

# Elektrotechnik-Elektronik-Informationstechnik

# EEI KOLLOQUIUM

## Normalized Nash Equilibrium for Heterogeneous Networks

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**Diskussionsleitung: Prof. Dr.-Ing. R. Müller**

Efficient, scalable, and low complexity resource allocation methods are needed to improve the efficiency of existing LTE-Advanced networks and to inspire protocol definition for 5G networks. We propose a method based on game theory, yielding an efficient distributed resource allocation.

We consider heterogeneous networks with multiple femtocells and macrocells. Femto-base stations (femto-BSs) are constrained to allocate transmit powers such that the total interference at each macro-user terminal (macro-UT) is below a given threshold. We formulate the power allocation problem as a concave game with femto-BSs as players and multiple macro-UTs enforcing coupled constraints. We illustrate the concept and benefits of normalized Nash equilibrium (NNE) and we select it as operating point of the system. When the interference at a femto-UT from adjacent femto-BSs is negligible and under some technical constraints on the utility functions, the NNE is unique and solution to a concave potential game. We also propose a distributed algorithm which converges to the unique NNE. When the interference is not negligible, an NNE may not be unique and its computation has exponential complexity. For this case, we introduce the concept of weakly normalized Nash equilibrium (WNNE) which keeps the most of interesting properties of the NNEs but, in contrast to the latter, can be determined with low complexity.

Furthermore, this resource allocation approach is extended to the case where femto-BSs are unaware of the exact values of the parameters of the channels between them and macro-UTs because of the lack of cooperation and fading. We propose and analyze two different design criteria related to outage probability and signal-to-interference-plus-noise ratio, respectively. For both of them, we discuss the uniqueness of the NNE and resort to the concept of WNNE when advantageous.