CZECH
TECHNICAL
UNIVERSITY
IN PRAGUEFACULTY
OF ELECTRICAL ENGINEERINGDEPARTMENT OF TELECOMMUNICATION ENGINEERING

Communication in integrated terrestrial and non-terrestrial mobile networks

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Outline

Overview of 6Gmobile research lab

Research topics related to space

- ► Radio resource management
- Mobility management
- Edge computing

Laboratory equipment

- Lab of mobile networks
- Quantum key distribution lab

Team overview

6Gmobile research lab

6Gmobile research lab focuses on key aspects and challenges related to future mobile networks and emerging wireless technologies

EURECOM

Gowex

Objective:

Propose innovative solutions beyond 5G and towards 6G mobile networks

Bar-Ilan University

Staffs

- ► 1 associate professor
- ~4 researchers and postdocs
- ~10 students (PhD, master)

Funding & Cooperation

European and national research projects

MUAWEI

Industrial projects
FOXCOND

X SEQUANS

Government

THALES

http://6Gmobile.fel.cvut.cz/research-areas

KING'S College

LONDŎ

Telkom

dune

Cez

SIRADEL

Atos

Research topics



http://6Gmobile.fel.cvut.cz/activities

Radio resource and communication management

Prediction of channel quality between any two devices

Channel quality prediction from information known to network

Interference mitigation

Transmission power and resource allocation

Non-orthogonal Multiple Access (NOMA)

Clustering of users, transmission power allocation

Management of relaying via devices and routing

Allocation of radio resources and motivation of relays to help

M. Najla, Z. Becvar, P. Mach, D. Gesbert, "System and Methods for Device-to-Device Communication," granted *US patent* US11284361B2, 2022. M. Nikooroo, Z. Becvar, "Optimal Positioning of Flying Base Stations and Transmission Power Allocation in NOMA Networks," *IEEE Transactions on Wireless Communications*, 2022.

M. Nikooroo, Z. Becvar, "Optimization of Total Power Consumed by Flying Base Station Serving Mobile Users," IEEE Transactions on Network Science and Engineering, 2022.

M. Najla, Z. Becvar, P. Mach, "Reuse of Multiple Channels by Multiple D2D Pairs in Dedicated Mode: Game Theoretic Approach," *IEEE Transactions on Wireless Communications*, 2021.

M. Najla, Z. Becvar, P. Mach, D. Gesbert, "Positioning and Association Rules for Transparent Flying Relay Stations," *IEEE Wireless Communications Letters*, 2021.

P. Mach, T. Spyropoulos, Z. Becvar, "Incentive-based D2D Relaying in Cellular Networks," IEEE Transactions on Communications, 2021.

M. Najla, Z. Becvar, P. Mach, D. Gesbert, "Predicting Device-to-Device Channels from Cellular Channel Measurements: A Learning Approach," IEEE Transactions on Wireless Communications, 2020.

GACR P102/17/175385 – Combined Radio Frequency and Visible Light Bands for Device-to-Device communication (2017-2019) GACR P102/18/270235 – Communication in Self-optimizing Mobile Networks with Drones (2018-2021) MEYS LTT18007 & LTT20004 – Cooperation with the International Research Centre in Area of (Digital) Communication Systems (2018-2025)



NLoS

FlyRS k

Mobility management

Users' association and handover for terrestrial networks

- Optimization of mobility-related processes
 - Handover (users switching among base stations)
 - Neighborhood scanning (discovery of potential handover targets)
 - Admission (availability of resources)
 - Load balancing among base stations
 - Communication resource availability
 - Energy consumption reduction

Users' association and handover for UAVs/HAPs

Joint management of handover of users and UAVs/HAPs

A. Madelkhanova, Z. Becvar, T. Spyropoulos, "Q-Learning-based Setting of Cell Individual Offset for Handover of Flying Base Stations," *IEEE Vehicular Technology Conference (IEEE VTC2022-Spring)*, 2022.

K. da Costa Silva, Z. Becvar, E. Cardoso, C. R. Francês, "Self-tuning Handover Algorithm Based on Fuzzy Logic in Mobile Networks with Dense Small Cells," *IEEE Wireless Communications and Networking Conference (IEEE WCNC 2018)*, 2018.

M. Vondra, Z. Becvar, "Distance-based Neighborhood Scanning for Handover Purposes in Network with Small Cells," *IEEE Transactions on Vehicular Technology*, 2016.

FP7 FREEDOM – Femtocell-based network enhancement by interference management and coordination of information for seamless connectivity (2010-2011)

GACR P102/12/613 – Prediction Algorithms for Efficient Mobility Management in Wireless Networks (2012-2014)

GACR P102/18/27023S - Communication in Self-optimizing Mobile Networks with Drones (2018-2021)

MEYS LTT20004 – Cooperation with the International Research Centre in Area of Digital Communication Systems (2020-2025)





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Edge computing

Edge computing for users' data processing

- Decide "where" the computing should be done
- Allocate computing and communication resources
- Manage mobility
- Initially focused on terrestrial networks

Data processing and communication management

- ► Distribution of computing resources between ground and aerial nodes
 - > Resources for network and communication management
- Non-terrestrial networks

J. Plachy, Z. Becvar, E. Calvanese Strinati, N. di Pietro, "Dynamic Allocation of Computing and Communication Resources in Multi-Access Edge Computing for Mobile Users," *IEEE Transactions on Network and Service Management*, June 2021.

J. Plachy, Z. Becvar, P. Mach, "Path Selection Enabling User Mobility and Efficient Distribution of Data for Computation at the Edge of Mobile Network," *Computer Networks*, 2016.

J. Dolezal, Z. Becvar, T. Zeman, "Performance Evaluation of Computation Offloading from Mobile Device to the Edge of Mobile Network," *IEEE Conference on Standards for Communications & Networking (IEEE CSCN 2016)*, 2016.

J. Plachy, Z. Becvar, E. Calvanese Strinati, "Dynamic Resource Allocation Exploiting Mobility Prediction in Mobile Edge Computing," *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (IEEE PIMRC 2016)*, 2016.

FP7 TROPIC – Distributed computing, storage and radio resource allocation over cooperative femtocells (2012-2015) MEYS projects LTT18007 & LTT20004 – Cooperation with the International Research Centre in Area of (Digital) Communication Systems (2018-2025)







Augmented reality Android app with offloading to edge

Laboratory of mobile networks

Software defined mobile network

- Radio Access and Core Networks compliant with standards
 - OpenAirInterface and srsRAN
- ► USRPs B205 mini (SDR on flying base station)
- USRPs B210 (SDR for fixed base stations and user equipment)
- USRPs N310 (SDR for fixed base stations and user equipment for 5G)
- Flying base station (hexa-copter and providing mobile connectivity)
- Two edge computing servers

Access to complete protocol stack of mobile networks

Satellite communication in frame of mobile networks (3GPP rel. 17&18)









Quantum key distribution Lab

Quantum physics for security key generation and transmission

Optical quantum repeaters and Free space Quantum Key Distribution (QKD)

- terrestrial, HAP, drones, and possible satellites
- Lab connection to National QKD Network
 - to be built in upcoming years



https://qt.eu/discover-quantum/underlying-principles/quantum-key-distribution-qkd/





https://www.researchgate.net/figure/QKD-network-hierarchy-with-quantum-key-management-andcommunication-key-usage-layers_fig2_344510948

Team



Zdeněk Bečvář WoS: H-index 14 (2000+ citations) GS: H-Index 22 (4000+ citations) zdenek.becvar@fel.cvut.cz https://6gmobile.fel.cvut.cz/zdenek-becvar/



Pavel Mach WoS: H-index 12 (1900+ citations) GS: H-Index 17 (3500+ citations) machp2@fel.cvut.cz https://6gmobile.fel.cvut.cz/pavel-mach/

Expertise in future mobile networks and communication systems Dissemination in last three years

- ► 10+ transactions-like (D1/Q1) journal papers
 - > IEEE TWC, IEEE TCom, IEEE TVT, IEEE TNSM, IEEE TNSE, IEEE WCL,...
- ► 15+ flagship conferences
 - ➢ IEEE WCNC, IEEE Globecom, IEEE VTC, IEEE PIMRC,...
- 4 granted US patents (+1 Czech and 1 Chinese patents)
- Contributions to standardization of mobile networks (3GPP)

One GACR and two MEYS projects on non-terrestrial communications

 Plus few EU projects, GACRs, other national projects, and industrial contracts on mobile networks

https://6gmobile.fel.cvut.cz/team/

http://6Gmobile.fel.cvut.cz/publications

https://6gmobile.fel.cvut.cz/projects/

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Thank you for your attention!

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