Abstract
An increasing demand on cellular wireless networks has targeted the heterogeneous network (HetNet) as an encouraging solution, despite unresolved issues. HetNet deploys small picocells in the coverage of a single macro base station to provide additional wireless access. Because picocells and macrocells transmit and receive signals at the same frequency, co-channel interference becomes an issue. However, a focus on minimizing interference starves certain users of resources and decreases fairness. We provide a user selection algorithm for zero-forcing beamforming (ZFBF) that maximizes the number of users given constraints for power and signal-to-interference-plus-noise ratio (SINR). We construct the user selection criteria, norm and orthogonality (NO) and pathloss reciprocal (PR). Using a hill climbing algorithm, we find that the optimal weights for each criterion are 0.5. Performance analyses show that, given several SINR thresholds, our user selection algorithm outperforms norm-based, angle-based and random user selection algorithms. Finally, we propose a weighting and priority selection method to prevent fairness violations.

Methods

Ranking System

The user selection ranking system involves two components: fairness and efficiency, which depends on norm and orthogonality, and pathloss reciprocal. Weights PR, NO, and F are constructed for user selection.

Ranking Formula

Suppose \( k \) is the active user group. Then the ranking function is

\[
R_k = 2^{\frac{1}{2}} \rightarrow R_k = \omega_N \cdot \frac{NO_k}{\omega_P \cdot PR_k}
\]

for user \( k \), where \( \omega_P \) and \( \omega_N \) are constant weights for the standardized norm and orthogonality score \( NO \) and the standardized pathloss reciprocal \( PR \), respectively. Note that:

One user at a time will be added to the selected group of users, \( S \subseteq U \), making the ranking function:

\[
R_S : A \rightarrow R \rightarrow X_0 \rightarrow R(S \cup \{X_0\})
\]

Pathloss Reciprocal (PR)

The signal-to-interference-plus-noise ratio (SINR) that maximizes the number of users given constraints for power and signal-to-interference-plus-noise ratio (SINR). We construct the user selection criteria, norm and orthogonality (NO) and pathloss reciprocal (PR). Using a hill climbing algorithm, we find that the optimal weights for each criterion are 0.5. Performance analyses show that, given several SINR thresholds, our user selection algorithm outperforms norm-based, angle-based and random user selection algorithms. Finally, we propose a weighting and priority selection method to prevent fairness violations.

Results

Simulated Weights (n=118) that Optimize Average Number of Users (Circle radius)

![Figure 4](image)

Comparison of User Selection Algorithms

![Figure 5](image)

Simulation Process

Initialize Physical Layer

Create/Update Set of Weights

Generate Channel/Noise Matrices

Perform User Selection Sequence

![Figure 3](image)

Discussion

Summary

1. Developed a mathematical user selection method to meet SINR and power constraints
2. NO is an effective user selection metric which simplifies calculations by combining norm-based and angle-based measures. PR improves the efficiency of standard methods for incorporating system constraints.
3. Demonstrated the effectiveness of our user selection method by conducting simulations

Future Directions

1. Incorporate and test fairness in our user selection method
2. Test the scalability of our method by increasing macro BS, adding femto BS, changing the number of users
3. Use improved optimization techniques such as stochastic gradient descent and genetic algorithms
4. Use different precoding techniques such as dirty paper coding

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