Abstract

Beyond fifth generation (5G+) communication aims to provide a 3-dimensional ubiquitous network to support high data rates caused by device proliferation. To aid 5G+ communications, higher frequency spectrum bands are being investigated. This dissertation focuses specifically on mmWave-enabled communications for serving users under different 2-dimensional as well as 3-dimensional network. The number of radio frequency (RF) chains that can be deployed at a device is a bottleneck in the mmWave range due to high hardware power consumption, hardware complexity, and user scheduling complexity. Therefore, the objective of this dissertation is to investigate and design energy and spectrally efficient reduced complexity terrestrial and aerial mmWave communications frameworks/architectures with a limited number of RF chains.

The first topic investigates sectored-cell framework for a 2-dimensional multi-user terrestrial mmWave communications with a single analog beam serving the sectors in a round-robin manner while maintaining constant equivalent isotropically radiated power. An optimization problem is formulated for combined resource allocation to users in a sector and sector beamwidth optimization to maximize average long-term user rate and system energy efficiency. The second part of the dissertation extends the study of the sectored-cell framework with a single RF chain to the case of multiple RF chains at gNodeB while accounting for resulting inter-beam interference and beam squint. Furthermore, an optimal number of RF chains at the gNodeB is estimated by accounting for power waste in RF units. A variable time frame structure for the sectored-cell framework is also proposed for a standalone mmWave communications system. The third part of the dissertation studies in detail the effect of beam squint in wideband mmWave communication. A new reduced complexity joint OFDM resource allocation and beamforming strategy is proposed, which employs beam squint to maximize system performance. The fourth part of the dissertation explores the feasibility of using an unmanned aerial vehicle (UAV) as a fronthaul unit at mmWaves and contrasts its performance with that at the sub-6 GHz range for ad hoc communication. Further, the optimal grouping and optimal number of RF chains in a multi-user UAV-assisted mmWave communications are investigated. The effect of additional weight because of the solar panel on the performance of the solar UAV is also analyzed. Finally, the dissertation's last part studies the feasibility of using an existing backscatter device infrastructure in an indoor environment to provide data support to an obstructed user at mmWaves.