Design and Evaluation of a Cost-Optimized Cell-Free Massive MIMO System

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Motivation:

Massive multiple input multiple output (MIMO) is one of the key technology components for the fifth generation (5G) of cellular systems to improve the achievable throughput. In this type of network, base stations (BSs) equipped with tens or hundreds of antennas serve a small number of users (UEs). Compared to the previous generations of cellular networks, most of the throughput gain is realized by focusing the transmit energy toward the scheduled UEs via beamforming and implementing spatial multiplexing. Having large number of antennas is beneficial for both these mechanisms as they enable the BS to create very sharp and high gain beams and transmit simultaneously several data streams toward the active UEs.

The conventional deployment of massive MIMO involved equipping BSs at the cell center with several antennas. An alternative to this is the so-called *cell-free massive MIMO*. In this system, a central unit is connected to several low-cost and low-power access points (APs), which are equipped with a few antennas and joint transmission/reception (JT/JR) is applied at these APs. With perfect backhaul and synchronization, this distributed scheme outperforms centralized massive MIMO for two main reasons: 1) it provides more diversity as the antennas are spatially located in different positions, 2) it is characterized by shorter distance between UEs and at least some of the APs. However, more analysis is required to understand the practical gain that cell-free massive MIMO can achieve when realistic assumptions regarding backhaul and impairments are taken into account.

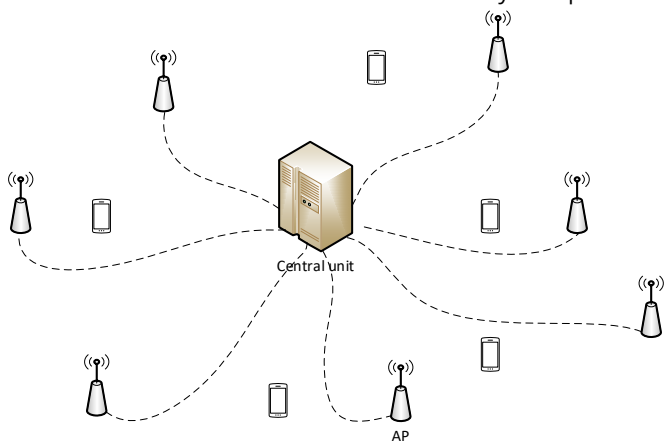
Objective:

To identify use cases and scenarios, where cell-free massive MIMO is the best antenna deployment solution compared centralized massive MIMO.

Vodafone Chair Contributions:

As part of this collaboration, the Vodafone Chair shall make the following contributions:

- Develop a simulation environment to evaluate the performance of cell-free massive MIMO with varying AP distribution and different precoding techniques. The primary focus is on time division duplex (TDD) downlink, where system performance is highly impacted by pilot contamination. Performance gain will be understood against common baseline approaches such as centralized massive MIMO (all antennas co-located at the site center) and fully distributed MIMO without cooperation among the APs.
- Extend the simulation setup to include cost models for APs, installation and backhaul. Depending on the type of backhaul, for example, mmWave link or optical fiber, there is a cost that must be considered in the evaluation of cell-free massive MIMO and in identifying the optimal deployment settings. While spreading the APs more in the cell helps in improving the performance, it comes also with additional cost and complexity.
- Study the impact of impairments such as lack of synchronization, propagation delays, or backhaul latencies on system performance.



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