

Distributed Signal Processing for Cell-Free Massive MIMO in the Uplink: A Factor Graph Perspective

Abstract: The increasing demand for scalable, low-latency, and energy-efficient wireless communication, especially in the context of massive machine-type communication (mMTC), Internet of Things (IoT), and future 6G networks, is driving the development of distributed architectures and algorithms for the uplink. This talk focuses on distributed signal processing, highlighting the power of Bayesian inference techniques implemented via factor graphs as a unifying and flexible framework.

We will present how factor graph-based techniques enable the decomposition of complex signal processing tasks, such as joint data detection, channel estimation, and activity detection in grant-free access, into simple, localized computations. This makes them especially well-suited for implementation in distributed and cell-free architectures, where central processing is limited.

As a key application scenario, we will discuss cell-free massive MIMO, where geographically distributed access points collaboratively serve users without cell boundaries. By leveraging the modular structure of factor graphs, we demonstrate how complex inference problems can be decomposed into localized message-passing algorithms that are well-suited for distributed implementation across access points. The approach leads to efficient use of fronthaul resources and robustness to interference.

We conclude the talk with a discussion of open challenges and future directions in applying probabilistic graphical models to distributed wireless systems.