Near-Optimal Beam Selection for Beamspace MmWave Massive MIMO Systems

Xinyu Gao, Linglong Dai, Zhijie Chen, Zhaocheng Wang, and Zhijun Zhang

Abstract—**The recent concept of beamspace MIMO can utilize beam selection to reduce the number of required radio-frequency (RF) chains in mmWave massive MIMO systems without obvious performance loss. However, as the same beam in the beamspace is likely to be selected for different users, conventional beam selection schemes will suffer from serious multiuser interferences, and some RF chains may be wasted since they have no contribution to the sum-rate performance. To solve these problems, in this letter, we propose an interference-aware (IA) beam selection. Specifically, by considering the potential multiuser interferences, the proposed IA beam selection first classifies all users into two user groups, i.e., the interference-users (IUs) and noninterference-users (NIUs). For NIUs, the beams with large power are selected, while for IUs, the appropriate beams are selected by a low-complexity incremental algorithm based on the criterion of sum-rate maximization. Simulation results verify that IA beam selection can achieve the near-optimal sum-rate performance and higher energy efficiency than conventional schemes.**

Index Terms—**Massive MIMO, mmWave communications, beamspace, beam selection, multiuser interferences.**

I. Introduction

MILLIMETER-WAVE (mmWave) massive multiple-input multiple-output (MIMO) has been considered as a key technique for future 5G wireless communications [1], since it can achieve significant increase in data rates due to its wider signal bandwidth [2] and higher spectrum efficiency [3].

However, realizing mmWave massive MIMO in practice is not a trivial task. One key challenging problem is that each antenna in MIMO systems usually requires one dedicated radio-frequency (RF) chain [3]. This results in unaffordable hardware cost and energy consumption in mmWave massive MIMO systems, as the number of antennas becomes huge and the energy consumption of RF chain is high at mmWave frequencies [4]. To reduce the number of required RF chains, the concept of beamspace MIMO has been recently proposed in the pioneering work [5]. By employing the discrete lens array (DLA) which induces negligible performance loss [6], beamspace MIMO can transform the conventional spatial channel to the beamspace channel to capture the channel sparsity at mmWave frequencies [2]. Since each beam corresponds to a single RF chain in beamspace MIMO [5], we can only select a small number of beams according to the sparse beamspace channel to reduce the number of required RF chains in mmWave massive MIMO systems[1]. Nevertheless, most of existing beam selection schemes are based on the criterion of magnitude maximization (referred as "MM beam selection" in this paper) [7], where several beams with large magnitude are selected for each user. MM beam selection is simple but faces two problems: i) it only aims to retain the power of each user as much as possible without considering multiuser interferences, which leads to a non-negligible performance loss of the achievable sum-rate; ii) as different RF chains are likely to select the same beam, some RF chains may be wasted since they have no contribution to the sum-rate performance [8].

To solve these problems, we propose an interference-aware (IA) beam selection in this paper. Specifically, by considering the potential multiuser interferences, IA beam selection first classifies all users into two user groups, i.e., the interference-users (IUs) and noninterference-users (NIUs). For NIUs, the beams with large power are selected, while for IUs, the beams are selected by a low-complexity incremental algorithm based on the criterion of sum-rate maximization. Simulation results verify that the proposed IA beam selection can achieve the near-optimal sum-rate performance and higher energy efficiency than conventional MM beam selection [7].

Notation: Lower-case and upper-case boldface letters $\mathbf{a}$ and $\mathbf{A}$ denote a vector and a matrix, respectively; $\mathbf{A}^H$, $\mathbf{A}^{-1}$, and $\mathrm{tr}(\mathbf{A})$ denote the conjugate transpose, inversion, and trace of matrix $\mathbf{A}$, respectively; $|a|$ denotes the amplitude of scalar a; $\mathrm{Card}(\mathcal{A})$ denotes the cardinality of set $\mathcal{A}$; Finally, $\mathbf{I}_K$ is the $K \times K$ identity matrix.

II. System Model

We consider a typical mmWave massive MIMO system, where the base station (BS) employs N antennas and N_{RF} RF chains to simultaneously serve K single-antenna users [6]–[8].

A. Traditional MIMO in the Spatial Domain

As shown in Fig. 1 (a), for traditional MIMO in the spatial domain, the $K \times 1$ received signal vector $\mathbf{y}$ for all K users in the downlink can be presented by

$$\mathbf{y} = \mathbf{H}^H \mathbf{P} \mathbf{s} + \mathbf{n}, \tag{1}$$

where $\mathbf{H} = [\mathbf{h}_1, \mathbf{h}_2, \cdots, \mathbf{h}_K]$ is the channel matrix, $\mathbf{h}_k$ of size $N \times 1$ is the channel vector between the BS and the kth user

[1]Beam selection can be considered as an updated version of conventional antenna selection, which deals with the beamspace channel [5].

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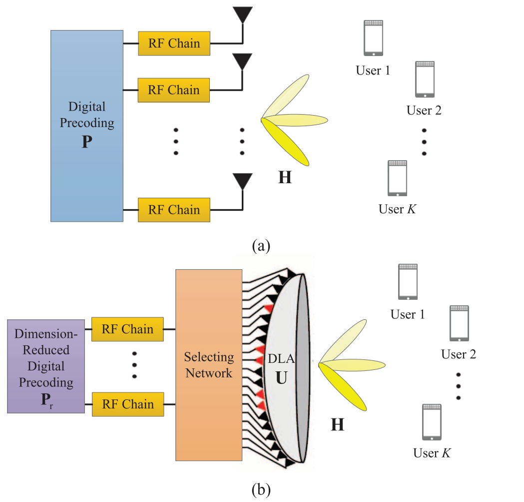

Fig. 1. Comparison of MIMO system architectures: (a) traditional MIMO in the spatial domain; (b) beamspace MIMO.

as will be discussed in details later, $\mathbf{s}$ of size $K \times 1$ is the original signal vector for all K users with normalized power $\mathbb{E}\left(\mathbf{s}\mathbf{s}^H\right) = \mathbf{I}_K$, $\mathbf{P}$ of size $N \times K$ is the precoding matrix satisfying the total transmit power ρ as $\operatorname{tr}\left(\mathbf{P}\mathbf{P}^H\right) \leq \rho$. Finally, $\mathbf{n} \sim \mathcal{CN}\left(0, \sigma^2 \mathbf{I}_K\right)$ is the $K \times 1$ additive white Gaussian noise (AWGN) vector. It is obvious from Fig. 1 (a) that for traditional MIMO systems, the number of required RF chains is $N_{\text{RF}} = N$, which is usually large for mmWave massive MIMO systems, e.g., $N_{\text{RF}} = N = 256$ [1].

Next, we will introduce the channel vector $\mathbf{h}_k$ of the kth user. In this paper, we adopt the widely used Saleh-Valenzuela channel model for mmWave communications as [5]–[8]

$$\mathbf{h}_k = \beta_k^{(0)} \mathbf{a}\left(\psi_k^{(0)}\right) + \sum_{l=1}^{L} \beta_k^{(l)} \mathbf{a}\left(\psi_k^{(l)}\right), \tag{2}$$

where $\beta_k^{(0)} \mathbf{a}\left(\psi_k^{(0)}\right)$ is the line-of-sight (LoS) component of the kth user with $\beta_k^{(0)}$ presenting the complex gain and $\psi_k^{(0)}$ denoting the spatial direction, $\beta_k^{(l)} \mathbf{a}\left(\psi_k^{(l)}\right)$ for $1 \leq l \leq L$ is the lth non-line-of-sight (NLoS) component of the kth user, and L is the total number of NLoS components, $\mathbf{a}(\psi)$ is the $N \times 1$ array steering vector. For the typical uniform linear array (ULA) with N antennas, we have $\mathbf{a}(\psi) = \frac{1}{\sqrt{N}}\left[e^{-j2\pi\psi m}\right]_{m\in\mathcal{I}(N)}$, where $\mathcal{I}(N) = \{q - (N-1)/2,\ q = 0, 1, \cdots, N-1\}$ is a symmetric set of indices centered around zero. The spatial direction is defined as $\psi \triangleq \frac{d}{\lambda}\sin\theta$ [5], where θ is the physical direction, λ is the signal wavelength, and d is the antenna spacing satisfying $d = \lambda/2$ at mmWave frequencies.

B. Beamspace MIMO

The conventional channel (2) in the spatial domain can be transformed to the beamspace channel by employing a carefully designed DLA [5] as shown in Fig. 1 (b). Specifically, such DLA plays the role of an $N \times N$ spatial discrete fourier transform matrix $\mathbf{U}$, which contains the array steering vectors of N orthogonal directions covering the entire space as

$$\mathbf{U} = \left[\mathbf{a}\left(\bar{\psi}_1\right), \mathbf{a}\left(\bar{\psi}_2\right), \cdots, \mathbf{a}\left(\bar{\psi}_N\right)\right]^H, \tag{3}$$

where $\bar{\psi}_n = \frac{1}{N}\left(n - \frac{N+1}{2}\right)$ for $n = 1, 2, \cdots, N$ are the predefined spatial directions. Then, according to Fig. 1 (b), the system model of beamspace MIMO can be represented by

$$\tilde{\mathbf{y}} = \mathbf{H}^H \mathbf{U}^H \mathbf{P}\mathbf{s} + \mathbf{n} = \tilde{\mathbf{H}}^H \mathbf{P}\mathbf{s} + \mathbf{n}, \tag{4}$$

where $\tilde{\mathbf{y}}$ is the received signal vector in the beamspace, and the beamspace channel $\tilde{\mathbf{H}}$ is defined as

$$\tilde{\mathbf{H}} = \left[\tilde{\mathbf{h}}_1, \tilde{\mathbf{h}}_2, \cdots, \tilde{\mathbf{h}}_K\right] = \mathbf{U}\mathbf{H} = \left[\mathbf{U}\mathbf{h}_1, \mathbf{U}\mathbf{h}_2, \cdots, \mathbf{U}\mathbf{h}_K\right], \tag{5}$$

where $\tilde{\mathbf{h}}_k$ is the beamspace channel of the kth user. In (5), the N rows (elements) of $\tilde{\mathbf{H}}$ ($\tilde{\mathbf{h}}_k$) correspond to N orthogonal beams whose spatial directions are $\bar{\psi}_1, \bar{\psi}_2, \cdots, \bar{\psi}_N$, respectively. Note that the number of dominant scatters in the mmWave prorogation environments is quite limited [2]. Therefore, the number of NLoS components L in (2) is much smaller than N, leading the beamspace channel to enjoy a sparse structure [5], i.e., the number of dominant elements of $\tilde{\mathbf{h}}_k$ is much smaller than N. As a result, we can select only a small number of appropriate beams according to the sparse beamspace channel[2] to reduce the dimension of MIMO system without obvious performance loss as

$$\tilde{\mathbf{y}} \approx \tilde{\mathbf{H}}_{\text{r}}^H \mathbf{P}_{\text{r}} \mathbf{s} + \mathbf{n}, \tag{6}$$

where $\tilde{\mathbf{H}}_{\text{r}} = \tilde{\mathbf{H}}(s,:)_{s\in\mathcal{B}}$, $\mathcal{B}$ contains the indices of selected beams, $\mathbf{P}_{\text{r}}$ is the dimension-reduced digital precoding matrix. As the dimension of $\mathbf{P}_{\text{r}}$ is much smaller than that of the original digital precoding matrix $\mathbf{P}$ in (1), beamspace MIMO can significantly reduce the number of required RF chains as shown in Fig. 1 (b). Note that the smallest number of required RF chains should be $N_{\text{RF}} = K$ to guarantee the spatial multiplexing gain of K users. Therefore, we consider $N_{\text{RF}} = K$ without loss of generality in this paper.

However, as the same beam in the beamspace is likely to be selected for different users by different RF chains, the conventional MM beam selection [7] will suffer from serious multiuser interferences, and some RF chains may be wasted, which is unfavorable in practice [8].

III. Beam Selection Scheme

In this section, to solve these problems above, we propose an IA beam selection consisting of two stages: i) identify the IUs and NIUs by considering the potential multiuser interferences; ii) search the best unshared beam for each IUs to maximize the sum-rate, which will be explained as below.

A. Stage 1: Identify IUs and NIUs

Instead of retaining most power of each user in MM beam selection [7], our target is to select K best unshared beams from total N beams for K users to maximize the achievable sum-rate. It is known that the most intuitive way to solve this problem is the exhaustive search, which enjoys the optimal

[2]In this paper, we assume the beamspace channel is known by the BS. Actually, efficient tools of compressive sensing can be utilized to reliably estimate the beamspace channel with low pilot overhead thanks to the sparsity of beamspace channel in mmWave massive MIMO systems [5].

performance but involves prohibitively high complexity with $\binom{N}{K}$ searches. For a typical mmWave massive MIMO system with $N = 256$ and $K = 32$ [6]–[8], the total number of searches is as large as 6×10^{40}. To this end, we need to design a more efficient beam selection scheme to achieve the near-optimal performance.

We start by sorting the elements (beams) of the beamspace channel $\tilde{\mathbf{h}}_k$ in a descending order of magnitude, and let $b_k^* \in \{1, 2, \cdots, N\}$ denote the strongest beam index of the kth user. Note that the K strongest beams $\left\{b_k^*\right\}_{k=1}^K$ contain most of the channel power. Therefore, if $b_1^* \neq b_2^* \neq \cdots \neq b_K^*$, the beam set $\mathcal{B} = \left\{b_1^*, b_2^*, \cdots, b_K^*\right\}$ is able to achieve the near-optimal performance, since the power of signal is maximized while the multiuser interferences are not serious, which has also been verified in [7]. However, if two users share the same strongest beam, they will suffer from serious multiuser interferences. Unfortunately, the probability that there exist users sharing the same strongest beam is always non-negligible even if N is large, as proved by the following **Lemma 1**.

Lemma 1. Assume that spatial directions $\psi_k^{(i)}$ for both $i = 0, 1, \cdots, L$ and $k = 1, 2, \cdots, K$ follow the i.i.d. uniform distribution within $\left[-\frac{1}{2}, \frac{1}{2}\right]$. The probability P that there exists users sharing the same strongest beam is $P = 1 - \frac{N!}{N^K (N-K)!}$.

Proof: Based on (2)–(5), the nth element $\tilde{h}_{k,n}$ of the beamspace channel $\tilde{\mathbf{h}}_k$ for the kth user can be presented as

$$\tilde{h}_{k,n} = \mathbf{a}^H\left(\bar{\psi}_n\right)\sum_{i=0}^{L}\beta_k^{(i)}\mathbf{a}\left(\psi_k^{(i)}\right) = \sum_{i=0}^{L}\beta_k^{(i)}\Upsilon\left(\bar{\psi}_n - \psi_k^{(i)}\right), \tag{7}$$

where $\Upsilon(x) \triangleq \frac{\sin N\pi x}{N \sin \pi x}$. Without loss of generality, we assume the ith path component (either LoS or NLoS) of the channel (2) is the dominant one. Then, according to the characteristic of the function $\Upsilon(x)$, we can conclude that the strongest beam b_k^* should be the one making the predefined direction $\bar{\psi}_{b_k^*} = \frac{1}{N}\left(b_k^* - \frac{(N+1)}{2}\right)$ in (4) sufficiently close to the spatial direction $\psi_k^{(i)}$ of the ith path component. In other words, if $\psi_k^{(i)}$ belongs to the range $\left[\bar{\psi}_{b_k^*} - \frac{1}{2N}, \bar{\psi}_{b_k^*} + \frac{1}{2N}\right]$, b_k^* will be the strongest beam.

Based on the analysis above and the assumption that the spatial directions $\psi_k^{(i)}$ for both $i = 0, 1, \cdots, L$ and $k = 1, 2, \cdots, K$ follow the i.i.d. uniform distribution within $\left[-\frac{1}{2}, \frac{1}{2}\right]$ [5], the probability that the strongest beam of the kth user is b_k^* can be calculated as $\int_{\bar{\psi}_{b_k^*} - \frac{1}{2N}}^{\bar{\psi}_{b_k^*} + \frac{1}{2N}} 1 d\psi_k^{(i)} = \frac{1}{N}$.

Now, the case that different users have different strongest beams (i.e., $b_1^* \neq b_2^* \neq \cdots \neq b_K^*$) is equivalent to selecting K different beams from total N beams, which has the probability $\frac{N!}{N^K (N-K)!}$. Therefore, the probability P that there exists users sharing the same strongest beam is $P = 1 - \frac{N!}{N^K (N-K)!}$. ■

For a typical mmWave massive MIMO system with $N = 256$ and $K = 32$ [6]–[8], $P \approx 87\%$, which is non-negligible. To this end, we propose to classify all K users into two user groups, i.e., interference-users (IUs) and noninterference-users (NIUs), according to their strongest beams. For different user groups, we adopt different criteria to select beams as follows:

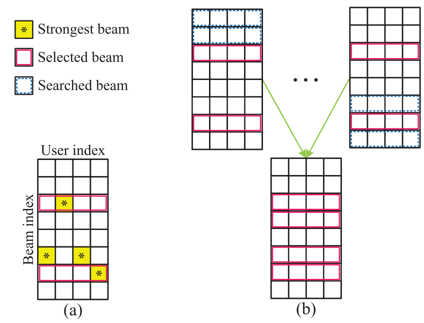

Fig. 2. An example of the proposed IA beam selection: (a) Stage 1: identify IUs and NIUs; (b) Stage 2: search the best unshared beam.

1) We define that user k is NIU if its strongest beam b_k^* is different from the strongest beams of any other users, i.e., $b_k^* \notin \left\{b_1^*, \cdots, b_{k-1}^*, b_{k+1}^*, \cdots, b_K^*\right\}$. All NIUs comprise the NIUs group $\mathcal{F}_{\text{NIU}}$. Consider the example shown in Fig. 2 (a), where $b_1^* = b_3^* = 6$, $b_2^* = 3$, and $b_4^* = 7$. We can observe that $\mathcal{F}_{\text{NIU}} = \{2, 4\}$, since $b_2^* \notin \left\{b_1^*, b_3^*, b_4^*\right\}$ and $b_4^* \notin \left\{b_1^*, b_2^*, b_3^*\right\}$. For user $k \in \mathcal{F}_{\text{NIU}}$, we directly select the strongest beam b_k^*, since this beam not only contains most power of the beamspace channel but also causes few interferences to others.
2) We define that user k is IU if its strongest beam b_k^* is the same as the strongest beams of some other users, i.e., $b_k^* \in \left\{b_1^*, \cdots, b_{k-1}^*, b_{k+1}^*, \cdots, b_K^*\right\}$. All IUs constitute the IUs group $\mathcal{F}_{\text{IU}}$. Obviously, we have $\mathcal{F}_{\text{IU}} \cup \mathcal{F}_{\text{NIU}} = \{1, 2, \cdots, K\}$ and $\mathcal{F}_{\text{IU}} \cap \mathcal{F}_{\text{NIU}} = \emptyset$. Also considering the example shown in Fig. 2 (a), we have $\mathcal{F}_{\text{IU}} = \{1, 3\}$, since $b_1^* \in \left\{b_2^*, b_3^*, b_4^*\right\}$ and $b_3^* \in \left\{b_1^*, b_2^*, b_4^*\right\}$. For user $k \in \mathcal{F}_{\text{IU}}$, we will search the appropriate beam from the set $\{1, 2, \cdots, N\} \setminus \left\{b_k^* | k \in \mathcal{F}_{\text{NIU}}\right\}$ as shown in Fig. 2 (b), which will be introduced in the next subsection. Here $\mathcal{A} \setminus \mathcal{B}$ denotes the set where the elements in set $\mathcal{B}$ are eliminated from set $\mathcal{A}$.

B. Stage 2: Search the Best Unshared Beam

Now we have obtained $\text{Card}\left(\mathcal{F}_{\text{NIU}}\right)$ rows of the dimension-reduced beamspace channel $\tilde{\mathbf{H}}_{\text{r}}$ in (7) by stage 1, which forms the $\text{Card}\left(\mathcal{F}_{\text{NIU}}\right) \times K$ matrix $\mathbf{A} = \tilde{\mathbf{H}}(s,:)_{s \in \left\{b_k^* | k \in \mathcal{F}_{\text{NIU}}\right\}}$. The task of stage 2 is to search another $\text{Card}\left(\mathcal{F}_{\text{IU}}\right) = K - \text{Card}\left(\mathcal{F}_{\text{NIU}}\right)$ beams from the remaining $\left(N - \text{Card}\left(\mathcal{F}_{\text{NIU}}\right)\right)$ beams to maximize the achievable sum-rate R. Without loss of generality, we use the classical digital ZF precoder as the dimension-reduced precoder $\mathbf{P}_{\text{r}}$ in (7) [5]–[8]. Then, the optimization problem in stage 2 can be presented as

$$\mathcal{D}^{\text{opt}} = \arg\max_{\mathcal{D}} R = \arg\max_{\mathcal{D}} K \log_2\left(1 + \frac{\rho}{\sigma^2 \text{tr}\left(\tilde{\mathbf{H}}_{\text{r}}^H \tilde{\mathbf{H}}_{\text{r}}\right)^{-1}}\right), \tag{8}$$

where $\mathcal{D}$ is a possible beam set with the indices of $\text{Card}\left(\mathcal{F}_{\text{IU}}\right)$ different beams selected from $\{1, 2, \cdots, N\} \setminus \left\{b_k^* | k \in \mathcal{F}_{\text{NIU}}\right\}$, and $\tilde{\mathbf{H}}_{\text{r}} = \tilde{\mathbf{H}}(s,:)_{s \in \mathcal{D} \cup \left\{b_k^* | k \in \mathcal{F}_{\text{NIU}}\right\}}$.

In stage 2, we propose a low-complexity incremental algorithm developed from antenna selection [9] to solve (8). The key idea is to select the $\mathrm{Card}(\mathcal{F}_{\mathrm{IU}})$ beams one by one in an incremental order. In each step, the beam with the greatest contribution to the sum-rate R is selected. Specifically, we can observe from (8) that maximizing the sum-rate R is equivalent to minimizing $\mathrm{tr}\left(\tilde{\mathbf{H}}_{\mathrm{r}}^H\tilde{\mathbf{H}}_{\mathrm{r}}\right)^{-1}$. Therefore, in the first step, the beam b_1 should be selected as

$$b_1 = \arg\min_{b} \mathrm{tr}\left(\mathbf{G} + \mathbf{g}_b^H\mathbf{g}_b\right)^{-1}, \ \mathbf{G} \overset{\Delta}{=} \mathbf{A}^H\mathbf{A} + \varepsilon\mathbf{I}, \qquad (9)$$

where $b \in \mathcal{S} = \{1, 2, \cdots, N\} \setminus \left\{b_k^* | k \in \mathcal{F}_{\mathrm{NIU}}\right\}$, $\mathbf{g}_b = \tilde{\mathbf{H}}(b,:)$, and ε is a small positive number (e.g., $\varepsilon = 10^{-3}$) to guarantee that the matrix inversion in (9) exists [3]. After b_1 has been selected, we can update $\mathbf{G}$ and $\mathcal{S}$ as $\mathbf{G} = \mathbf{G} + \mathbf{g}_{b_1}^H\mathbf{g}_{b_1}$ and $\mathcal{S} = \mathcal{S}\backslash b_1$, respectively. Then, the similar method described above can be reused to select other beams until all $\mathrm{Card}(\mathcal{F}_{\mathrm{IU}})$ beams have been selected. Finally, the beam set $\mathcal{B}^*$ of all selected beams can be formed as

$$\mathcal{B}^* = \left\{b_1, \cdots, b_{\mathrm{Card}(\mathcal{F}_{\mathrm{IU}})}\right\} \cup \left\{b_k^* | k \in \mathcal{F}_{\mathrm{NIU}}\right\}, \qquad (10)$$

and the dimension-reduced beamspace channel will be $\tilde{\mathbf{H}}_{\mathrm{r}} = \tilde{\mathbf{H}}(s,:)_{s \in \mathcal{B}^*}$.

IV. Simulation Results

In this section, we consider a typical mmWave massive MIMO system where the BS equips an ULA with $N = 256$ antennas and $N_{\mathrm{RF}} = 32$ RF chains to simultaneously serve $K = 32$ users. For the spatial channel of user k, we have [7]: 1) one LoS component with $L = 2$ NLoS components; 2) $\beta_k^{(0)} \sim \mathcal{CN}(0,1)$, $\beta_k^{(l)} \sim \mathcal{CN}\left(0, 10^{-1}\right)$ for $l = 1, 2$; 3) $\psi_k^{(0)}$, $\psi_k^{(l)}$ follow the i.i.d. uniform distribution within $\left[-\frac{1}{2}, \frac{1}{2}\right]$.

Fig. 3 shows the sum-rate performance comparison between the proposed IA beam selection and the conventional MM beam selection [7]. We also provide the performance of the fully digital ZF precoding using all beams (256 RF chains) as the benchmark for comparison. From Fig. 3, we can observe that the proposed IA beam selection achieves better sum-rate performance than MM beam selection with 1 beam per user, where the SNR gap is about 3.5 dB at high SNR region. This is due to the fact that for MM beam selection with 1 beam per user, the same beam will be selected for different IUs, and the dimension-reduced beamspace channel matrix $\tilde{\mathbf{H}}_{\mathrm{r}}$ is rank-deficient. This means that some users cannot be served, leading to user unfairness and an obvious performance loss in the achievable sum-rate. In contrast, IA beam selection can guarantee that all K users can be served simultaneously with near-optimal sum-rate performance. Fig. 3 also shows that although MM beam selection with 2 beams per user can also simultaneously serve K users [7], it can only achieve a little better performance than IA beam selection but with much higher energy consumption, since some RF chains are wasted. This conclusion can be further verified in Fig. 4, which shows the energy efficiency comparison against the number of users K, where the number of antennas is fixed as $N = 256$. The energy efficiency ζ is modeled as [8] $\zeta = \frac{R}{\rho + N_{\mathrm{RF}}P_{\mathrm{RF}}}$ (bps/Hz/W),

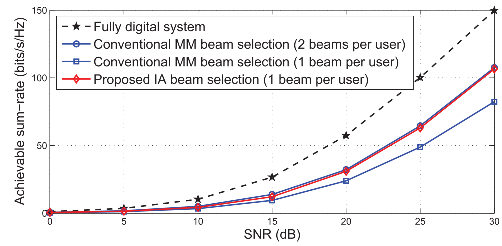

Fig. 3. Achievable sum-rate comparison.

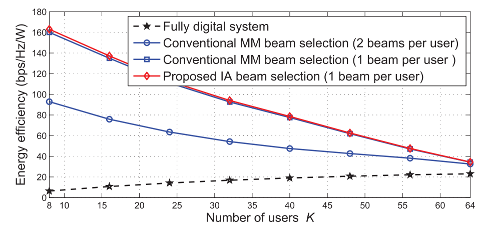

Fig. 4. Energy efficiency comparison.

ρ is the transmit power defined in (1), P_{RF} is the energy consumed by RF chain. In this paper, we adopt the practical values $P_{\mathrm{RF}} = 34.4$mW and $\rho = 32$mW (15 dBm) [8]. We can observe that IA beam selection achieves much higher energy efficiency than MM beam selection with 2 beams per user, especially when K is not very large.

V. Conclusions

In this paper, by considering the potential multiuser interferences, we proposed an IA beam selection consisting of two stages to achieve the near-optimal sum-rate performance with low complexity. Simulation results verify that the proposed IA beam selection can achieve the sum-rate performance close to the fully digital system with much higher energy efficiency. Our further work will focus on extending the proposed IA beam selection to 3D scenarios with planer antenna array.

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