Impact of Non-uniform User Distribution on ZF-based Cluster-wise MU-MIMO

Sijie Xia[†1] Chang Ge[†1] Qiang Chen[†1] Fumiyuki Adachi[†2]

[†1] Department of Communications Engineering, Tohoku University
[†2] Research Organization of Electrical Communication, Tohoku University

1. Introduction

To improve the spectrum efficiency and to mitigate the computational complexity problem of ultra-dense radio access network, we have been studying cluster-wise MU-MIMO [1, 2]. Users do not exist densely everywhere. In this paper, we examine how the non-uniform user distribution impacts the achievable capacity of zero-forcing (ZF)-based cluster-wise MU-MIMO and then, discuss a possible deployment scenario of distributed antennas.

2. System Model and Simulations

In this paper, we consider the downlink communication of a cluster-wise ZF-based MU-MIMO system. *U* single-antenna users are distributed over a BS coverage area (BS cell) covered by *A* distributed antennas. Firstly, K-means clustering algorithm with a Euclidean metric is applied to form *K* initial user-clusters and then, a centroid-based assignment method is used to assign antennas to each cluster. In each cluster, ZF-based MU-MIMO [1] is utilized to eliminate inter-user-interference. For MIMO channels, the pathloss, shadowing, and Rayleigh fading are considered.

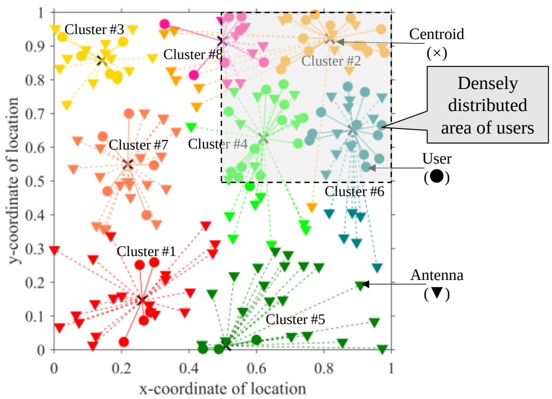

Fig. 1 An example of *K*=8-cluster formation for *A*=128 and *U*=64 in a normalized 1×1 BS cell.

In our previous study [1, 2], we assumed that users and distributed antennas are randomly distributed in the BS cell following to the uniform distribution. However, in many practical cases, users are more likely to gather in e.g. shopping malls, stations and office areas, while other places are relatively sparsely populated. Therefore, in this paper, we assume a square-shaped BS cell and consider a case that a half of the users are concentrated in a quarter of the BS cell while antennas are distributed uniformly over the BS cell. An example of *K*=8-cluster formation is shown in Fig. 1 for *A*=128 and *U*=64. The cumulative distribution function of the achievable sum capacity obtained by computer simulation is shown in Fig. 2. It can be seen clearly from Fig. 2 that the uniform deployment of distributed antennas significantly reduces the achievable capacity. If we deploy a half of *A*=128 distributed antennas in a quarter of the BS cell where users are densely populated, then, the capacity can be improved and approaches to the case that users and antennas are uniformly distributed over the BS cell. This indicates that the antenna deployment should be carefully determined taking into account the user distribution.

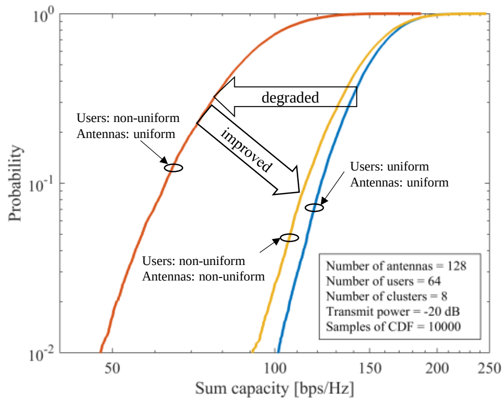

Fig. 2 Comparison of sum capacity between different user/antenna distributions.

3. Conclusion

In this paper, we examined how the non-uniform user distribution impacts the achievable capacity of ZF-based cluster-wise MU-MIMO. We showed that the distributed antennas should be carefully deployed according to the user distribution. How to adapt the antenna deployment to dynamically but slowly changing user distribution in time, e.g. from morning to night, is left for our future study.

Acknowledgement

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Reference

[1] S. Xia, C. Ge, Q. Chen, F. Adachi, "K-Means Clustering and Multi-user Zero-Forcing for Ultra-dense RAN in 5G Advanced Systems," IEICE Technical Report, vol. 119, no. 448, RCS2019-324, pp. 25-30, March 2020.

[2] S. Xia, C. Ge, Q. Chen, F. Adachi, "A Study on Cluster-wise User-antenna Association in 5G Advanced Ultra-dense RAN" IEICE Technical Report, vol. 120, no. 29, RCS2020-11, pp. 7-12, May 2020.