19th International Conference on Telecommunications (ICT 2012)

DSmT Based Scheduling Algorithm in OFDMA Systems

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***Abstract*—This paper proposes a novel scheduling scheme based on Dezert-Smarandache Theory (DSmT) in an Orthogonal Frequency Division Multiple Access (OFDMA) downlink scenario. The proposed scheme is utilized in a decoupled time/frequency domain packet scheduling framework and allows jointly optimizing both system throughput and fairness. Compared with the proportional fair (PF) scheduling algorithm, the proposed method is able to achieve higher system throughput and lower average packet delay with approximately the same fairness among users. Simulation results verify that the proposed scheme can make a better tradeoff between system throughput and fairness among users than its counterparts.**

I. INTRODUCTION

Orthogonal Frequency Division Multiple Access (OFDMA) is one of the most important multiple access techniques in multiuser broadband wireless communications and has been proposed as the multiple access technique for the air interface by wireless communication standards including IEEE 802.16m [1] and 3GPP Long Term Evolution (LTE) [2]. In OFDMA systems, the radio resources are allocated to the users in time-frequency unit, i.e., physical resource block (PRB) which consists of several subcarriers during a time slot. Therefore, proper scheduling methods can be applied in time and frequency domains to acquire multiuser diversity in both domains [3].

A decoupled time/frequency domain scheduling scheme is adopted in [3] for LTE downlink scenario and it is attractive for reducing the complexity of the scheduler and signaling overhead. Obviously, the scheduling strategy can also be performed in OFDMA systems. Several scheduling algorithms based on the decoupled time/frequency scheduling scheme are investigated in [3]–[5]. The maximum throughput (MT) scheduling algorithm prioritizes the users with better channel conditions and can obtain the highest possible system throughput [4]. However, the major weak point of MT scheduling is that the fairness and quality of service (QoS) are not guaranteed. Taking fairness into consideration, the proportional fair (PF) algorithm is a satisfactory scheduling scheme. Both the PF scheduling [3], [4] and the modified PF scheduling [5] can make a tradeoff between throughput and fairness, whereas the packet delay of each user is not concerned.

Dezert-Smarandache Theory (DSmT) proposed in [6], is the development and generalization of Dempster-Shafer Theory (DST) [7]. Based on DSmT or DST, plenty of intelligent algorithms have been adopted in many fields, such as data fusion [8], artificial intelligence research [9] and MIMO systems [10], [11]. A satisfactory performance can be achieved by DSmT or DST as shown in [8]–[11]. DSmT is appropriate for scheduling problems owning to its counteracting uncertainty merit. In this paper, a DSmT based time/frequency domain scheduling algorithm is proposed in OFDMA systems to jointly optimize system throughput and fairness. The channel condition, user throughput and packet delay are considered as the three evidences in both time domain (TD) and frequency domain (FD). The proposed algorithm has similar procedures in the two domains and the scheduling decisions can be made from the evaluations of the three evidences. Specifically, at first, the generalized basic belief assignment (GBBA) for each user in each time slot is calculated according to the certain evidence. Then, the combination of the GBBAs associated to the three evidences for a certain user is performed based on Dezert-Smarandache combination rule (DSmC) with corresponding evidence weights. Finally, the generalized pignistic probabilities are generated from the combination results to make the final decision. Contrastively, the proposed algorithm achieves higher system throughput and lower packet delay with approximately the same fairness compared with the PF algorithm. Furthermore, the evidence weight, i.e., the tradeoff parameter, can be set to either a fixed value or an adaptive value under different practical situations. Illustrations under practical channel model demonstrate that the proposed scheduling algorithm is able to make a better tradeoff between system throughput and fairness than its counterparts.

The rest of this paper is organized as follows: Section II describes the system model of the scheduling problem. Section III presents a brief review of the conventional scheduling algorithms. In Section IV, a DSmT based approach is analyzed in details. Simulations and comparisons are presented in section V. Finally, the conclusions are summarized in Section VI.

II. SYSTEM MODEL

This paper considers a single cell scenario which consists of one base station with a single antenna and M active users each equipped with a single antenna. As shown in Figure 1, the OFDMA system radio resource is assigned per PRB at each time slot. Each PRB consists of S adjacent subcarriers with a subcarrier spacing of 15kHz and spans a time duration of T_s, which corresponds to 6 or 7 OFDM symbols [12]. The maximum multiplexed users is denoted K ($K < M$) which defines the maximun number of users that can be multiplexed in each time slot.

This work is financially supported by the National Natural Science Foundation of China (NSFC) (Grant No. 60972075) and National 863 Project (No. 2011AA01A205).

978-1-4673-0747-5/12/$31.00

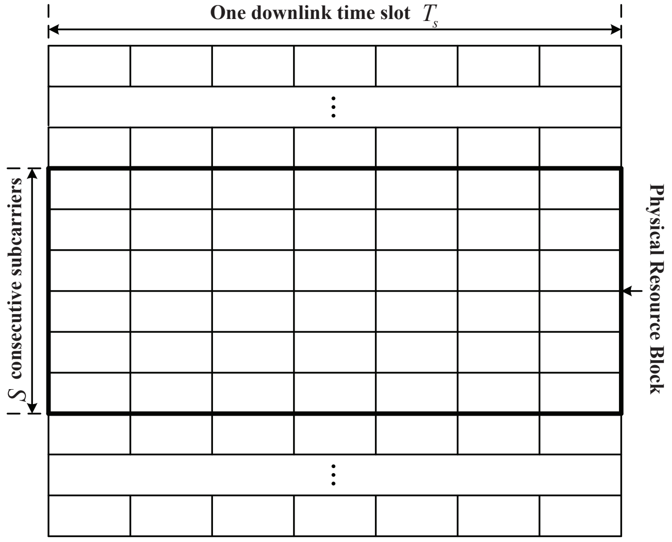

Figure 1. Physical resource block grid in OFDMA systems

The scheduling process is divided into two phases in each time slot. In the first phase, i.e., time domain packet scheduling, the scheduler located in BS selects K users with the highest scheduling priorities from M active users according to certain scheduling priority metrics, based on throughput, delay or current channel condition. The K selected users are appended to a scheduling candidate set (SCS), which will be used in the next phase. In the second phase, i.e., frequency domain packet scheduling, the PRBs in the time slot are allocated to the users in the SCS. However, it should be noted that the scheduler does not necessarily guarantee that all the K selected users will be allocated PRBs because the users in SCS are considered only candidates. In the second phase, multiple PRBs can be assigned to one user, while a certain PRB can be assigned for only one user at each time slot.

It is assumed that the signal to interference plus noise ratio (SINR) information of each user in the cell are instantaneously available at the scheduler at the beginning of each time slot. Let $R_k[n]$ express the instantaneously supportable data rate for user k at time slot n, assuming full bandwidth transmission with the BS transmit power allocated equally among the PRBs. $R_k[n]$ can be calculated by Shannon's capacity formula. In order to measure the fairness among different scheduling algorithms, two fairness criteria are considered:

Jain's Fairness Index of data rate, denoted I_D, is equivalent to the Jain's fairness index defined in [13] and is defined as

$$I_D = \frac{\left(\sum_{k=1}^{M} \bar{R}_k\right)^2}{M \sum_{k=1}^{M} \bar{R}_k^2}, \tag{1}$$

where $\bar{R}_k = \sum_{n=1}^{N} R_k[n]/N$ and N is the number of time slots.

Jain's Fairness Index of resource, denoted I_R, similar with the allocation fairness index in [5] is formulated as

$$I_R = \frac{\left(\sum_{k=1}^{M} \bar{G}_k\right)^2}{M \sum_{k=1}^{M} \bar{G}_k^2}, \tag{2}$$

where $\bar{G}_k = \sum_{n=1}^{N} G_k[n]/N$ and $G_k[n]$ represents the number of PRBs allocated for user k at time slot n.

Furthermore, the average packet delay is calculated as

$$\overline{\Gamma} = \frac{\sum_{k=1}^{M}\sum_{n=1}^{N} \Gamma_k[n]}{M \cdot N}, \tag{3}$$

where $\Gamma_k[n]$ denotes the cumulative packet delay, i.e., waiting time, of the user k at time slot n, and it is updated when scheduling is finished at each time slot as follows

$$\Gamma_k[n+1] = \begin{cases} 0 & k \in \Omega \\ \Gamma_k[n] + \tau_0 & k \notin \Omega \end{cases}, \tag{4}$$

where Ω represents the set of users that are served at time slot n and τ_0 is a constant which equals to the duration of the time slot. The initial value of $\Gamma_k[n]$, i.e., $\Gamma_k[1]$, is set to τ_0.

III. CONVENTIONAL SCHEDULING ALGORITHMS

As described in section II, the packet scheduling process consists of two basic steps. In TD packet scheduling (TDPS), a subset, i.e., SCS, of all the active users in the cell is chosen and in FD packet scheduling (FDPS), the actual PRBs allocation for the users in the SCS is carried out. The decoupled time/frequency domain scheduler is attractive from a complexity point of view, since limiting the maximun multiplexed users through TDPS helps to decrease the signaling overhead and the complexity of the scheduler. It is shown in [3], that the QoS of the users is primarily controlled by TDPS and the spectral efficiency is optimized mostly through FDPS. Many scheduling algorithms can be used in both time and frequency domains. Here, two typical time/frequency domain packet scheduling algorithms, i.e., MT and PF algorithms, are considered.

A. TD Scheduling

D_k is defined as a priority metric for user k, and the K users with highest priority metric values will be chosen as candidates for the FD scheduling. We consider the following two priority metrics:

1) Time Domain Maximum Throughput (TD-MT): The TD-MT algorithm gives priorities to the users which can support higher data rate, i.e., the ones have better channel conditions. The priority metric is expressed as

$$D_k = R_k[n], \tag{5}$$

where $R_k[n]$ is defined in section II. Obviously, the algorithm has advantages in system throughput but the fairness is not considered.

2) Time Domain Proportional Fair (TD-PF): The system throughput and fairness are both considered in the TD-PF scheduling algorithm, the priority metric is formulated as follows

$$D_k = \frac{R_k\left[n\right]}{T_k\left[n\right]}, \tag{6}$$

where $T_k\left[n\right]$ is the average throughput for user k at time slot n and it is updated by

$$T_k\left[n+1\right] = \begin{cases} (1-\frac{1}{T_c})T_k\left[n\right] + \frac{1}{T_c}R_k\left[n\right] & k \in SCS \\ (1-\frac{1}{T_c})T_k\left[n\right] & k \notin SCS \end{cases}, \tag{7}$$

where T_c denotes the effective memory of the throughput averaging window [14].

B. FD Scheduling

Similar to the TD scheduling, it is assumed that the SINR information of each user on each PRB are known at the scheduler. Let $R_{k,b}\left[n\right]$ indicate the instantaneous throughput for user k at time slot n on PRB b and it can be calculated by Shannon's capacity formula. The following two scheduling algorithms are considered:

1) Frequency Domain Maximum Throughput (FD-MT): The user k^* which is selected from SCS for scheduling at time slot n on PRB b is determined by

$$k^* = \arg\max_{k\in\{1,2,\ldots,K\}} R_{k,b}\left[n\right]. \tag{8}$$

2) Frequency Domain Proportional Fair (FD-PF): Similar to the TD-PF algorithm, the user chosen to be served at time slot n is

$$k^* = \arg\max_{k\in\{1,2,\ldots,K\}} \frac{R_{k,b}\left[n\right]}{T_k\left[n\right]}. \tag{9}$$

IV. DSMT BASED SCHEDULING ALGORITHM

In this section, a brief review of the DSmT is presented and the proposed DSmT based time/frequency scheduling algorithm is further explained. For more details of DSmT, readers can refer to the original book of Dezert and Smarandache [6].

A. A Brief Review of DSmT

Let $\Theta = \{\theta_1, \theta_2, \ldots, \theta_n\}$ be a finite set of n exhaustive elements, which is called the frame Θ. Define 2^Θ, i.e., the power set, as the set of all subsets of Θ, and D^Θ, i.e., the hyper-power set, which is defined as

1) $\emptyset, \theta_1, \ldots, \theta_n \in D^\Theta$;

2) If $A, B \in D^\Theta$, then $A \cap B \in D^\Theta$ and $A \cup B \in D^\Theta$;

3) No other elements belong to D^Θ, except those in 1) or 2).

The generic notation G^Θ is used for denoting either 2^Θ or D^Θ. In Shafer's model in DST, written $\mathcal{M}^0\left(\Theta\right)$, all the elements in Θ are exhaustive and exclusive. However, in DSmT frame, elements in Θ are exhaustive only and this is called the free DSm model, written $\mathcal{M}^f\left(\Theta\right)$.

For a frame Θ, a map $m\left(.\right) : G^\Theta \to [0,1]$ is defined associated to a given body of evidence E as

$$m_E\left(\emptyset\right) = 0 \text{ and } \sum_{A\in G^\Theta} m_E\left(A\right) = 1, \tag{10}$$

and $m_E\left(A\right)$ is called the GBBA of element A.

DSmC is applied in $\mathcal{M}^f\left(\Theta\right)$ to combine different evaluations from independent evidences. It is given by

$$m_{DSmC}\left(A\right) = \sum_{X,Y\in D^\Theta,\, X\cap Y=A} m_{E1}^{\beta_1}\left(X\right) m_{E2}^{\beta_2}\left(Y\right), \tag{11}$$

where E_1 and E_2 are independent evidences, and β_1 and β_2 are evidence weight coefficients satisfying $\beta_1 + \beta_2 = 1$. The rule of combination is associative and commutative, and it can be extended for combining evaluations from more than two evidences.

Finally, a rational decision can be made through acquiring the maximum of the generalized pignistic probability, written $BetP\left(.\right)$, of the elements in D^Θ. The $BetP\left(.\right)$ means the belief level of a certain element in the DSmT framework. It is defined as $BetP\left(\emptyset\right) = 0$ and for $\forall A \in D^\Theta \setminus \{\emptyset\}$

$$BetP\left(A\right) = \sum_{X\in D^\Theta} \frac{C_{\mathcal{M}}\left(X\cap A\right)}{C_{\mathcal{M}}\left(X\right)} m\left(X\right), \tag{12}$$

where $C_{\mathcal{M}}\left(Z\right)$ denotes the cardinality of Z.

In the following subsections, the DSmT based scheduling algorithm will be addressed in details.

B. TD Scheduling based on DSmT

1) Frame and Model: In TD scheduling, the scheduler selects K users from M active users in the cell at each time slot. Let $A_k, k = 1, 2, \ldots, M$, denote the user k in the cell requiring to be served and $B\left(A_k\right)$ denote the hypothesis that the user k is selected into the SCS at a certain time slot. The users with the largest generalized pignistic probability of $B\left(A_k\right)$ will be chosen as candidates for the FD scheduling. Assuming the frame of the TD scheduling problem is consisted of $B\left(A_k\right)$, i.e., $\Theta = \{B\left(A_1\right), B\left(A_2\right), \ldots, B\left(A_M\right)\}$, therefore the free DSm model $\mathcal{M}^f\left(\Theta\right)$ is carried out on $G^\Theta = D^\Theta = 2^\Theta$. This assumption is accepted due to reducing the complexity of the algorithm realization without leading to obvious degradation of the system performance.

2) Definition of GBBA: Three independent evidences which include channel quality (denoted E_1), each user's throughput (denoted E_2) and each user's packet delay (denoted E_3), are considered in TD scheduling. The GBBAs based on a certain evidence for user k at time slot n is calculated as

$$m_{E_1}\left(A_k\right) = \frac{R_k\left[n\right]}{\sum_{i=1}^{M} R_i\left[n\right]}, \tag{13}$$

where $R_k\left[n\right]$ has the same meaning as in section III. As shown in (13), the channel quality of each user is considered as the key point from the evidence E_1's point of view.

$$m_{E_2}\left(A_k\right) = \frac{\left(\sum_{i=1}^{M}\sum_{j=1}^{n} R_i\left[j\right]\right) - \left(\sum_{j=1}^{n} R_k\left[j\right]\right)}{\left(M-1\right)\left(\sum_{i=1}^{M}\sum_{j=1}^{n} R_i\left[j\right]\right)} \tag{14}$$

represents the evaluation from evidence E_2, and the denominator can be regarded as the normalization coefficient. (14) indicates that evidence E_2 focuses on the cumulative throughput of each user from the first time slot to the current time slot n. The larger the cumulative throughput of a user is, the less likely it will be selected into the SCS. The GBBA associated with the evidence E_3 is defined as

$$m_{E_3}\left(A_k\right) = \frac{\tau_k\left[n\right]}{\sum_{i=1}^{M} \tau_i\left[n\right]}, \tag{15}$$

where $\tau_k\left[n\right]$ denotes the cumulative packet delay, i.e., waiting time, of the user k at time slot n, and it is updated when the TD scheduling is finished (the K users are selected into the SCS) as follows

$$\tau_k\left[n+1\right] = \begin{cases} \tau_k\left[n\right] & k \in SCS \\ \tau_k\left[n\right] + \tau_0 & k \notin SCS \end{cases}, \tag{16}$$

where τ_0 is defined in (4) and the initial value of $\tau_k\left[n\right]$, i.e., $\tau_k\left[1\right]$, is set to τ_0.

3) DSmC based Combination: The combination of the GBBAs corresponding to different evidences can be achieved based on the DSmC. With the consideration of three existing evidences, therefore the combination is formulated as

$$m_{DSmC}\left(B\left(A_k\right)\right) = \sum_{X,Y,Z \in G^\Theta,\, X\cap Y\cap Z = B\left(A_k\right)} m_{E_1}^{\beta_1}\left(X\right) m_{E_2}^{\beta_2}\left(Y\right) m_{E_3}^{\beta_3}\left(Z\right), \tag{17}$$

where β_1, β_2 and β_3 are evidence weight coefficients associated to the three evidences satisfying $\beta_1 + \beta_2 + \beta_3 = 1$. Consider the system throughput is the primary index of the system, and the throughput and delay of each user have equal importance. Therefore, the coefficients can be set as $\beta_1 = \beta$, $\beta_2 = \beta_3 = \left(1-\beta\right)/2$ with the constraint $0 < \beta < 1$. The tradeoff between system throughput and fairness can be effctively controlled by β, and β can be set to a fixed value in practical environment.

4) $BetP\left(.\right)$ based Decision Making: The generalized pignistic probability, i.e., $\mathrm{Bet}P\left(.\right)$, represents the priority metric for a certain user in TD scheduling and with the consideration of $G^\Theta = D^\Theta = 2^\Theta$, the calculation of $BetP\left(.\right)$ defined in (12) is simplified as

$$\begin{aligned} D_k &= BetP\left(B\left(A_k\right)\right) \\ &= \sum_{X \in D^\Theta} \frac{\mid B\left(A_k\right) \cap X \mid}{\mid X \mid} m_{DSmC}\left(X\right) \\ &= m_{DSmC}\left(B\left(A_k\right)\right). \end{aligned} \tag{18}$$

C. FD Scheduling based on DSmT

1) Frame and Model: The FD scheduling is performed on a certain PRB sense. Let $A_{k,b}$, $k = 1, 2, \ldots, K$, express the user k in the SCS competing for the PRB b at a certain time slot and $B\left(A_{k,b}\right)$ denote the hypothesis that the user k wins in the competition for the PRB b at the time slot. Considering a certain PRB can be assigned for only one user at each time slot, therefore the elements of the frame, i.e., $\left\{B\left(A_{1,b}\right), B\left(A_{2,b}\right), \ldots, B\left(A_{k,b}\right)\right\}$, are exhaustive and exclusive. Similarly, the free DSm model $\mathcal{M}^f\left(\Theta\right)$ can be conducted on $G^\Theta = D^\Theta = 2^\Theta$ in this situation.

2) Definition of GBBA: The three evidences in TD scheduling are also used in this subsection with few modifications, due to the calculation of GBBAs limited to a certain PRB sense. For the PRB b, the GBBA for the user k at time slot n is defined according to a certain evidence, such as for the evidence E_1, the GBBA is formulated as

$$m_{E_1}\left(A_{k,b}\right) = \frac{R_{k,b}\left[n\right]}{\sum_{i=1}^{K} R_{i,b}\left[n\right]}, \tag{19}$$

where the $R_{k,b}\left[n\right]$ is identical with the definition in section III. The GBBA associated to the evidence E_2 is defined as

$$m_{E_2}\left(A_{k,b}\right) = \frac{\left(\sum_{i=1}^{K}\sum_{j=1}^{n} R_{i,b}\left[j\right]\right) - \left(\sum_{j=1}^{n} R_{k,b}\left[j\right]\right)}{\left(K-1\right)\left(\sum_{i=1}^{K}\sum_{j=1}^{n} R_{i,b}\left[j\right]\right)}. \tag{20}$$

As shown in (20), the value of $m_{E_2}\left(A_{k,b}\right)$ is mainly depended on the total throughput of the user k at time slot n and the increase of the user k's total throughput will result in the decrease of the $m_{E_2}\left(A_{k,b}\right)$. For the evidence E_3, the GBBA is denoted as

$$m_{E_3}\left(A_{k,b}\right) = \frac{\tau_{k,b}\left[n\right]}{\sum_{i=1}^{K} \tau_{i,b}\left[n\right]}, \tag{21}$$

where $\tau_{k,b}\left[n\right]$ represents the cumulative packet delay of the user k at time slot n on the PRB b. $\tau_{k,b}\left[n\right]$ is updated when the FD scheduling at time slot n is finished and it is updated by

$$\tau_{k,b}\left[n+1\right] = \begin{cases} \tau_{k,b}\left[n\right] & k = k^* \\ \tau_{k,b}\left[n\right] + \tau_0 & k \neq k^* \end{cases}, \tag{22}$$

where τ_0 is defined in (4) and the $\tau_{k,b}\left[1\right]$ is set to τ_0.

3) DSmC based Combination: The GBBAs from the three evidences are effectively combined by (11) based on the DSmC, and can be formulated as

$$m_{DSmC}\left(B\left(A_{k,b}\right)\right) = \sum_{X,Y,Z \in G^\Theta,\, X\cap Y\cap Z = B\left(A_{k,b}\right)} m_{E_1}^{\beta_1}\left(X\right) m_{E_2}^{\beta_2}\left(Y\right) m_{E_3}^{\beta_3}\left(Z\right), \tag{23}$$

where β_1, β_2 and β_3 are identical with (17) satisfying $\beta_1+\beta_2+\beta_3 = 1$. The setting of $\beta_1 = \beta$, $\beta_2 = \beta_3 = \left(1-\beta\right)/2$ with the constraint $0 < \beta < 1$ is also accepted for simplification.

4) $BetP\left(.\right)$ based Decision Making: In the FD scheduling, the decision which user will be served for the PRB b is made based on the calculation of $BetP\left(.\right)$ by (12). Since $G^\Theta = D^\Theta = 2^\Theta$ in this situation, the calculation can be simplified as

$$\begin{aligned} BetP\left(B\left(A_{k,b}\right)\right) &= \sum_{X \in G^\Theta} \frac{\mid B\left(A_{k,b}\right) \cap X \mid}{\mid X \mid} m_{DSmC}\left(X\right) \\ &= m_{DSmC}\left(B\left(A_{k,b}\right)\right). \end{aligned} \tag{24}$$

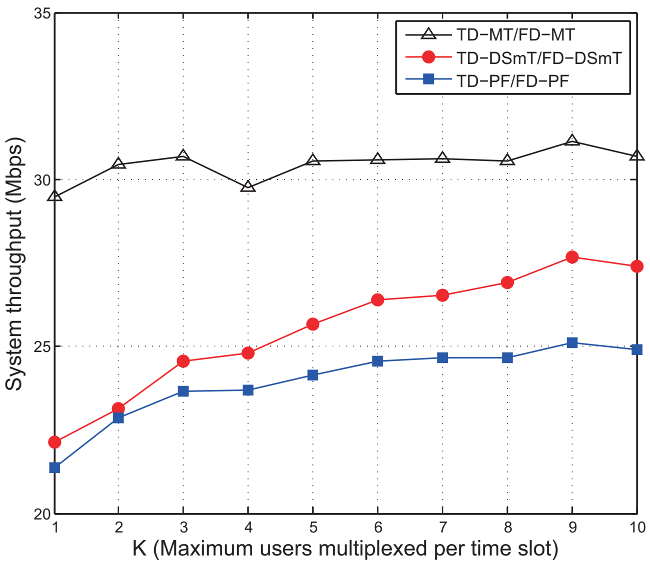

Figure 2. Comparison of system throughput of DSmT based scheduling, PF and MT

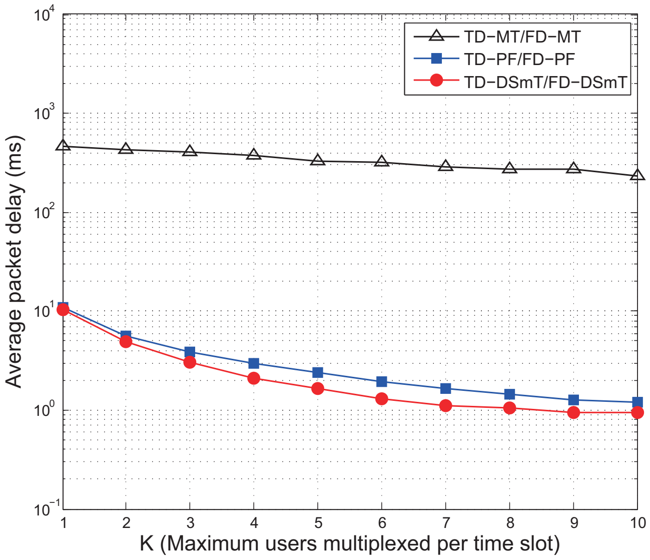

Figure 3. Comparison of average packet delay of DSmT based scheduling, PF and MT

Finally, the user for the PRB b is chosen by

$$k^* = \arg \max_{k \in \{1,2,\ldots,K\}} BetP\left(B\left(A_{k,b}\right)\right). \tag{25}$$

V. SIMULATION RESULTS

In this section, numerical results are presented to illustrate the performance of the proposed DSmT based time/frequency domain scheduling algorithm, compared with MT and PF scheduling algorithms. Considering all the $M = 20$ users are randomly distributed in the cell and the minimum distance between the user and the BS is 35m. The Rayleigh fading channel is considered and the delay due to multipath is not concerned. T_c is set to 5000 time slots, τ_0 is set to 1ms and β is set to 0.5. The simulation results are obtained via averaging 100 times' results and each consists of 10000 time slots. The simulation parameters are shown in Table I refering to [2].

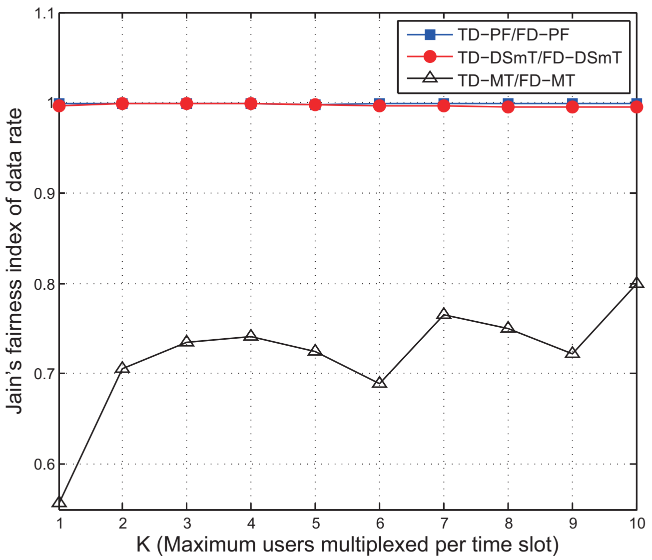

Figure 4. Comparison of Jain's fairness index of data rate (I_D) of DSmT based scheduling, PF and MT

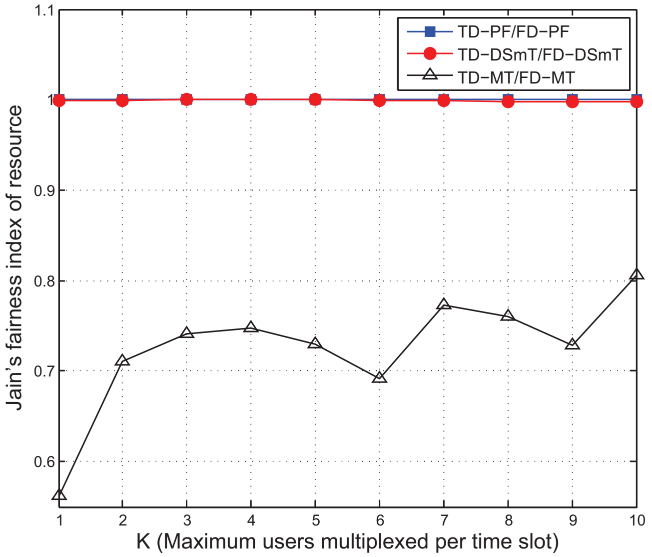

Figure 5. Comparison of Jain's fairness index of resource (I_R) of DSmT based scheduling, PF and MT

The average system throughput of different time/frequency domain scheduling algorithms are portrayed in Figure 2. It is easily observed that the TD-MT/FD-MT algorithm obtains the highest average system throughput and the DSmT based scheme outperforms the PF algorithm in the simulation. The average packet delays for the three schemes are calculated by (3) and shown in Figure 3. Obviously, the proposed algorithm achieves much lower average packet delay than the two other methods and the packet delay corresponding to the

Table I
SIMULATION PARAMETERS

Cell radius	1 km
System bandwidth	10 MHz
Subcarriers per PRB	12
Subcarrier spacing	15 kHz
Number of PRBs	55
Total BS transmit power	46 dBm
Time slot duration	1 ms
Distance dependent pathloss	100+35log(r/km) dB
Shadowing standard deviation	8 dB
Thermal noise density	-174 dBm/Hz
Traffic Model	Full buffer

MT algorithm is hard to tolerate. Figure 3 also demonstrates the DSmT based method can provide better QoS for users compared with its counterparts. The two fairness criteria, I_D and I_R, defined in section II are taken into account separately in Figure 4 and Figure 5. As shown in the two figures, the values of I_D and I_R for the PF algorithm and the DSmT based algorithm are significantly higher than the ones for their MT counterparts. It also can be seen that the two fairness indexes of the proposed scheme are quite close to the indexes of the PF scheme. It is indicated that the DSmT based algorithm can achieve approximately the same fairness among users (either I_D or I_R) compared with the PF method. Furthermore, both of them can provide much better fairness than the MT algorithm.

VI. CONCLUSIONS

A novel DSmT based time/frequency domain scheduling algorithm is proposed in this paper. The numerical results show that, compared with the conventional PF scheduling algorithm, the proposed scheme achieves higher system throughput and lower average packet delay with almost the same fairness among users. Furthermore, a complexity-reduced DSmT based scheduling algorithm in OFDMA systems is being studied and will be presented in another paper.

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