Green HetNets: Capacity Improvements, Coverage Expansion and Backhaul Requirements

Abstract: Heterogeneous small-cell networks (HetNets) are considered as a remarkable solution to the challenging demands such as high spectral and energy efficiency of mobile communication networks. HetNets are typically composed of multiple radio access technologies (RATs) where multiple low-power, low-cost user/operator deployed base stations (BSs) are complementing the existing network. In this tutorial, we will investigate and study the spectral- and energy-aware deployment of small-cells in heterogeneous networks and their several need-oriented deployments around the edges of the macrocells, such that the small-cell base stations (SBSs) serve the cell-edge mobile users, thereby expanding the network coverage and increasing the capacity. Moreover, the reduction in energy consumption is achieved by considering power control in the uplink where the mobile users are transmitting with adaptive power to compensate the path loss, shadowing and fading. In this context, in order to quantify the gains of the HetNets, we will introduce useful performance metrics such as area spectral efficiency (ASE) which is defined as bps per Hz per macrocell area and area green efficiency (AGE) which is defined as the aggregate energy savings in the uplink per unit macrocell area. In order to calibrate the reduction in CO_2 emissions of mobile communication networks, this tutorial quantifies the ecological and associated economic impacts of energy savings in under-consideration deployments. Moreover, in order to calibrate the impact of power consumption on the system performance and network topology, this tutorial also presents a comprehensive end-to-end breakdown of total power consumption which includes backhaul, access and aggregation network power consumption. Simulation results are provided to demonstrate the spectral and energy improvements in comparison to existing and other traditional small-cell deployment strategies. Specifically, this tutorial will provide answers for the following:

- What are the Green competitive technologies to expand the cellular coverage?
- What are the contributing factors to the downlink and uplink energy consumption of HetNets (end-to-end power consumption breakdown including backhaul)?
- What are the recent capacity enhancement techniques for advanced HetNets?
- What are the ecological (carbon footprint) and economic (low carbon economy index) impacts of the future generations of wireless networks?

Presenters:

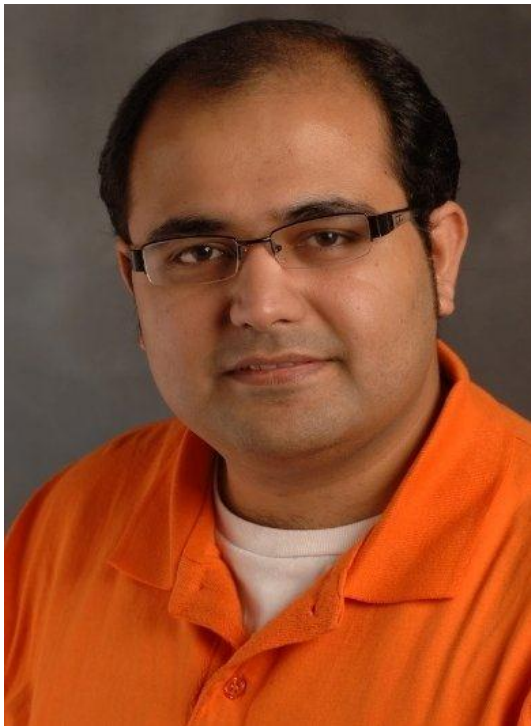Muhammad Zeeshan Shakir, Texas A&M University at Qatar (Qatar)

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Dr. Shakir's research interests include design and deployment of diverse wireless communication systems including hyper-dense heterogeneous small-cell networks with particular focus on traffic offloading techniques and backhauling technologies. He is also interested in deriving emerging wireless application oriented unified frameworks for machine type communications, cognitive radio communications and ubiquitous remote/mobile healthcare communications. He has published more than 50 technical journal and conference papers and has contributed to 6 books, all in well reputed venues. His most of the research has been sponsored by Qatar National Research Fund (QNRF) and national industrial partners.

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Mohamed-Slim Alouini was born in Tunis, Tunisia. He received the Ph.D. degree in Electrical Engineering from the California Institute of Technology (Caltech), Pasadena, CA, USA, in 1998. He served as a faculty member in the University of Minnesota, Minneapolis, MN, USA, then in the Texas A\&M University at Qatar, Education City, Doha, Qatar before joining King Abdullah University of Science and Technology (KAUST), Thuwal, Makkah Province, Saudi Arabia as a Professor of Electrical Engineering in 2009. His current research interests include the modeling, design, and performance analysis of wireless communication systems.

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