channel Model for Macrocellular Mobile Propagation

Developed by MERA, this model of an angle-spread source is described, termed the “Gaussian Channel Model”. It is used to represent signals transmitted between a UE and a cellular BS. The model assumes a Gaussian law of scatterer occurrence probability, depending upon the scatterer distance from the user.
Metrics of RF Network Optimization (OFDM System)

1. Coverage Metric

\[ SNIR^{(i)} = \frac{P_{\text{server}}^{(i)}}{I^{(i)} + P_{\text{noise}}} \]

Outage concept. Outage arises if the UE cannot be served when the SNIR is below some critical level of outage probability (e.g. 10%) can be fixed. Having obtained the SNIR for all possible UE positions, we can calculate the corresponding cumulative distribution function.

2. Capacity Metric

\[ BL^{(i)} = \log_2 (1 + SNIR^{(i)}) \]

Bit Loading (BL) for the \( i \)-th user

\[ RA^{(i)} = \frac{k}{BL^{(i)}} \]

Resource Allocation (RA) for the \( i \)-th user

\[ MRA = \frac{1}{N} \sum_{n=1}^{N} RA^{(n)} \]

Mean Resource Allocation (MRA) for whole network

3. Beam Loading Metric

\[ BLM = \frac{\sum_{l=1}^{l=\beta} BL_l}{\sum_{l=1}^{l=\beta} BL_{L+1-l}} \]

The BLM is the mean loading of the \( \beta \) lowest-loaded beams divided by the mean loading of the \( \beta \) highest-loaded beams (\( L \) is the total number of beams)
MERA SON Use case’s Simulation Proposal

- eNodeB Simulator(s)
- Snapshot/Call traces (UDP)
- Profiles, Policies Snapshot
- Mera SON Sandbox (Gmap, Matlab, Simulink)
  - Visualization (X-Map)
  - SON Metrics Core (OpenEPC platform)
  - Use case scenario (ex: Cell Outage compensation)
MERA SON activities: Next steps

- Distributed vs centralized SON concepts study. Deep SON use cases study. MERA SON simulation concept development,
- SON scenarios interrelations research:
  - Metagaming
  - Neural networks
- Advanced metrics support
  - Performance (GoS/Qos)
  - Stability/Complexity
- Advanced models support:
  - mobility (ex: Random walk model, Random waypoint model)
  - traffic (ex: Full queue model, Interactive traffic: web-browsing using HTTP)
  - signal propagation (Multi-path propagation for urban and suburban areas, ex: Okumura-Hata model)
  - radio channel (interference, delays, fading models etc.)
- Advanced visualization:
  - Detailed beam model support
  - 3D city model support
  - Metrics
  - Detailed call path
  - QoS aspects
- MERA SON simulators development – next version
- MERA SON playground development
Appendix 1: Patents and Publications (1)

- **3 US patents:**

- **Publications:**
Appendix 1: Publications (2)


- Ermolayev V.T., Flaksman A.G., Lysyakov D.N. Error probability of the data transmission in MIMO-systems with space division multiple access under the conditions of Rayleigh fading of signals // Radiophysics and Quantum electronics. 2006, V.49, No.9, pp. 735-746.


SON: base stations self-configuration
SON: base stations self-configuration (cont’d)

• Goal: To develop solution allowing base stations provisioning without user intervention
• Solution: the self-configurable system supporting:
  • Mutual BS authentication
  • The system protection from hacker attacks
  • Automatic configuration of base stations
  • Automatic upgrade of base stations, e.g. in case of new installations or HW boards replacement
  • Real-time equipment monitoring and users notifications through alarms mechanism
  • KPI data downloading and building the appropriate reports
  • Load balancing and geo-redundancy
Questions?

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