Non-orthogonal Multiple Access in Massive MIMO Aided Heterogeneous Networks

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IS-CT: Interactive Session: Communication Theory

Motivation

- **High spectrum efficiency**: NOMA improves the spectrum efficiency with multiplexing users in power domain and invoking succussive interference cancelation (SIC) technique for canceling interference.
- **Good compatibility**: NOMA is regarded as a promising ``add-on" technology for the existing multiple access systems.
- **Low complexity:** The complex precoding/cluster design for MIMO-NOMA systems can be avoided.
- **Fairness/throughput tradeoff:** NOMA is capable of dealing with the fairness issue by allocating more power to weak users, which is of great significance for HetNets when investigating efficient resource allocation in the sophisticated multi-tier networks.

System Model

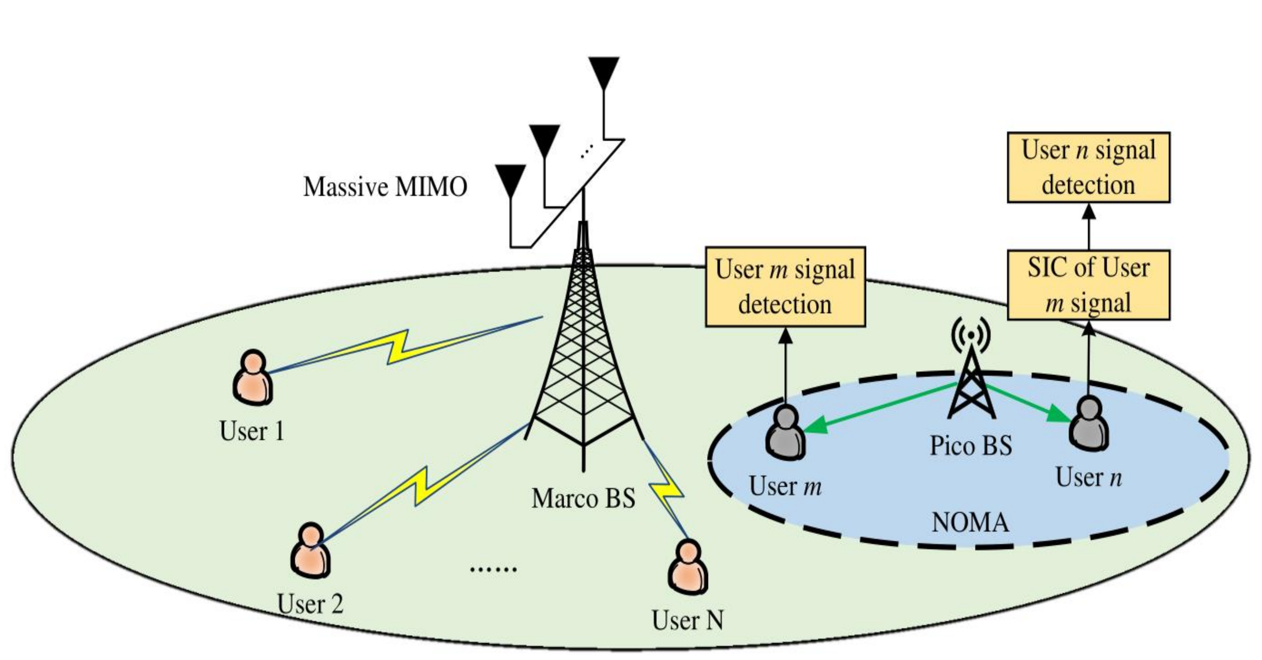

Fig. 1. Illustration of NOMA and massive MIMO based hybrid HetNets.

We consider a K-tier HetNets model, where the first tier represents the macro cells and the other tiers represent the small cells such as pico cells and femto cells. The positions of macro BSs and all the k-th tier BSs are modeled as homogeneous poisson point processes (HPPPs). We consider to apply massive MIMO technologies to macro cells and NOMA transmission to small cells in this work as shown in Fig. 1.

Flexible User association:

A user is allowed to access any tier BS, which can provide the best coverage. We consider that the flexible user association is based on the maximum average received power of both macro cells and small cells.

Information Signal Model:

The received signal-to-interference-plus-noise ratio (SINR) that a typical user connects with a macro BS is

$$\gamma_{r,1} = \frac{P_1 / N h_{o,1} L\left(d_{o,1}\right)}{I_{M,1} + I_{S,1} + \sigma^2}.$$

The received SINR that a typical user n connects with the k-th tier small cell is

$$\gamma_{k_n} = \frac{a_{n,k} P_k g_{o,k} L\left(d_{o,k_n}\right)}{I_{M,k} + I_{S,k} + \sigma^2}.$$

The received SINR that for the existing user m in the k-th tier small cell is

$$\gamma_{k_m^*} = \frac{a_{m,k} P_k g_{o,k} L\left(R_k\right)}{I_{k,n} + I_{M,k} + I_{S,k} + \sigma^2}.$$

Numerical Results

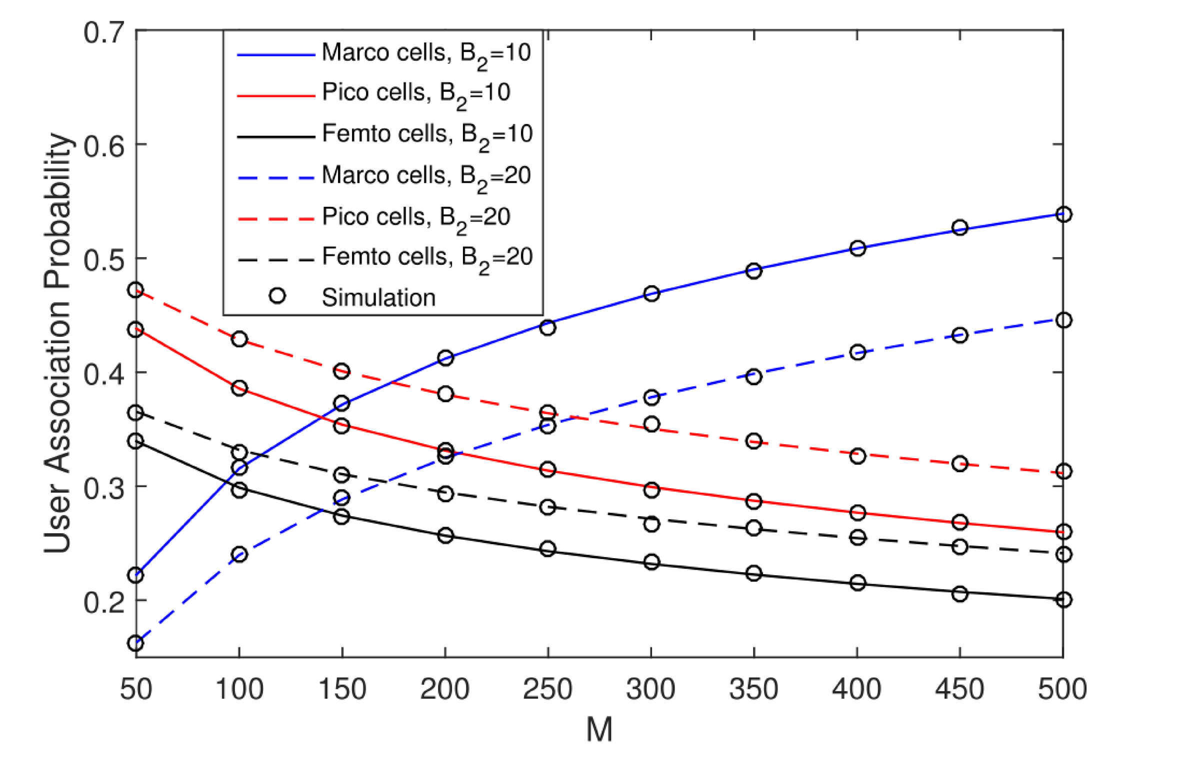

Fig. 2. User association probability of the considered network, with $K = 3$, $N = 15$, $P_1 = 40$ dBm, $P_2 = 30$ dBm and $P_3 = 20$ dBm, $\lambda_2 = \lambda_3 = 20 \times \lambda_1$, and $B_3 = 20B_2$.

- The number of antennas at macro BS increases, more users are likely to associate to macro cells. This is because that the massive MIMO aided macro cells are capable of providing larger array gain, which in turns enhance the average received power for the connected users.
- Increasing the bias factor can encourage more users to connect to the small cells, which is an efficient method to extend the coverage of small cells or control loading balance among each tier of HetNets.

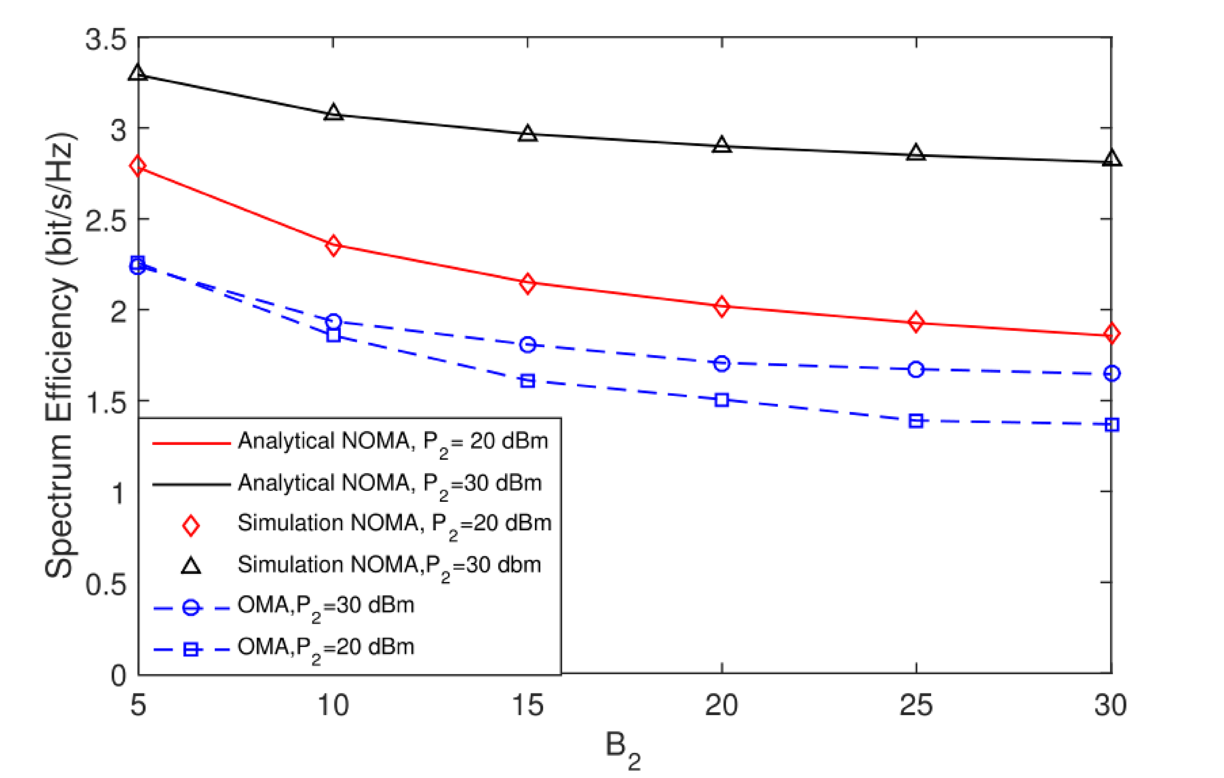

Fig. 3. Comparison of NOMA based and OMA based small cells in terms of spectrum efficiency, with $K = 2$, $M = 200$, $N = 15$, $\lambda_2 = 20 \times \lambda_1$, and $P_1 = 40$ dBm.

- The spectrum efficiency of small cells decreases as the bias factor increases. This is because larger bias factor makes more macro users with low SINR are associated to small cells, which in turn degrades the spectrum efficiency of small cells.
- It is also worth noting that the performance of NOMA based small cells outperforms the conventional OMA based small cells, which in turn can enhance the spectrum efficiency of the whole HetNets.

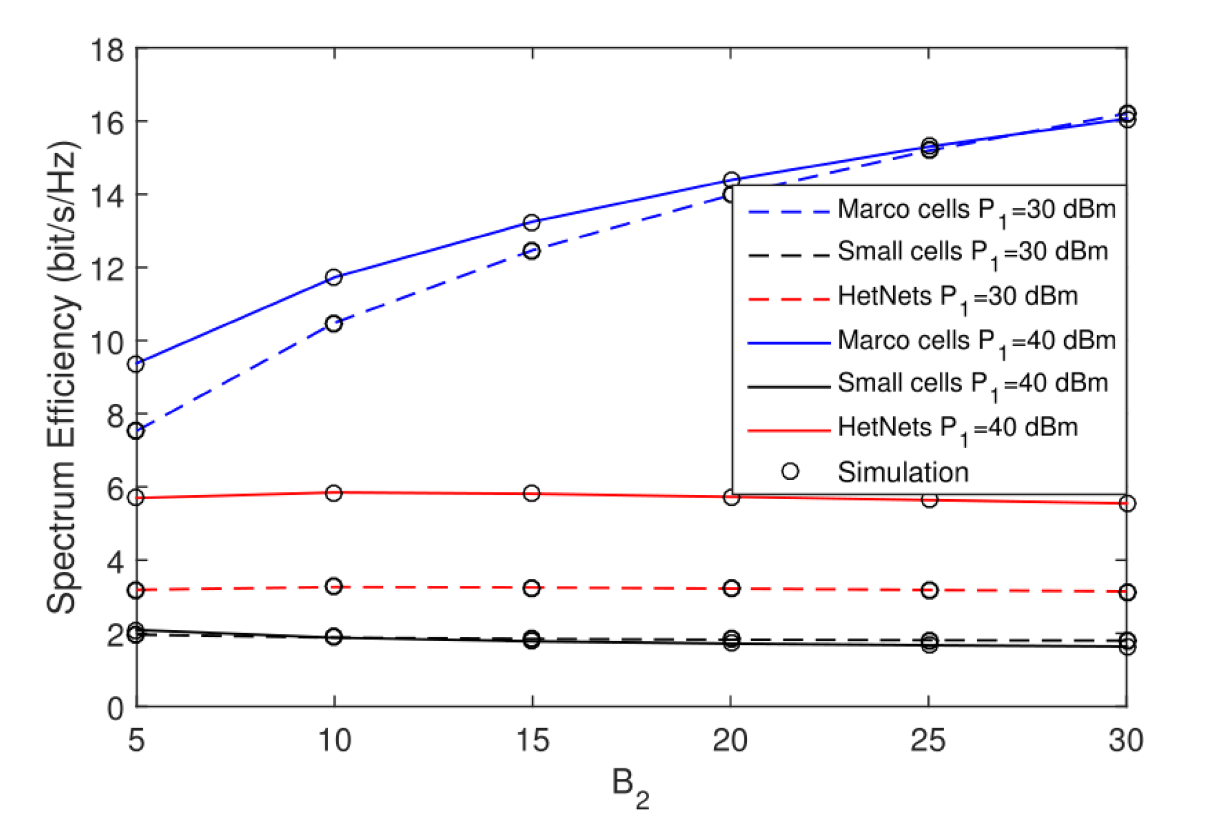

Fig. 4. Spectrum efficiency of the proposed framework, with $K = 2$, $M = 50$, $N = 5$, $P_2 = 20$ dBm, $\lambda_2 = 100 \times \lambda_1$.

- Macro cells can achieve higher spectrum efficiency compared to small cells. This is attributed to the fact that macro BSs are able to serve multiple users simultaneously with offering promising array gains to each user.
- The spectrum efficiency of macro cells improves as bias factor increases. The reason is again that more low SINR macro cell users are associated to small cells, which in turn makes the spectrum efficiency of macro cells enhance.