International Conference on Advances in Materials, Computing and Communication Technologies
In Association with International Journal of Scientific Research in Science and Technology
Volume 9 | Issue 1 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)

Joint Beam and User Scheduling for Millimetre Wave Downlink MIMO System

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ABSTRACT

This paper investigates the user selection algorithm for millimetre wave (mm-wave) Multiple Input and Multiple Output (MIMO) systems, where multiple users are served simultaneously, that cause interference among the users. Therefore, to improve the performance in terms of maximization of sum rate and reduce the interference, scheduling plays a major role in the mm-wave MIMO system. The proposed scheduling algorithm is simulated in sub 6GHz frequency and the algorithm depends on the channel information. Finally, the simulation results validate the algorithm in terms of sum rate. The proposed algorithm provides higher sum rate when compared to the conventional method

Keywords: Millimeter Wave, Multiple Input Multiple Output, Scheduling.

I. INTRODUCTION

In the future wireless and mobile communication system, there is a huge crunch in the wireless spectrum, due to the large number of devices connected. To overcome this mm-wave communication is the most prominent technology, which utilizes a frequency band of 30 GHz to 300 GHz [1]. Moreover, the mm-wave communication provides larger bandwidth and a larger antenna array. Hence it is easy to serve more users with high capacity and it also compensates for serious path loss. Additionally, it supports high spectral efficiency by transmitting multiple data streams. In Massive MIMO, both the base station and the user has a large number of antennas that fulfil the 5G requirements such as huge data rate and high throughput.

In 5G wireless systems, the number of users is huge and are located randomly at different distances from the base station with different path losses. Therefore, the system model is more versatile. In such cases, scheduling a user plays a major role to increase the system performance. The objective of Scheduling (user selection) is to collect the physical layer information and make better decisions at the Media Access Control layer (MAC). From the mobile station, the base station collects the channel state information of each user. From the key references, the user scheduling is based on some conventional algorithms, such as round-robin (RR), proportional fair (PF) and greedy algorithm for Multi-user MIMO (MU-MIMO) system. The round-robin algorithm schedules the user based on the time user arrives. While proportional fair algorithm provides a fair level of service to maximize the throughput. Later, when the numbers of users are larger than the number of supportable users, users are selected by brute force method to maximize the data rate. The drawback of the brute force method is the computational complexity as the number of users grows exponential. Therefore, this issue attracts many researchers. In [5], the author implemented a user selection algorithm based on the channel capacity, as the sum rate and channel capacity are directly related. The author in [6] introduces the selection algorithm based on user distance.

This paper mainly focuses on downlink user scheduling to maximize the sum rate of the mm-wave massive MIMO system based on the following 2 features: (i) magnitude of the channel should be high and (ii) orthogonal property should be small. The organization of this paper as follows. System and channel model are explained in Section II and the various user selection algorithms are discussed in Section III. In Section IV the algorithms are evaluated based on sum rate. In the end, the conclusion of this paper is presented in Section V.

II. SYSTEM MODEL

A Single-cell mm-wave massive MIMO system is considered for the downlink network. This network consists of a single base station with multiple users. Base station equipped with Nt transmitting antenna and K multiple users with single antenna out which L users are scheduled. The antenna element composed of a uniform linear array and the position of each element in the array is defined as half the wavelength. The received signal is given by

$$Y = HXs + n \qquad (1)$$

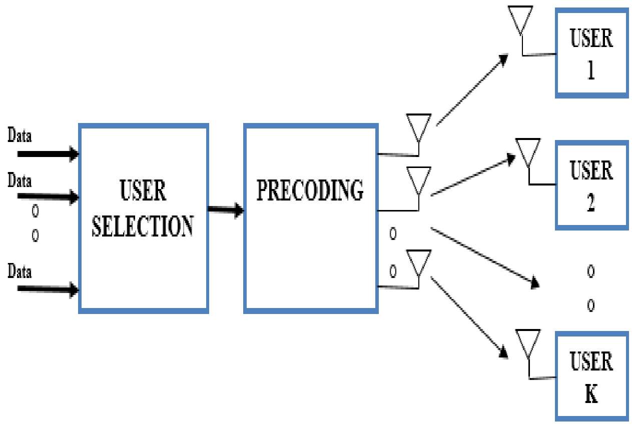

Figure 1: Multi-User MIMO System Model

In equation (1), H is the channel matrix with H= [h1, h2, …hK]H being the channel vector between the Kth user and the base station. H Nt x K. For all K users s is the transmitted signal vector by satisfying (ssH) = IK. The n indicates the additive white gaussian noise vector of size Kx1, n ~ (0,) with zero mean and variance . X is the precoder. Assume the channel state information is known to the transmitter.

A. Channel Model

The array steering vector for uniform linear array has Nt dimensional vector. The array steering vector is given by

$$a(\theta) = \frac{1}{\sqrt{N_t}}\left[e^{-j2\pi\theta}\right] \qquad (2)$$

The θ represents the spatial angle and it is defined by

$$\theta = \left(\frac{d}{\lambda}\right)\sin(\vartheta) \qquad (3)$$

The physical angle takes the value between -π/2 and π/2. The wavelength λ, which is defined by the light speed by carrier frequency and d represents space between the two-antenna element. In this work, an mm-wave channel is considered with a large number of antennas at the transmitter. The channel vector for the Kth user in [4] is defined as

$$h_k = \alpha_k a(\theta_k) \qquad (4)$$

In equation (4), the channel gain is denoted by and the angle of departure is denoted by . Each user receives a LOS path is assumed. the sum rate of the system is given by

$$R = \sum_{j=1}^{K} \log_2(1 + \frac{1}{\|H_s^{-1} S_s\|^2 \sigma^2}) \qquad (5)$$

To achieve a better sum rate for the system, a suitable mechanism is required to select L users from K active users.

III. PROPOSED SCHEDULING MECHANISM

The objective of this paper is to enhance the sum rate by scheduling user. The Procedure of the proposed algorithm as follows

- In mm-wave MIMO, assume channel information is known to the transmitter
- Initialization: All active users are assigned to a set T, where T= [1,2, 3…K]. At the beginning assign the selected user set to be an empty set.
- User Selection: Now, to decrease the complexity in user selection, channel gain is calculated to the all users and the priority in user selection, is given to the user has best channel gain. Next find the sum rate for each user and then select the user that maximizes the sum rate.
- Beam Selection: After User is selected and the beam is selected to the appropriately selected user.
- Repeat until L user selected from K users.

B. Algorithm for user selection

Input: Number of antennas at Transmitter Nt and Number of User K

Initialization:

for i $\leftarrow 1$

$S \leftarrow \{1,2,3...K\}$

$S_{sel} \leftarrow \phi$

while i <L

For each user find the channel gain and sum rate

end

i_{sel} = *arg max R*

$S_{sel} \leftarrow S_{sel} \cup \{i_{sel}\}$

$S \leftarrow S \setminus S_{sel}$

The selected user channel vector

$h = h_{sel}$

i=i+1

end

C. Algorithm for beam selection

Input: Channel vector of selected user hk and Number of antennas at Transmitter Nt

Initialization:

for t $\leftarrow 1$

$T \leftarrow \{1,2,3...N_t\}$

$S_T \leftarrow \phi$

while t <L

j_{sel} = *max channel gain*

$S_T \leftarrow S_T \cup \{j_{sel}\}$

$T \leftarrow T \setminus S_T$

The selected user channel vector and the beam

$h_T = h_{sel}$

t=t+1

end

IV. SIMULATION AND RESULTS

This section evaluates the proposed scheduling algorithm. For the simulation, the following assumptions are considered: (i) Channel information of the user is known at the transmitter (ii) power is distributed uniformly between the user. This work considered a base station antenna of Nt = 64 and the single antenna user of K= 32 out of which L=10 users scheduled (selected) Table:1 describes the System cell and link budget parameter for 5G. The proposed algorithm investigates and evaluates the Sum rate performance in the mm-wave Massive MIMO system and the proposed scheduling algorithm is compared with the conventional algorithm.

TABLE I
SYSTEM CELL AND LINK BUDGET PARAMETER FOR 5G

Parameter	Value
Cell Radius (m)	200
Carrier Frequency (GHz)	2.4
Base Station Height (m)	32
User Height (m)	[1 2]
Bandwidth (MHz)	50
Noise Figure (dB)	5
Base Station Power (dB)	10
Std.Dev. Shadow Fading (dB)	8
Pathloss exponent	3

The figure 2 indicated the Sum rate vs SNR for the proposed algorithm and the conventional algorithm i.e. Semi orthogonal method. From the Figure 2 it is observed that there is a small performance gap. It illustrates that the proposed one has higher Sum rate when compared with conventional one

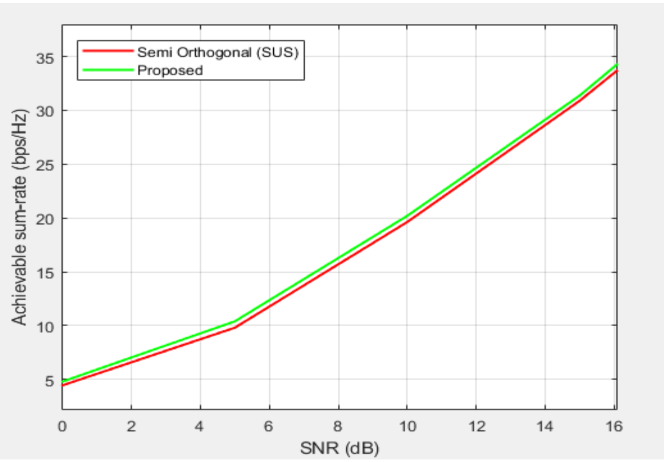

Figure 2: SNR Vs Sum Rate

The figure 3 indicated the Sum rate vs Number of users selected and it compares the proposed algorithm with the conventional algorithm. Figure 3 illustrate when SNR=10dB and 20 users are selected, the proposed one has higher Sum rate when compared with conventional one i.e. 0.4 bps/Hz greater than the conventional algorithm.

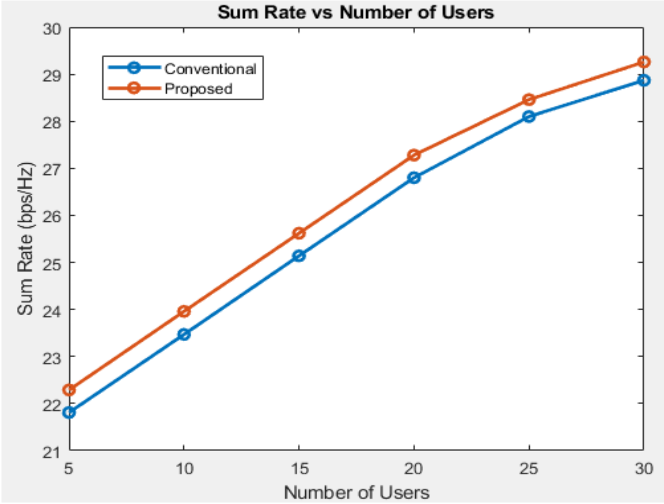

Figure 3: Sum Rate Vs Number of Users

V. CONCLUSION

This paper investigates the user scheduling algorithm for mm-wave massive MIMO system. A novel user scheduling algorithm is proposed for a single cell downlink transmission MIMO system. From the result it is observed that the proposed method has approximately 1% higher sum rate when compared to the conventional method.

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