Christian Doppler Laboratory for Dependable Wireless Connectivity for the Society in Motion

Linking to 5G Research, Developments and Standardization
Annual Open Day and Workshop

Stefan Schwarz
15.11.2016
CD-Lab Overview

Module 1:
Non-Orthogonal Multicarrier and Massive MIMO for High-Mobility

NOKIA

The Vienna mmWave Test Bed

Module 2:
Millimeter Wave Transmission and Ad-Hoc Networks for High-Mobility

A1

Module 3:
HetNets and DASs for Masses of Mobile Users

KATHREIN

The Vienna LTE and 5G Simulators

The Vienna MIMO and Rotary Test Beds
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Relation between our CD-Lab and 5G

Conclusion
5G – Why Yet Another Generation?

- Development from 2G to 3G/4G was driven by the mobile phone
  - Transition from telephony to data services
  - Improvements in capacity, data rate, latency
- Prime goal of 5G: One network — many business cases
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![Diagram showing 5G use cases](image-url)
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Different applications map to different requirements

Virtual network slicing to support individual key performance indicators
Automated driving: advantages of information exchange

- Expansion of **sensing range** (blind-spots, blockages)
- Higher level of **traffic coordination** (platooning, intersection scheduling)
- **Better informed** decisions in safety-relevant situations

Yet, necessary dependence on communication must be avoided
3GPP Roadmap towards 5G

- **LTE 3.5G**
  - CA - 5CC (100MHz)
  - MIMO 8 streams
  - 20MHz
  - MIMO 4 streams

- **LTE-A 4G**
  - CoMP

- **FDD/TDD CA**
  - D2D
  - Dual connectivity

- **CA - 32CC (640MHz)**
  - FD-MIMO
  - Narrowband IoT
  - LTE-U

- **IMT 2020**

- **5G Era**

- **5G**
  - LTE-A Pro

**3G Era**

**4G Development**

**4G Era**

**5G Development**

**5G Era**
3GPP Roadmap towards 5G

Maintain backwards compatibility
Existing spectrum below 3.5GHz

„Unrestricted“ play-ground
(Non)-standalone
New spectrum below and above 3.5GHz

R14:
- latency - shorter TTI, instant UL
- LTE-U improvements
- FD-MIMO enhancements
- MTC, V2X

Channel modeling for >6GHz
- Hot-spot capacity boost
- Ultra-lean design
- Multi-site beamforming
- Flexible multicarrier
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MODULE 1: PHY Enhancements

MODULE 2: Innovative Technologies

MODULE 3: Network Architecture

Flexible Multicarrier  FD/Massive MIMO  mmWave Technology  Vehicular Networks  HetNets

NOKIA  A1  KATHREIN
Adaptation of modulation scheme to channel characteristics and user requirements

- **FBMC**
  - Per-subcarrier filtered multicarrier
  - Highest bandwidth efficiency
  - Parameter optimization w.r.t. channel
  - MIMO enhancements
  - Not a candidate for LTE-A Pro

- **filtered OFDM**
  - Post-filtering of OFDM
  - Improved spectral properties
  - Multi-user parameter optimization
  - Candidate considered by the 3GPP
Three-dimensional doubly-directional channel modeling

System level investigations of 3D beamforming ⇒ F. Ademaj

FD/Massive MIMO with realistic antenna arrays ⇒ S. Pratschner
Measurement-based mmWave channel characterization ⇒ E. Zöchmann
  - Delay/Doppler-spread, directional channel properties

Cellular-assisted V2X communications ⇒ B. Ramos-Elbal
  - Enhancing 3GPP LTE and 5G developments
  - Cooperation of technologies (cellular, ad-hoc DSRC)

mmWave technology in V2X communications
  - Joint radar sensing and communication
  - Raw sensor data exchange versus pre-processed data
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mmWave Technology and V2X – CD-Lab Research

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Simulator Development

- Enabling standard-compliant and beyond-standard simulations
- Open source distribution – reproducibility
- System level: basis for investigations on heterogeneous networks
Journal and Magazine papers:


Conference publications: 18 papers
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▷ **5G standardization is ramping up** to meet the IMT2020 deadline

▷ We are continuously aligning with standardization in order to **explore and develop methods beyond the standard**

▷ Our research topics are well-positioned within the **high-mobility segment** of 5G developments

▷ Early disclosure: CD-lab **expansion plans**

  Joint research-module with renowned Austrian railroad company

  Research focus: big data analysis in public transportation
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www.nt.tuwien.ac.at/christian-doppler-laboratory


