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# Energy-Efficient Power Allocation in Cell-Free Massive MIMO via Graph Neural Networks

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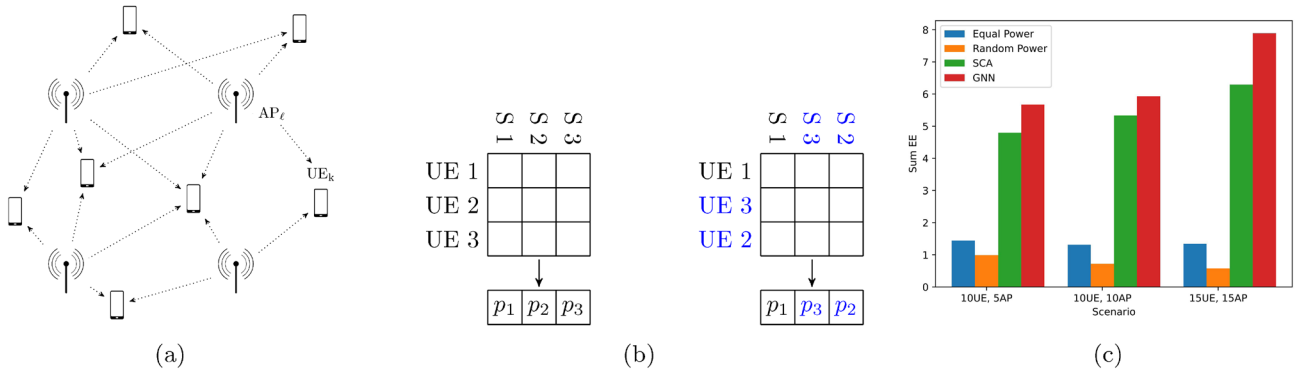
## How can machine learning improve resource allocation while improving energy efficiency of cell free systems?




*(A) Scenario of a cell free network where each user (UE) can be served by multiple access points (AP). (B) Permutation equivariant architecture of the neural network. It requires standardized CSI as input and provides power allocation as output. (C) Comparison of the energy efficiency performance of the proposed machine learning model with the state of the art successive convex approximation and other baseline methods like random and equal power allocation. It is shown how using the ML model improves the performance of the network.*

### KEY FINDINGS

Cell free massive MIMO (CF-mMIMO) uses many spatially distributed APs to serve UEs and overcome the performance bottleneck in the cellular networks. From the UE's point of view the cell boundaries disappear and thus obtain seamless and uniform coverage even with high mobility.

The distributed nature of CF-mMIMO can have many advantages. For example, the UE is more likely to have a line-of-sight channel and CF-mMIMO enables distributed processing useful in serving large number of UEs. However, the challenge of power allocation still remains. We present a solution to the power control problem with a permutation equivariant graph neural network (GNN) with nested SINRnet. It requires standardized channel state information (CSI) as input and can be trained to provide optimal power allocation for different objectives. Currently GNN with nested SINRnet is able to maximize energy efficiency (EE) in an unsupervised fashion and outperform other baseline methods. By doing so, the complexity is offloaded to training and in application, can be much faster compared to analytical optimization methods. This approach can enable the use of machine learning techniques to enhance CF-mMIMO networks.

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