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Fog Massive MIMO: A User-Centric Seamless Hot-Spots Architecture

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The decoupling of data and control planes, as proposed for 5G networks, will enable the efficient implementation of multi-tier networks where Users Equipment (UE) nodes obtain coverage and connectivity through the top tier formed by macro-cells operating at low frequency bands, while achieving high throughput and low latency data communication from lower tiers in the hierarchy. This paper considers a new architecture for such lower tiers, dubbed Fog massive MIMO, where the UEs are able to establish high-throughput and low latency data links in a seamless and opportunistic manner, as they travel through a dense "fog" of high-capacity Remote Radio Heads (RRHs). A general major problem for dense multicell networks consists of frequent handovers and pilot sequence re-assignment, that may incur a large protocol overhead and significant latency. In the proposed fog massive MIMO architecture, UEs seamlessly and implicitly associate themselves to the most convenient RRH in a completely autonomous manner. Each UE is associated with a unique uplink pilot sequence, and pilot contamination is mitigated by a novel coded "on-the-fly" pilot contamination control mechanism. We analyze the spectral efficiency and outage probability of the proposed architecture via stochastic geometry, using some recent results on unique coverage in Boolean models, and provide a detailed comparison with respect to an idealized baseline massive MIMO cellular system, that neglects protocol overhead and latency due to explicit user-cell association. Our analysis, supported by extensive system simulation, reveals that there exists a "sweet spot" of the per-pilot user load (number of users per pilot), such that the proposed system achieves spectral efficiency close to that of an cellular system with minimum distance cells and no pilot/handover overhead, while exhibiting the simplicity and low-latency of completely user-centric operations.