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Performance Improvement of MU-MIMO System by Optimizing the K-Factor for the K-Mean User Grouping Algorithm

Ankush Kansal, Pawandeep Singh*
Thapar University, Patiala-147004, Punjab, India

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ABSTRACT

In this paper, downlink multiuser-MIMO system with large number of transmitting antennas at the base station and R user terminals each having single antenna is considered. According to this design, an access point communicates with large number of users in the Rayleigh fading scenario. Due to large number of users, it becomes difficult to accommodate all of them in the system simultaneously. So, a user grouping technique known as K-mean clustering is used, such that a group of users with similar conditions at that particular time are served together. While making groups, the interference is surely reduced but the number of users being served at a time also reduces. So, it is necessary to make out the balance such that the performance of the system is maintained while accommodating maximum number of users. So, optimum number of user groups needs to be formed. The results show that when groups are increaseed from two till four sum rate increases but when five groups are made the sum rate decreases to a point but, is still higher than two groups.

Corresponding Author:

Pawandeep Singh,
Thapar University, Patiala-147004, Punjab, India
Email: pawandeepsingh515@gmail.com

1. INTRODUCTION

Wireless is a technique which has created the new dimensions in the field of communication. Due to the ease of implementation and access of the wireless technology, it is being implemented widely now a day. The main area of focus has been the reliability and the capacity of the system. All these requirements has been fulfilled by MIMO technology which is in use lately as it helps to increase the capacity of the communication system along with being robust and reliable. Also, the use of multiple antennas hinders the need for expansion of bandwidth as well as the transmitter power [1]. But this technology was first developed for single user systems i.e. transmitter having multiple antennas along with multiple antennas at the receiver. But due to exponential increase in the number of users in the wireless field, this technology has been extended to the multiuser systems. Multiuser MIMO is considered the advancement of SDMA permitting large number of end users on single channel [2]. Multiuser MIMO provides large number of benefits over single user MIMO like multiuser diversity enhances channel condition as users having best channel quality are allowed to occupy the channel [3]. Multiuser MIMO is rigid to the propagation limitations like rank loss or antenna correlation pertaining in single user MIMO [4].

In multiuser MIMO systems, the base station has multiple numbers of antennas along with the multiple numbers of users. The users can have multiple antennas or single antennas. But these variations in the user equipment can be of much importance. Firstly, there needs to be less hardware for the user equipment in order to save power and make the system portable and easy to handle. Secondly, the cost at the user end needs to be minimal in order to make the system more viable to the users [5]. So, it is of more importance that user should have less number of antennas and if possible only one antenna should be

employed at the user equipment. Along with this, the large number of users needs to be accommodated in the system so that the demand for the network by the people is satisfied. While habituating large number of users in the network, it is sure that the system performance will be deteriorated surely. So, it has been a problem while optimizing the system. So, one of the way is to make the groups of users which will use the network alternately [6]. More the number of groups the less will be the interference and more will be the signal strength. But also, it has an effect on the number of users being served. So, it is of great importance that up to which level the grouping should be done such that the maximum number of users is accommodated along with providing the good signal strength to the users in system.

2. SYSTEM MODEL

In this, consider the system for the downlink scenario, in which there are T transmit antennas at the base station and R receive terminals i.e. users. All user terminals are having only one antenna because of the hardware and cost constraints of the user equipment. All the transmit antennas form the uniform linear array as they are placed along a line at equidistant points.

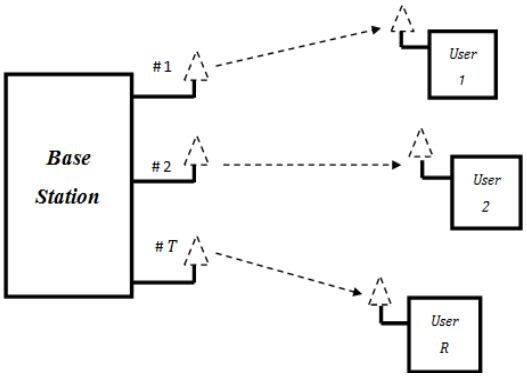

Figure 1. Multiuser MIMO System Model

The signal received by the users is given by [2]

$$R = H^H X + z \quad (1)$$

H, is the channel matrix between the transmit antennas and the users and have dimension $T \times R$ and $(.)^H$ denotes the Hermitian of the matrix;

$$H = [h_1, h_2 \dots\dots\dots, h_k] \quad (2)$$

Now in this, h_k denotes the $T \times 1$ dimensional channel matrix for the R^{th} user from all base station antennas. Here, X is the transmitted signal vector. Also, z being additive complex Gaussian noise with zero mean and unit variance. The base station has complete knowledge of channels for all users.

2.1. User Grouping Based on K-Mean Clustering

In real life scenarios, there are large numbers of users such that all cannot be accommodated in the system at the same time. To avoid such cases, some users are selected from total number of users to make groups. But, this grouping of users is a bit problem. For example, if selection of $'r'$ users from all the R number of users is to be done, then there will be C_R^r combinations. This will be really a complicated process. So, adapting user grouping based on some parameter reduces the computational complexity of the system [7]. So, the user grouping used is the K-mean clustering which helps to group the users by means of their distance from the base station antennas. For example, a random set of data (users) is given, and we want to divide them into groups using this algorithm. Firstly, the number of groups needs to be determined i.e. in how many groups the users need to be divided. Accordingly, the value of K is determined as it denotes the number of groups formed. If two groups are formed then the value of K is two.

The steps to form the clusters using K-mean algorithms [7]:

a. Choose one data point as the centre from the total set of data points and make the subset from by choosing which are close enough to the centroid and are similar in required properties.
b. The means of the data points in each cluster are computed, and this mean vector becomes the new centre for that cluster.

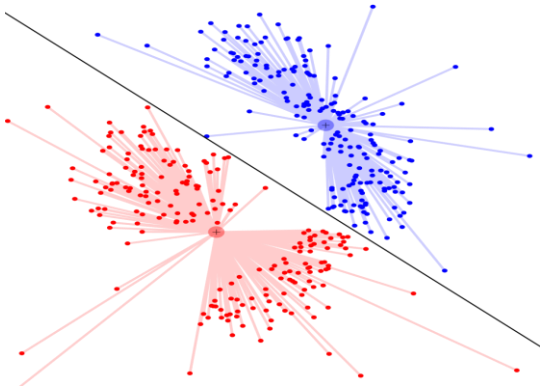

Figure 2. Example of K-Mean Clustering

All the users in the practical scenario are displaced to different locations. Some of them are at rest and some are moving. So, this leads to varying strength of signal which reaches out to the users from the base station antennas. So, it becomes more necessary to group the users according to their conditions at that particular time. This algorithm when used in multiuser MIMO systems, considers various parameters like signal to noise ratio (SNR), position, velocity of the users and channel through which the signal passes while travelling from base station to users [8]. All these conditions help to form the grouping which maximizes the capacity of the system. The main steps to form the grouping are as shown in flow chart below.

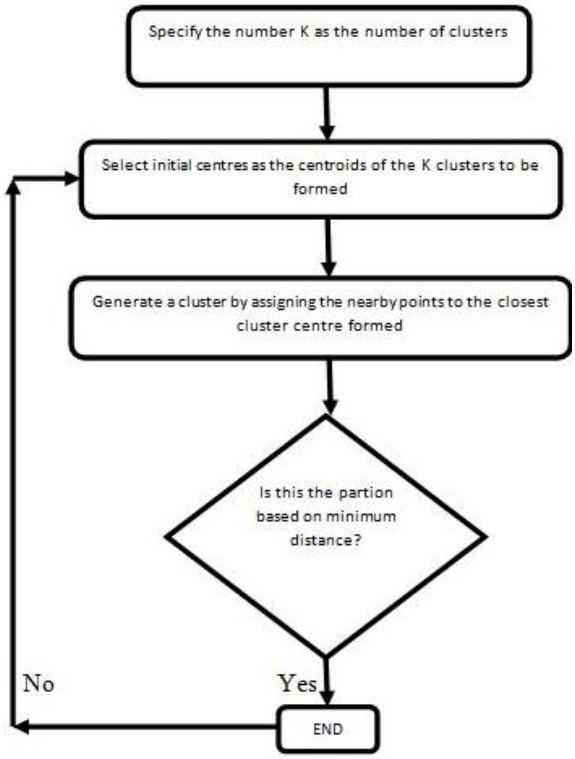

Figure 3. Flow Chart for User Grouping Using K-Mean Clustering

As it is known, when user groups are made it helps to increase the system capacity by mitigating the interference from the other groups and within the same user group by performing the precoding. Along with that, it helps to make the user groups based on some common properties which further helps to maintain the quality of the signal. While making groups, the interference is surely reduced but the number of users being served at a time also reduces. So, it is necessary to make out the balance such that the performance of the system is maintained while accommodating maximum number of users. So, optimum number of user groups needs to be formed.

3. RESULTS AND DISCUSSION

The simulation results demonstrating the optimization of grouping are presented here. In this system, total of 100 antennas at the base station and 100 users with single antenna are considered for communication. The environment taken is the Rayleigh fading. For all the simulations, transmit power used is 10 dB and received power for each user varies according to the distance from the base station antennas while using K-mean clustering. In the graphs, it can be seen that up to some value of the groups the sum rate tends to increase but after particular number of groups it tends to decrease.

In Figure 4, sum rate vs. number of users is shown for different number of groupings i.e. for different value of K. It can be seen that when 50 users are divided in groups, the sum rate for two groups (K=2) is 26.5 bps/Hz and it keeps on increasing while the number of groups formed are increased till four i.e. it is 29 bps/Hz and 29.5 bps/Hz respectively for three (K=3) and four (K=4) groups. But, when the five (K=5) groups are made for same number of users; it decreases to 28 bps/Hz, which is less than value of two and three grouping. But it is still higher for grouping done into two.

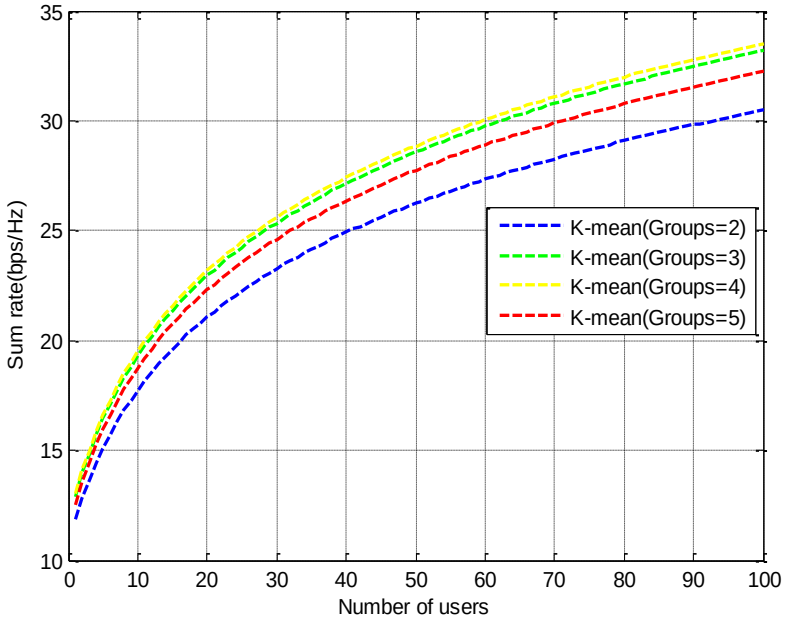

Figure 4. Number of Users vs. Sum Rate for Different Values of K

In Figure 5, sum rate vs. SNR for the K-mean clustering is given for different value of K i.e. different number of groups formed. For two (K=2) groups at SNR of 15dB value is 7 bps/Hz and it keeps on increasing when value of K increases till four. For K=3, the value is 8.5 bps/Hz and for value of K=4 it increase little bit to 9 bps/Hz.

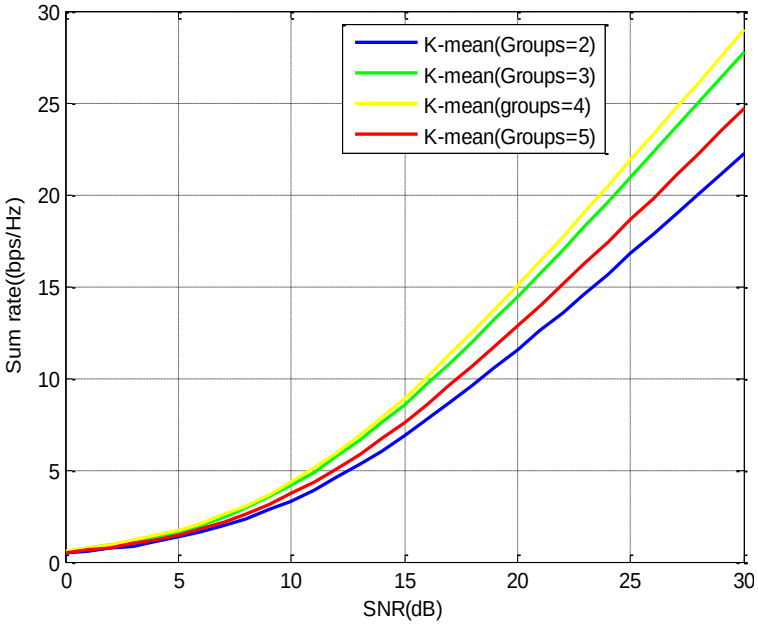

Figure 5. Sum Rate vs. SNR for Different Values of K

But when the value of K is further increased i.e. when K=5, the value deteriorates to 7.5 bps/Hz. But this value is still higher than the grouping done into two i.e. for K=2.

4. CONCLUSION

In this paper, the optimization of the user grouping for different values of K for the K-mean clustering is done. The total number of users is divided into groups and the sum rate performance of these is determined. The main problem for the optimization is to choose the accurate value of K i.e. the number of groups to be made such that the value of capacity is maximized for this value. In this, the capacity is maximized when the value of K is four. As the value of K is further increased to five the sum rate decreases. So the optimized grouping is done for the value of four.

REFERENCES

[1] D Tse; P Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.
[2] Kai-Kit Wong; Ross D Murch; Khaled Ben Letaief, Performance Enhancement of Multiuser MIMO Wireless Communication Systems, *IEEE Transactions on Communications*, vol.50, pp.1960-1970, 2002.
[3] Serbetli S; Yener A, Transceiver Optimization for Multiuser MIMO Systems, *IEEE Transactions on Signal Processing*, vol.52, pp.214-226, 2004.
[4] Andrea Goldsmith, Wireless Communication, Cambridge University Press, 2005.
[5] Serbetli S; Yener A, Transceiver Optimization for Multiuser MIMO Systems, *IEEE Transactions on Signal Processing*, vol.52, pp.214-226, 2004.
[6] Yi Xu; Guosen Yue; Narayan Prasad; Sampath Rangarajan; Shiwen Mao, *User Grouping and Scheduling for Large Scale MIMO Systems with Two-Stage Precoding*, IEEE International Conference on Communications, pp.5197-5202, 2014.
[7] Kanungo T; Mount DM; Netanyahu NS. An efficient K-means clustering algorithm: Analysis and implementation Pattern Analysis and Machine Intelligence, *IEEE Transactions on Communications*, vol.24, pp.881-892, 2002.
[8] Minchae Jung; Younsun Kim; Juho Lee; Sooyong Choi, Optimal Number of Users in Zero-Forcing Based Multiuser MIMO Systems with Large Number of Antennas, *Journal Of Communications And Networks*, vol.15, pp.362-369, 2013.
[9] Lin X. Cai; Hangguan Shan; Weihua Zhuang; Xuemin Shen; Jon W Mark; Zongxin Wang, *A Distributed Multi-User MIMO MAC Protocol for Wireless Local Area Network*, IEEE Global Telecommunication Conference, pp.1-5, 2008.