Resource Allocation in Downlink MIMO-OFDMA with Proportional Fairness

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***Abstract*—A new scheme for MIMO-OFDMA (Multiple Input Multiple Output - Orthogonal Frequency Division Multiple Access) downlink resource allocation is presented in this paper. It has an objective of maximizing the total system capacity while having constraints on the total available power and proportional fairness. Dominant eigen-channels obtained from MIMO state matrix are used to formulate this scheme with low complexity. It gives a tradeoff strategy among system capacity, computational complexity and proportional fairness. Simulation results show that this new adaptive allocation scheme can provide much better capacity gain than static allocation methods while achieve near optimal fairness of rate distribution with a linear complexity. As a result, it may be suitable for fulfilling diverse QoS requirements of MIMO-OFDMA systems.**

Index Terms—adaptive resource allocation, SISO/MIMO-OFDMA, diverse QoS requirements

I. INTRODUCTION

In recent years, OFDM (Orthogonal Frequency Division Multiplex) as a promising technique to fulfill the need of various high data-rate transmission systems has been extensively explored. This technique has the ability to combat multipath fading, shadowing, path loss and other time-varying detrimental effects in wireless environments, and is also robust against frequency selective fading and inter-symbol interference (ISI). Besides, OFDM is often exploited as a multiple access technique in high date-rate systems such as WLAN and WiMax. With joint bit, power and subcarrier allocations investigated in [1], OFDMA can exploit both frequency-domain diversity and multiuser diversity to improve the spectrum efficiency.

MIMO (Multiple-Input Multiple-Output) as another promising method can greatly improve the physical layer performance of modern wireless communication systems. Many studies [2-3, 9-10] of such systems have been done in multi-user environments. In MIMO systems, multiple antennas are employed at both the transmitter and receiver to introduce spatial diversity. With the need to use additional antennas, MIMO receivers are generally more complex, and are sometimes combined with OFDM or OFDMA to handle the problems induced by multi-path channel more efficiently. Specifically, MIMO-OFDMA has been incorporated into the IEEE 802.16e standard and MIMO-OFDM is also recommended in the IEEE 802.11n standard.

Most resource allocation problems in SISO/MIMO-OFDMA systems involve the optimization of a certain objective function from two angles. One is to minimize the total transmit power at the Base Station (BS) [1-3], while another one is to maximize the total system capacity [4-12]. Specifically, the maximization of system capacity has been studied in [4] without considering rate fairness among users for downlink SISO-OFDMA systems. Then, this was extended by Shen in [5] to achieve almost ideal proportional rate distribution. For such a system, Wong formulated a lower complexity algorithm in [6], and Hui introduced a priority based sequential scheduling criteria to enhance system capacity with largely reduced fairness in [7]. In addition, the tradeoff between capacity and fairness has been discussed in [8]. Due to different natures between SISO and MIMO systems, the re-formulation of SISO-OFDMA resource allocation scheme to MIMO-OFDMA systems have also been investigated in [2-3, 9-12]. Nevertheless, these algorithms seldom consider rate fairness among users or do not have a flexible controllability on rate fairness.

In the future, high data-rate wireless communication systems must dramatically increase the system capacity to serve a large number of users. Also, the increased capacity must be distributed to individual users in a fair manner to guarantee diverse QoS requirements [12]. Essentially, capacity enhancement and fairness improvement, which are usually conflicting in nature, are two crucial issues in resource allocation. Specifically, spectrum efficiency in wireless systems is traditionally evaluated in terms of total system capacity, which will usually lead to unfair allocation due to different user channel conditions even though the optimal capacity can be guaranteed [11]. On the other hand, absolute fairness may lead to low spectrum efficiency. Clearly, it will be desirable in many applications to have a tradeoff strategy between capacity and fairness for allocating wireless resources.

With these in mind, the problem of downlink resource allocation for MIMO-OFDMA systems is investigated in this paper. It has an objective of maximizing the total system capacity subject to the total available power and proportional fairness. Especially, the proportional fairness is emphasized in a controllable manner by an iterative process. First, a suboptimal power allocation is discussed. Then, a new scheme with low complexity is proposed to achieve controllability on capacity and fairness. In this scheme, a priority based scheduling method is considered to enhance fairness first, and then a Tradeoff-Factor (TF) is introduced to rearrange subcarriers among users with the aim of achieving least capacity loss and most fairness gain under the introduced algorithm design criteria. With this aim, the new scheme can achieve near optimal proportional fairness among users after maximum subcarrier rearrangements at a linear complexity.

The rest of this paper is organized as follows. In section II, the MIMO-OFDMA system model and the capacity optimization objective function are introduced. A suboptimal power allocation method is discussed in section III. Then, the proposed scheme is described in detail in section IV. Section V shows some simulation results and Section VI concludes this paper.

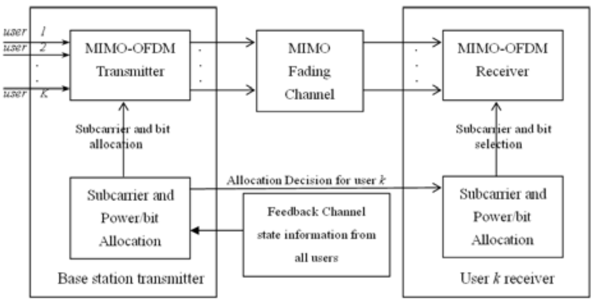

Fig. 1 Downlink MIMO-OFDMA system diagram

II. SYSTEM MODEL

Following the implementation and description in [3-4, 12], Fig. 1 shows the block diagram of a downlink MIMO-OFDMA system with an emphasis on resource allocation. Without loss of generality, consider a system with K users and N subcarriers. Assume that each user has M_r receiving antennas and the base station has M_t transmitting antennas. For user k (k=1,2,…,K) on subcarrier n (n=1,2,…,N), the channel state matrix is $\mathbf{H}_{k,n}$ with dimension $M_r \times M_t$. $\mathbf{H}_{k,n}$ can be decomposed through singular value decomposition (SVD) as

$$\mathbf{H}_{k,n} = \mathbf{U}_{k,n}\mathbf{\Sigma}_{k,n}\mathbf{V}_{k,n}^H = \sum_{i=1}^{M} \mathbf{u}_{k,n}^{(i)} \sigma_{k,n}^{(i)} \left(\mathbf{v}_{k,n}^{(i)}\right)^H , \qquad (1)$$

where $M = \min(M_r, M_t)$ is the rank of $\mathbf{H}_{k,n}$, $\{\sigma_{k,n}^{(i)}\}_{i=1}^{M}$ are the singular values of $\mathbf{H}_{k,n}$ in descending order, $\{\mathbf{u}_{k,n}^{(i)}\}_{i=1}^{M}$ and $\{\mathbf{v}_{k,n}^{(i)}\}_{i=1}^{M}$ are the corresponding left and right singular vectors, respectively. The maximum singular value $\sigma_{k,n}^{(1)}$ is generally much larger than the others $\{\sigma_{k,n}^{(i)}\}_{i=2}^{M}$ in an outdoor environment [3]. For convenience, the decoupled SISO channel denoted by $\sigma_{k,n}^{(1)}$ will be referred to as the dominant eigen-channel for user k on subcarrier n.

Fig. 1 also shows how the resource allocation scheme can be performed. The BS first uses the instantaneous feedback CSI to make resource allocation decision. This decision is forwarded to the MIMO-OFDM transmission block. Then, the transmitter loads each user's data onto its allocated subcarriers. It is assumed that the resource allocation decision is sent to each user via a separate channel. Therefore, each user can decode the data on its assigned subcarriers. The resource allocation scheme will be updated as fast as the channel information is collected [5]. In [11] where the optimality of MIMO-OFDMA has been investigated, Li shows that one subcarrier should be allocated to only one user at any time in order to achieve optimality. Based on these studies, the following assumptions will be used in this paper:

- Each subcarrier for every user experiences independent downlink MIMO fading.
- The subcarriers cannot be shared by different users.
- The system suffers from the effects of a slowly time-varying frequency selective fading channel, which means that the MIMO channel is assumed to be constant during the subcarrier and power allocation process.
- Perfect CSI of all users are available at the BS. Note that only the singular values of the channel state matrix will be required in the proposed resource allocation scheme.

Based on the optimization problem studied in [9-11], the objective function investigated in this paper can be formulated as follows

$$\max_{p_{k,n}} \frac{B}{N} \sum_{k=1}^{K} \sum_{n\in\Omega_k} \left[\sum_{i=1}^{M} \log_2(1 + p_{k,n} g_{k,n}^{(i)}) \right] \qquad (2)$$

subject to

$$C1: \bigcup_{k=1}^{K} \Omega_k \subseteq \{1,2,\cdots,N\} \text{ with } \{\Omega_k\}_{k=1}^{K} \text{ being disjoint sets}$$

$$C2: \sum_{k=1}^{K} \sum_{n\in\Omega_k} p_{k,n} \le P_{tot} \text{ with } p_{k,n} \ge 0, \forall k,n$$

$$C3: R_1 : R_2 : \cdots : R_K = \tau_1 : \tau_2 : \cdots : \tau_K$$

Note that the channel-to-noise gain of the ith eigen-channel for user k on subcarrier n is defined as $g_{k,n}^{(i)} = [\sigma_{k,n}^{(i)}]^2 / N_0$ and $p_{k,n} g_{k,n}^{(i)}$ gives the corresponding SNR, where N_0 is the noise power. B is the total available bandwidth, while the allocated power of user k on subcarrier n is $p_{k,n}$ and the total available power is P_{tot}. The predetermined values $\{\tau_k\}_{k=1}^{K}$ are used to ensure the proportionalities among users, i.e., $\gamma_k = \tau_k / \sum_{k=1}^{K} \tau_k$ for k=1,…,K. $\{\Omega_k\}_{k=1}^{K}$ are disjoint sets, where Ω_k is the set of subcarriers assigned to user k. The data rate of user k is then

$$R_k = \frac{B}{N}\sum_{n\in\Omega_k}\left[\sum_{i=1}^{M}\log_2\left(1+p_{k,n}g_{k,n}^{(i)}\right)\right], \quad (3)$$

and the total data rate of all users is $R_{tot}=\sum_{k=1}^{K}R_k$. In addition, the dominant channel-to-noise gains of all users and subcarriers can be obtained as

$$g_{k,n}^{\Delta}=[\sigma_{k,n}^{(1)}]^2/N_0 \quad (4)$$

for k=1,2,…,K and n=1,2,…,N.

The resource optimization problem given by (2) is NP-hard, implying that it is difficult to obtain a solution within any reasonable time frame. As a result, a new scheme is formulated shortly to solve this problem with linear complexity.

III. POWER ALLOCATION

In this section, the power allocation is briefly discussed. As shown in [11], the optimal power and subcarrier allocation are interleaved. Thus it is computationally prohibitive to solve the optimal power allocation. As a result, some suboptimal power allocation methods have been proposed in [9-10, 12] to achieve a performance that is a little worse than optimality. The easiest way is to use equal power allocation across all subcarriers under different access protocols. The suitability of equal power allocation in our study is shown as follows.

With subcarrier allocation having been carried out, i.e. $\{\Omega_k\}_{k=1}^{K}$ have been determined, the problem given by (2) is equivalent to maximizing the following cost function by using Lagrangian relaxation.

$$L=\frac{B}{N}\sum_{k=1}^{K}\sum_{n\in\Omega_k}\left[\sum_{i=1}^{M}\log_2\left(1+p_{k,n}g_{k,n}^{(i)}\right)\right]+\lambda_1\left(\sum_{k=1}^{K}\sum_{n\in\Omega_k}p_{k,n}-P_{tot}\right)$$
$$+\frac{B}{N}\sum_{k=2}^{K}\lambda_k\left[\sum_{n\in\Omega_k}\sum_{i=1}^{M}\log_2\left(1+p_{1,n}g_{k,n}^{(i)}\right)-\frac{\gamma_1}{\gamma_k}\sum_{n\in\Omega_k}\sum_{i=1}^{M}\log_2\left(1+p_{k,n}g_{k,n}^{(i)}\right)\right] \quad (5)$$

Differentiating L with respect to $p_{k,n}$ and setting each derivative to 0, we can obtain the optimal power distribution for a single user

$$\sum_{i=1}^{M}\frac{g_{k,n}^{(i)}}{1+p_{k,n}g_{k,n}^{(i)}}=\sum_{i=1}^{M}\frac{g_{k,m}^{(i)}}{1+p_{k,m}g_{k,m}^{(i)}} \quad (6)$$

for $n,m\in\Omega_k, n\neq m$ and k=1,2,…,K. Note that the function $f(x)=x/(1+px)$ is monotonically increasing and tends to be $1/p$ i.e. $\lim_{x\to+\infty}[x/(1+px)]=1/p$. Thus, an approximation to (6) can be obtained under high SNR as follows

$$\frac{M}{p_{k,n}}=\frac{M}{p_{k,m}}. \quad (7)$$

That is equivalent to $p_{k,n}=p_{k,m}$ for $n,m\in\Omega_k, n\neq m$ and k=1,2,…,K. Due to no subcarrier sharing among users, it can be concluded that power could be approximately distributed across all subcarriers of each user in an equal manner. Obviously, this equal power allocation is not optimized to improve fairness. However, it can achieve near optimal proportional fairness for our investigated problem when being combined with the proposed subcarrier allocation, which will shown in the subsequent section.

IV. PROPOSED SCHEME

A new scheme which can maximize system capacity and enhance proportional rate fairness in a controllable manner is described in detail in this section. Based on MIMO channel state information, dominant eigen-channels with gains in (4) are used to determine subcarrier allocation with low complexity. In addition, a Tradeoff Factor (TF) used to rearrange the subcarriers among users is introduced in the proposed scheme. This introduced TF can iteratively achieve near optimal proportional fairness among users at the cost of certain reduced system capacity and increased complexity.

To reduce complexity, this scheme consists of two separate stages which are subcarrier allocation and power allocation as in [2-3, 10]. The five-step scheme is described in detail as follows and its performance will be studied later.

Step ① Parameter Initialization

$\Lambda=\{1,2,\cdots,K\}$; $\Gamma=\{1,2,\cdots,N\}$;

$R_k=0$; $p=P_{tot}/N$; $\Omega_k=\varnothing$ for $k\in\Lambda$;

$N_k=\lfloor\gamma_k N\rfloor M$ for $k\in\Lambda$;

$N_{un}=N-\sum_{k=1}^{K}\left(\frac{N_k}{M}\right)$;

$c_{k,n}=0$ for $k\in\Lambda, n\in\Gamma$;

where Λ and Γ are the sets of user and subcarrier indices, R_k is the data rate of user k, Ω_k represents the set of subcarriers allocated to user k, N_k indicates the number of eigen-channels needed for user k, N_{un} is the number of unallocated subcarriers, p denotes equal power allocation across all eigen-channels and $c_{k,n}$ is the subcarrier allocation indicator and $c_{k,n}=1$ if subcarrier n is allocated to user k.

Step ② First Subcarrier Allocation

In this step, each user will be allocated its first subcarrier under the scheduling principle that the user with less pre-assigned number N_k of eigen-channels has higher priority to choose its first subcarrier. Clearly, such user will be protected to select a subcarrier with better channel conditions and tends to achieve higher capacity. Rate fairness and system capacity are thus initially emphasized. The subcarrier selection in this step is done by using the dominant channel-to-noise gains in (4). That is if $g_{k,n}^{\Delta}$ is selected for certain k and n, the set $\{g_{k,n}^{(i)}\}_{i=1}^{M}$, to which $g_{k,n}^{\Delta}$ belongs, will contribute to update the instantaneous rate (3) of user k. The details are shown as follows.

For j=1 to K **Do**

$k = \arg\min_{k\in\Lambda} N_k$; $n = \arg\max_{n\in\Gamma} g^{\Delta}_{k,n}$;

$\Omega_k = \Omega_k \bigcup \{n\}$; $c_{k,n} = 1$; $\Lambda = \Lambda - \{k\}$;

$\Gamma = \Gamma - \{n\}$; $N_k = N_k - M$;

$R_k = R_k + \frac{B}{N}\sum_{i=1}^{M}\log_2(1+pg^{(i)}_{k,n})$;

End For

where $A = A - \{v\}$ means deleting element v from set A, and $A = A \bigcup \{v\}$ stands for adding element v into set A. After doing this step, K subcarriers have been chosen and $\Lambda = \varnothing$. Thus, there are (N-K) subcarriers available for all users to select and Λ should be re-initialized in the subsequent step.

Step ③ Priority-based Subcarrier Allocation

Proportional fairness among users is emphasized in this step. The basic allocation principle here is that the user with the least ratio of instantaneously achieved rate to its required proportion has the priority to choose one subcarrier at a time. Obviously, the user with most starvation to its desired proportion can feed itself as much as possible through choosing additional subcarriers with better channel conditions. This step is described as follows.

$\Lambda = \{1,2,\cdots,K\}$;

While $|\Gamma| < N - U_{un}$ **Do**

$k = \arg\min_{k\in\Lambda}(R_k/\gamma_k)$;

If $N_k > 0$ **Do**

$n = \arg\max_{n\in\Gamma} g^{\Delta}_{k,n}$;

$\Omega_k = \Omega_k \bigcup \{n\}$; $c_{k,n} = 1$;

$\Gamma = \Gamma - \{n\}$; $N_k = N_k - M$;

$R_k = R_k + \frac{B}{N}\sum_{i=1}^{M}\log_2(1+pg^{(i)}_{k,n})$;

Else $\Lambda = \Lambda - \{k\}$;

End If

End While

Note that $|\Gamma|$ denotes the number of elements of set Γ, and R_k/γ_k is the ratio of the instantaneously achieved rate to the required proportion of user k. After this step, $N_k = 0$ for $k \in \Lambda$ and $\Lambda = \varnothing$.

Step ④ Residual Subcarrier Allocation

In this final step, an additionally simple procedure is done that is all residual subcarriers are allocated to users with the objective of enhancing the total system capacity.

$\Lambda = \{1,2,\cdots,K\}$;

For choose the fist subcarrier index n from Γ **Do**

$k = \arg\max_{k\in\Lambda} g^{\Delta}_{k,n}$;

$\Lambda = \Lambda - \{k\}$; $\Omega_k = \Omega_k \bigcup \{n\}$;

$c_{k,n} = 1$; $\Gamma = \Gamma - \{n\}$;

$R_k = R_k + \frac{B}{N}\sum_{i=1}^{M}\log_2(1+pg^{(i)}_{k,n})$;

End For

Step ⑤ Subcarrier Rearrangement

After previous four steps, the maximum system capacity under our scheme is achieved. Subsequently, a novel step to rearrange subcarriers among user with most fairness gain and least capacity loss is used. The following D_{rms} value, which is the root mean square of $(\varphi_k - \gamma_k)$, is defined to compare proportional fairness among users.

$$D_{rms} = \sqrt{\frac{1}{K}\sum_{k=1}^{K}(\varphi_k - \gamma_k)^2} \tag{8}$$

where $\varphi_k = R_k/R_{tot}$ is the normalized practical rate proportion of user k. The value in (8) can show the overall proportion derivation of all users from their desired proportions. When this value becomes smaller, the proportional fairness would be enhanced. In the extreme, absolute fairness is achieved when $D_{rms} = 0$.

A Tradeoff-Factor (TF) is used to control the number of subcarrier exchanges and details of this process are shown as follows.

While *TF*>0 **Do**

$\Lambda = \{1,2,...,K\}$; $\Gamma = \{1,2,...,N\}$; $R_{tot} = \sum_{k=1}^{K} R_k$

$s = \arg\min_{s\in\Lambda}(R_s / R_{tot} - \gamma_s)$;

$b = \arg\max_{b\in\Lambda}(R_b / R_{tot} - \gamma_b)$;

$D^{old}_{rms} = \sqrt{\frac{1}{K}\sum_{k=1}^{K}(R_k / R_{tot} - \gamma_k)^2}$; $R_{t1} = R_s$; $R_{t2} = R_b$;

$e = \arg\min_{n\in\Gamma}(c_{b,n}g^{\Delta}_{b,n} - c_{s,n}g^{\Delta}_{s,n})^2$ for $e \neq 0$;

$R_s = R_s + \frac{B}{N}\sum_{i=1}^{M}\log_2(1+pg^{(i)}_{s,e})$;

$R_b = R_b - \frac{B}{N}\sum_{i=1}^{M}\log_2(1+pg^{(i)}_{b,e})$;

$D^{new}_{rms} = \sqrt{\frac{1}{K}\sum_{k=1}^{K}(R_k / R_{tot} - \phi_k)^2}$;

If $D^{new}_{rms} < D^{old}_{rms}$ **Do**

$c_{b,e} = 0$; $c_{s,e} = 1$;

Else $R_s = R_{t1}$; $R_b = R_{t2}$; break;

TF=TF-1;

End If

End While

where e is selected to ensure least capacity loss. In each loop, subcarriers between two selected users with most unfair proportions are exchanged. Thus, this step is an iterative exchange process, which can enhance fairness at the cost of losing certain amount of system capacity.

Although three or more users could be selected at one time in this step, however, much more sophisticated subcarrier exchange method should be used. To reduce complexity, two most unfair users are thus selected at a time. To ensure convergence, this step will be stopped once the proportional fairness cannot be improved.

TABLE I

Order of complexity

Step ①	$O(K)$
Step ②	$O(KN)$
Step ③	$O((N\text{-}K)\times K)$
Step ④	$O(K)$
Step ⑤	$O(TF\times N)$

The above five steps form our proposed scheme, which can compromise capacity, fairness and complexity in a controllable manner. Thus, this scheme may be suitable for diverse QoS requirements. In addition, Table I briefly shows the computational complexity of each step. Note that N is assumed to be much larger than K and M.

V. SIMULATION RESULTS

In the step, the following parameters are configured for computer simulations. The frequency selective multi-path channel is modeled as consisting of six multi-paths with an exponentially decaying profile for downlink MIMO channel between any couple of transmitting and receiving antennas. A maximum delay spread is assumed to be $5\mu s$ and the maximum Doppler frequency shift being 30Hz. The total available power is assumed to be 1W and the total bandwidth is 1MHz. In addition, the AWGN power spectral density is -80 dBW/Hz. To compare system capacity, the proportionality constraints assigned to each user are assumed to have the following probability function in each channel realization.

$$p_\tau = \begin{cases} 1 & with \quad probability \quad 0.5 \\ 2 & with \quad probability \quad 0.3 \\ 4 & with \quad probability \quad 0.2 \end{cases} \tag{9}$$

Static OFDM-FDMA and OFDM-TDMA resource allocation schemes will be presented for comparison. Static OFDM-FDMA, as a special case of adaptive OFDMA, allocates fixed sequences of subcarriers to each user according to their proportionality constraints and the allocated subcarriers of each user cannot be changed over time. In the following statements, ‘adaptive’ only refers to non-static allocation that means subcarriers are expected to have different allocations over different time slots. On the other hand, OFDM-TDMA allocates all spectrum resources to only one user at each time slot.

The simulation results are presented in Fig. 2 - 4 and Table II. The number of user varies from 2 to 16 while 256 subcarriers and M_r=M_t=2 are considered. Fig. 2 depicts the total system capacity proportionality constraints give by (9). Obviously, adaptive allocation method can outperform both FDMA and TDMA methods. It can be observed that the proposed scheme without subcarrier rearrangement i.e. TF=0 can achieve the maximum capacity. In addition, larger TF value will lead to more reduced capacity. Note that the system capacity under this new scheme increases with the increasing number of users, which is due to the multi-user diversity. Nevertheless, both FDMA and TDMA schemes do not have such a property.

Fig. 3 gives the TF value range (upper rounded integer) suggesting a maximum value in Step ⑤ to control the number of subcarrier exchanges. As seen from this figure, larger number of users will result in more number of subcarrier exchanges due to the increased multi-user diversity. Fig. 4 shows the normalized proportions for 16 users under the proportion-

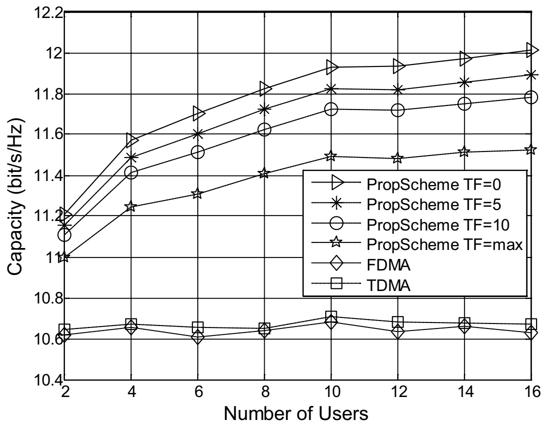

Fig. 2 K=2 to 16, N=256, M_r=M_t=2, total capacity vs. user number.

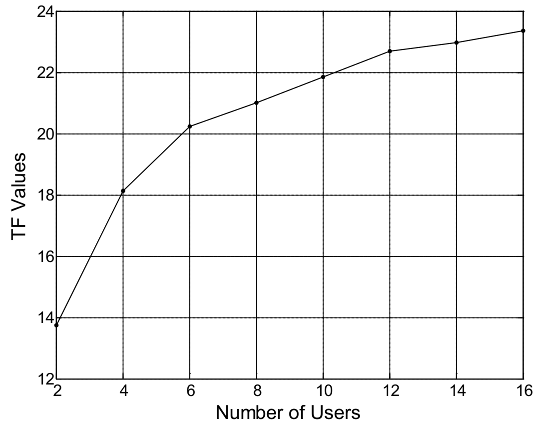

Fig. 3 K=2 to16, N=256, M_r=M_t=2, TF value range.

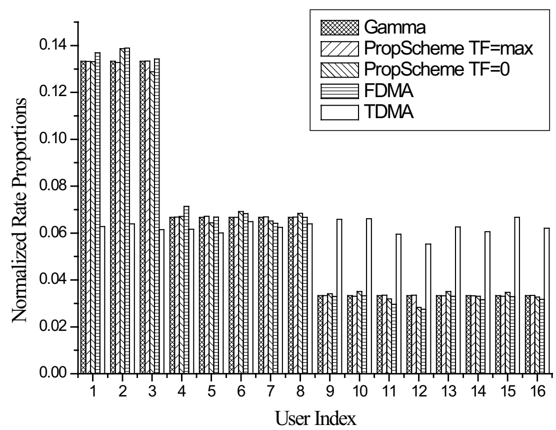

Fig. 4 K=16, N=256, M_r=M_t=2, normalized rate ratios per user with the desired proportions (Gamma - the leftmost bar).

TABLE II
Fairness comparison for different schemes, D_{rms} in (8)
(K=16, N=256, Mr=Mt=2)

Tau Set j	0	1	2	3	4
$\tau_1 = \tau_2 = 2^{j}$ *	1	2	4	8	16
PropScheme (TF=0)	0.0080	0.0082	0.0084	0.0091	0.0099
PropScheme (TF=5)	0.0054	0.0057	0.0057	0.0063	0.0069
PropScheme (TF=10)	0.0034	0.0037	0.0036	0.0041	0.0045
PropScheme (TF=max)	0.0009	0.0009	0.0009	0.0010	0.0010
FDMA	0.0094	0.0096	0.0096	0.0100	0.0114
TDMA	0.0395	0.0361	0.0364	0.0504	0.0767

*the other tau values are set to be $\tau_3 = \cdots \tau_6 = 4, \tau_7 = \cdots \tau_{10} = 2, \tau_{11} = \cdots \tau_{16} = 1$

nality constraint of $\tau_1 = \cdots \tau_3 = 4$, $\tau_4 = \cdots \tau_8 = 2$, $\tau_9 = \cdots \tau_{16} = 1$. This figure presents that the proposed scheme with maximum TF value (TF=24 in this simulation) can achieve near optimal proportional fairness.

In addition, Table II shows a detailed fairness comparison measured in (8) under five different proportionality constraints. As can be seen, the proposed scheme can give an iteratively refined performance as TF value increases while the maximal number of iterations leads to the an almost ideal fairness. In addition, the proposed scheme can outperform traditional FDMA and TDMA methods.

VI. CONCLUSTIONS

A new adaptive resource allocation scheme with flexible controllability on capacity, fairness and complexity is investigated in this paper. With above analyses in mind, some conclusions can be drawn. The proposed scheme with maximum TF value is suggested to be used in strict fairness scenario, however it has most reduced system capacity. This new scheme without subcarrier exchange may be used to capacity-emphasized scenario with acceptable reduced fairness. A well-selected TF value can tradeoff between the previous two extreme. The flexibility of our proposed has been demonstrated in information-theoretical viewpoint and its implementation in practical MIMO-OFDMA systems will be studied in further research.

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