The group has been formed in January, 2010

Specialized on agile, time-critical, and focused industrially-oriented research

- **Four** major projects on beyond-4G (5G) networks
- **20+ standardization contributions** to 3GPP RAN and IEEE 802.16
- **10+ scientific articles** in journals and **40+ conference papers**
- Numerous conferences, seminars, and tutorials on future networking
Major Challenges of Today

**Increased** mobile data **traffic**, some say **1000x and beyond**

Growth in **connected devices**, up to 50 billion devices

Diverse **requirements** and **characteristics**

Current mobile networks are likely to face **capacity crunch**

• a new technology that replaces 4G
• or several (integrated) technologies?

Attention shifts to what comes **beyond 4G** (Fifth Generation!)
What’s in a Name?

Given a 10-year cycle for every existing generation, we expect 5G systems sometime **around 2020**

Whereas there is currently **no** complete definition, 5G may already be understood from the **user** perspective

Human users would like to be **connected at all times**
- regardless of their current **location**
- take advantage of **services** provided by multimedia-over-wireless networks
A Glimpse of Tomorrow

Main challenge: user’s **connectivity experience** should match service rate requirements and be uniform.

A comprehensive solution is to deploy the **higher density** of **smaller cells** in cellular architecture.

Network densification generally promises **higher bit rates** and **reduced energy** for uplink transmission.

But **licensed** spectrum continues to be scarce and expensive, whereas the traditional methods to improve its efficient use approach their theoretical limits!
The Paradigm Shift at Work

We expect the majority of near-term capacity and connectivity gains from leveraging unlicensed spectrum. Consequently, the incentive to efficiently coordinate between the alternative radio access technologies is growing stronger.

A Heterogeneous Network (HetNet) employs hierarchical deployment of wide-area macro cells for basic connectivity and coverage augmented with small cells of various footprints and by different RATs to boost capacity. WLAN becomes an integral part of the wireless landscape.

Friends or Foes?
Intelligent Use of Multiple Radio Access Technologies

Our focus is on **dense HetNets**
- Integration of cellular and WLAN
- Impact of network densification
- Advanced interference coordination
- Potential of WWAN offloading
- Energy efficient user operation

Own **dynamic** system-level simulator
- 7-cell 3GPP LTE Rel.-10 FDD
- Features diverse small cells
- Full support for IEEE 802.11-2012
- Event-driven state machine: signal transmission, channel abstraction, traffic and user dynamics, etc.
- Flexible statistics collection
Current Picture and Perspectives

- Simulation-based study of multi-radio HetNets
- Dynamic stochastic geometry analysis
- Comprehensive system architecture
- **Current focus on integrated deployments**
- Impact of centralized vs. distributed control
Enhanced Spectral Reuse via Device-to-Device Communications

We study LTE/WiFi D2D offloading

- Analysis and system-level simulations
- Performance requirements and benefits
- Advanced network-assistance features
- 3GPP LTE-A & WiFi-Direct demonstration

Significant boost in cell throughput (up to 2x)

Practical alternative to densification
Current Picture and Perspectives

- Simulation-based study of network-assisted D2D communication
- Dynamic system analysis based on stochastic geometry
- Comprehensive architecture for D2D offloading + MWC’14 DEMO
- Current focus on emerging applications (vehicular, wearables, etc.)
- Integrating D2D as an alternative connectivity option under 3GPP
Demo: Cellular Offloading onto WiFi Direct

Devices **receive help** from cell during device discovery and D2D connection establishment.

Secure D2D connectivity between **stranger** users!
Improved Power Efficiency

We concentrate on **energy efficiency** of a mobile device

- Optimization of Tx power per radio
- Recommendations on when each RAT should be used
- Analysis supported by simulations
- Efficient practical control algorithms
- Framework extended to D2D & MTC
Current Picture and Perspectives

- Use optimization theory to solve energy efficiency problems
- Rich set of applications across HetNets, D2D, MTC, etc.
- Current focus on emerging applications (e.g., wireless energy harvesting)
- Integrating existing energy efficient algorithms into current networks

**Attractive trade-offs between spectral and energy efficiencies**
Efficient Support for Machine-Type Communications in LTE

Our goal is to improve LTE support of MTC
- Large device population w/energy constraints
- Random vs. scheduled network access
- Advanced energy/delay/success rate analysis
- Own detailed protocol-level simulator
- Efficient small data transmission mechanism
- Enhancements for idle and connected mode

![Diagram of LTE network with MTC devices, eNodeB, and PUCCH, PRACH, COBALT power consumption comparison graph showing good energy savings.]
Current Picture and Perspectives

- Comprehensive analysis of MTC overload scenario
- Efficient small data access mechanism: COBALT
- Extensive support with protocol-level simulations of 3GPP LTE
- **Current focus on coexistence between MTC and H2H**
- **Further improvements in channel access, RRM, scalability, etc.**
Some of Our Recent Publications


O. Galinina, et al., Capturing Spatial Randomness of Heterogeneous Cellular/WLAN Deployments With Dynamic Traffic, *IEEE J. on Selected Areas in Communications*, 2014


Our Research Partners

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