Abstract—This paper investigates the scheduling of user signals in MIMO systems with spatially correlated channels. By maximizing an upper bound of the sum capacity, we propose a scheduling scheme which requires only a single scalar feedback from each receiving user. To further reduce the need for user information feedback and better explore the spatial correlation information, a more efficient scheduling method is also developed. This new approach only requires a 1-bit indicator from each user and selects users according to the slowly varying MIMO channel correlation information. Numerical results verify the effectiveness of our proposed schemes.

I. INTRODUCTION

Recently, multiple-input and multiple-output (MIMO) technologies have shown great potentials to achieve broadband wireless communications. In single-user systems, the gain of MIMO diversity has been well established. With multiple antennas on both sides, a data vector of parallel streams can be transmitted simultaneously in coordination to exploit spatial diversity, thereby achieving high data rate [1].

For multiuser MIMO systems, simultaneous transmissions of multiple users can be supported by space division multiple access (SDMA). Dirty paper coding (DPC) is a well-known method for achieving full multiuser diversity gain by SDMA [2], [3]. Because of DPC’s high complexity, multiple studies proposed more efficient transmission schemes such as precoding and beamforming techniques [4]–[6]. Nevertheless, when serving a large number of active users, their complexities can still be very high. In addition, for precoding techniques based on zero-forcing or block-diagonalization, the maximum number of users that can be simultaneously scheduled would generally be limited by the antenna configurations at both sides. To address the concerns of complexity and precoding user limitation, user scheduling becomes essential in order to realize multiuser diversity gain in a MIMO broadcast channel (BC) with a large user population.

When full channel state information (CSI) of all users is available at the base station (BS), the problem of multiuser scheduling for MIMO systems has been investigated [7], [8]. However, full CSI requirement at BS imposes a heavy and demanding burden on the feedback channel. In fact, the level of required feedback information grows with the number of users in a cell. For this reason, several recent works have focused on multiuser scheduling algorithms requiring only partial CSI. There can be two ways of sending partial CSI. First, direct CSI quantization can be effective in reducing the feedback information in [9]. On the other hand, feedback can also be reduced by only selecting a subset of users to feedback their full CSI [10], [11]. In [12], distributed scheduling schemes are designed for each user to individually determine whether it should feedback its CSI. Additionally, scheduling schemes with only 1-bit feedback from each user are proposed in [13]. Generally, these approaches rely on instantaneous CSI for scheduling. A notable exception is [14], which shows that users can be scheduled according to the long-term channel information of users, without any instantaneous feedback.

In this paper, we investigate new multiuser scheduling schemes by maximizing the sum capacity with reduced feedback information. Our approach is different from existing works as it applies both the long time channel information and partial CSI for scheduling. It is midway between the two extremes of full CSI and zero CSI feedbacks. To begin, we derive an upper bound on the sum capacity of the multiuser system for optimization. We first propose a scheduling scheme which requires only a single scalar feedback from each user. The scalar serves as an indicator used to evaluate each user’s channel quality. Given the scalar feedback, the BS only selects a sub-group of users with the highest channel quality for transmission. This method is based on the instantaneous channel quality. To further reduce the feedback information and fully explore the long-term spatial correlation information, we then design an efficient scheduling scheme with 1-bit feedback. The 1-bit indicator is defined to separate users with good channels from those with relatively poor channels. Among the users with good channels, some of them will then be scheduled by using the spatial correlation information.

We organize our presentation as follows. Section II provides a brief overview on multiuser MIMO transmissions and scheduling. We then describe and analyze our new scheduling methods in Section III and Section IV. More specifically, we investigate the multiuser scheduling based on scalar feedback and the 1-bit based scheduling based on spatial correlation of user channels. In Section V, we present numerical results on the performance of the proposed multiuser scheduling algorithms and comparison against some existing methods.
II. System Model

We use uppercase and lower case boldface letters to represent matrices and vectors, respectively. $A^H$, $\text{tr}(A)$, and $|A|$ denote the conjugate transpose, the trace, and the determinant of matrix $A$, respectively. $|A|$ is the cardinality of set $A$. $I$ is an identity matrix whereas $E\{\cdot\}$ denotes ensemble average.

We only consider the broadcast channel of a single-cell multiuser MIMO system with $K$ users. There are $M$ antennas located at the BS and $N$ antennas at each mobile terminal. The MIMO flat fading BC channel of the $k$-th user is an $N \times M$ matrix $H_k$. Assuming that an $M \times M$ matrix $R_k$ represents the transmitter correlation matrix for the $k$-th user, the channel matrix $H_k$ is equivalent to

$$H_k = H_k R_k^{1/2},$$

where $H_k$ is an $N \times M$ matrix with independently distributed Gaussian matrix with zero mean and unit variance. The spatial correlation matrix $R_k$ depends on both the geometry of the current propagation scenario of user $k$ and the antenna configuration at BS [14], [18]. These components vary slowly unlike the fast fading $H_k$. Let $x$ denote the data symbol vector at BS and let $n_k$ be the additive white Gaussian noise (AWGN) vector at the $k$-th receiver. The received signal vector $y_k$ of user $k$ is

$$y_k = H_k x + n_k, \quad k = 1, \ldots, K. \quad (2)$$

The AWGN is normalized such that $n_k \sim CN(0, I)$, and the overall BS transmission power $E\{|x|^2\}$ is limited by $P$.

The sum capacity of MIMO BC has been extensively investigated in the literature [3], [15]. Using the duality properties given in [15], the sum capacity can be formulated as a convex maximization problem, which also defines the capacity of its dual multiple access channel (MAC) with the same total power constraint. Letting $Q_k$ be the signal covariance matrix for user $k$ in the dual MAC, we have

$$R = \max_{Q_k \geq 0, \sum_k \text{tr}(Q_k) \leq P} \text{log}_2 \left| I + \sum_{k=1}^K H_k^H Q_k H_k \right|. \quad (3)$$

For analytical simplicity, we assume that the total power is uniformly distributed across the $NK$ antennas in the rest of this paper. Thus, the sum capacity reduces to

$$R = \text{log}_2 \left| I + \rho \sum_{k=1}^K H_k^H H_k \right|$$

where $\rho = \frac{P}{NK}$ is the allocated power at each antenna.

III. Multiuser Scheduling with Scalar Feedback

It is known that full sum capacity of MIMO BC can be achieved by using DPC [3]. However, DPC requires full CSI of all users be available to the BS. This may be impossible for many practical applications, particularly the ones with large user number $K$. As an alternative, since the complexity of DPC implementation is relatively high, more efficient precoding techniques could be exploited for transmission. When applying transmitter precoding, the number of simultaneously supported data streams is limited to $M$. To deal with these practical problems, it is therefore necessary to design proper scheduling schemes which can dynamically select a subset of users among all ($K$ users) for transmission at a time.

In this section, we present a scheduling scheme aiming at maximizing the instantaneous sum capacity with only a single scalar feedback from each user. Assume that the channel of users are invariant during each time-slot. At the beginning of each time-slot, the BS scheduling scheme will select $K_S$ among $K$ users according to their feedback scalars. Then, the BS will transmit to the $K_S$ users and update CSI for future transmissions. Denote the users by using their indices as $K = \{1, 2, \ldots, K\}$ and let $S$ be the subgroup made up of scheduled users, i.e., $|S| = K_S$. Mathematically, the scheduling scheme can be formulated by

$$\max_{S} R_1 = \log_2 \left| I + \rho_S \sum_{k \in S} H_k^H H_k \right| \quad (5)$$

subject to: $S \subseteq K$, $|S| = K_S$

where $\rho_S = \frac{P}{NK_S}$ is the equally allocated power.

The greedy searching mechanism can be used to attack this problem. However, this method still requires full CSI of all users at BS. To relax the feedback need, we design a suboptimal scheme by attacking the upper bound on the sum capacity in (5). First, we need to determine a useful bound.

**Lemma 1:** The sum capacity given in (5) satisfies

$$R_1 \leq m \log \left( 1 + \frac{\rho_S}{m} \sum_{k \in S} \text{tr} \left( H_k^H H_k \right) \right) \quad (6)$$

where $m = \min(NK_S, M)$.

**Proof:** Applying singular value decomposition (SVD), the Hermitian matrix $\sum_{k \in S} H_k^H H_k$ can be decomposed into

$$\sum_{k \in S} H_k^H H_k = U \Lambda_S U^H \quad (7)$$

where $U \in \mathbb{C}^{M \times M}$ is unitary and $\Lambda_S \in \mathbb{C}^{M \times M}$ is a diagonal matrix whose diagonal elements are the singular values sorted in descending order. Substituting (7) into $R_1$ in (5), we can use the determinant equality $|I + AB| = |I + BA|$ to obtain

$$R_1 = \log_2 \left| I + \rho_S \Lambda_S \right|. \quad (8)$$

Since the rank of the sum matrix $\sum_{k \in S} H_k^H H_k$ is at most $m$, (8) is further equivalent to

$$R_1 = \log_2 \left| I + \rho_S \overline{\Lambda} \right| \quad (9)$$

where $\overline{\Lambda} = \sum_{k \in S} H_k^H H_k$ is the $m \times m$ principal submatrix of $\Lambda$.

Since the matrices $H_k^H H_k$ are positive semidefinite, so is their sum. Recall inequality $|A| \leq (\text{tr}(A)/r)^r$ for $A$ positive semidefinite [17], the sum capacity in (9) can be upper bounded by

$$R_1 \leq m \log \left( 1 + \frac{\rho_S}{m} \text{tr} \left( \overline{\Lambda} \right) \right). \quad (10)$$

Thus, this lemma directly follows from (10).
Based on Lemma 1, we can simplify the scheduling algorithm by replacing $\mathcal{K}_1$ in (5) with the derived upper bound in (6):

$$\max_{S} \sum_{k \in S} \text{tr} \left( \mathbf{H}_k^H \mathbf{H}_k \right) ; \text{ subject to: } S \subseteq \mathcal{K}, |S| = K_S. \quad (11)$$

In this simple scheduling scheme, each user must first send back a scalar channel information $\text{tr} \left( \mathbf{H}_k^H \mathbf{H}_k \right)$ to the BS. The BS will then select the $K_S$ users with the largest scalars CSI, and instruct the selected users for transmission. The description of this scheduling method is given below.

**Algorithm 1:** Scheduling with Scalar Feedback (SSF)

*At user side (Feedback)*

```python
for k = 1 to K
  t_k = \text{tr} \left( \mathbf{H}_k^H \mathbf{H}_k \right)
end for
```

*At BS side (Scheduling)*

Initialization: $S = \emptyset$ and $\mathcal{K} = \{1, 2, ..., K\}$

```python
for i = 1 to $K_S$
  $k^* = \max_{k \in \mathcal{K}} t_k$
  $S = S \cup \{k^*\}$ and $\mathcal{K} = \mathcal{K} \setminus \{k^*\}$
end for
```

This scheme requires only a single scalar CSI, instead of full CSI, from each user for scheduling. After the scheduled users are determined, detailed channel information of only those $K_S$ users are needed at BS based on the adopted transmission strategies, such as DPC or precoding.

We should note that, in a multiuser system with many users, even the scalar feedback may still consume considerable bandwidth. To further shorten the scheduling feedback needs, additional channel information should be utilized. In the next section, we will jointly explore the long term channel information already available at the BS and a coarse 1-bit CSI feedback from each user.

### IV. Efficient Scheduling with Spatial Correlation

#### A. 1-Bit Channel Quality Indicator Feedback

The basic concept of 1-bit feedback is to let each user evaluate its own channel quality against a threshold $\alpha$. Note that the value of $\alpha$ is predetermined and it is assumed to be the same for all users. As in the last section, we use the trace of the user’s channel covariance matrix to signify the channel quality. Thus, the 1-bit indicator for user $k$, denoted by $I_k$, can be obtained by

$$I_k = \begin{cases} 1, & \text{tr} \left( \mathbf{H}_k^H \mathbf{H}_k \right) \geq \alpha, \\ 0, & \text{tr} \left( \mathbf{H}_k^H \mathbf{H}_k \right) < \alpha. \end{cases} \quad (12)$$

At the start of each time-slot, each user will firstly transmit $I_k$ to the BS. Without loss of generality, we assume that users indexed by $\mathcal{L} = \{1, 2, ..., L\}$ have indicators $I_k = 1$, whereas rests are zero. If $L \leq K_S$, then all $L$ users will be scheduled and additionally, we will select another $(K_S - L)$ users with zero indicator value for transmission according to the long-term channel information. If $L > K_S$, then the BS needs to single out $K_S$ users out of the $L$ users with $I_k = 1$. The details of the selection process when users have the same indicator value will be discussed next.

#### B. Channel Correlation Based User Scheduling

In both cases of $L > K_S$ and $L < K_S$, a subset of $K_S$ users with the same indicator value (1 or 0) must be further selected by the scheduling algorithm. Without loss of generality, we investigate the case of $L > K_S$ when we must select users from the user group $\mathcal{L}$. Since the long-term channel correlations of users are known at BS, our scheduling scheme is designed to choose users to maximize the ergodic sum capacity. Mathematically, the scheduling problem can be formulated as

$$\max_{S} \quad C = \mathbb{E}\left\{ \log_2 \left| I + \rho_S \sum_{k \in S} \mathbf{H}_k^H \mathbf{H}_k \right| \right\} \quad (13)$$

subject to: $S \subseteq \mathcal{L}$, $|S| = K_S$.

Note that this problem is different from (5) in that it optimizes the ergodic sum capacity instead of the instantaneous one. To make this problem tractable, we resort to maximizing the upper bound of $C$.

**Lemma 2:** The ergodic sum capacity $C$ in (13) can be upper bounded by

$$C \leq \log \left| I + \frac{P}{K_S} \sum_{k \in S} \mathbf{R}_k \right|. \quad (14)$$

**Proof:** For simplicity of presentation (without loss of generality), the scheduled users are indexed by $S = \{1, 2, ..., K_S\}$. Start with the instantaneous sum capacity

$$\mathcal{R} = \log \left| I + \rho_S \sum_{k=1}^{K_S} \mathbf{H}_k^H \mathbf{H}_k \right| = \log \left| I + \rho_S \left[ \begin{array}{c} \mathbf{H}_1^H \\ \mathbf{H}_2^H \\ \vdots \\ \mathbf{H}_{K_S}^H \end{array} \right] \right|$$

$$= \log \left| I + \rho_S \mathbf{R} \right|$$

$$= \log \left| I + \rho_S \mathbf{R} \right| = \log \left| I + \rho_S \left[ \begin{array}{c} \mathbf{W}_1 & 0 & \cdots & 0 \\ 0 & \mathbf{W}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{W}_{K_S} \end{array} \right] \right| \quad (15)$$

Equality (15) follows from $|I + A| = |I + AB|$. Accordingly, the ergodic sum capacity can be written as

$$C = \mathbb{E}\left\{ \mathcal{R} \right\} \leq \log \left| I + \rho_S \mathbb{E}\left\{ \left[ \begin{array}{c} \mathbf{W}_1 & 0 & \cdots & 0 \\ 0 & \mathbf{W}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{W}_{K_S} \end{array} \right] \right| \right| \mathbf{R}^H \right\|. \quad (17)$$
This relationship follows from Jensen’s inequality because the function \( \log|A| \) is concave for \( A \) on the set of symmetric positive definite square matrices [19]. From the definition of \( W_k \), it is true that \( \{W_k\} \)'s are independent and of Wishart distribution \( W_M(N,I) \). Moreover, because \( \mathbb{E}\{W_k\} = NI \) [20]. (17) leads to
\[
C \leq \log|I + N\rho_S RR^H| = \log|I + N\rho_S \sum_{k=1}^{K_S} R_k|, \tag{18}
\]
and completes the proof.

Using the upper bound on \( C \) given in Lemma 2, the scheduling problem in (13) can be simplified into
\[
\max_{S} \left| \begin{array}{c} I + \frac{P}{K_S} \sum_{k \in S} R_k \end{array} \right| \tag{19}
\]
subject to: \( S \subseteq L, |S| = K_S \).

Therefore, we may need to check overall \( \binom{K}{K_S} \) different user selections to find the exact solution to (19). In Algorithm 2, a progressive user scheduling scheme is proposed to obtain a sub-optimal solution to (19). The details of our proposed scheduling scheme are described as follows.

**Algorithm 2 : Scheduling with Channel Correlation (SCC)**

**At user side (Feedback)**

for \( k = 1 \) to \( K \) do

user \( k \) feeds back \( I_k \) according to (12)

end for

**At BS side (Scheduling)**

Initialization: \( S = \phi, L = \{l|I_l = 1\} \) and \( n = 1 \).

if \( |L| \leq K_S \) then

\( S = L \)

\( L = \{l|I_l = 0\} \) and \( n = L + 1 \)

end if

for \( i = n \) to \( K_S \) do

\( k^* = \max_{k \in L} \left| I + \frac{P}{K_S} \left( \sum_{s \in S} R_s + R_k \right) \right| \)

\( S = S \cup \{k^*\} \) and \( L = L \backslash \{k^*\} \)

end for

C. Determination of \( \alpha \)

Notice that the implementation of SCC requires a proper value of \( \alpha \). If \( \alpha \) is too small, the multiuser channel gain obtained by SCC is reduced because some users with poor channel quality also may be scheduled. On the other hand, if \( \alpha \) is too large, very few users will feedback \( I_k = 1 \), again some users with poor quality channels may be scheduled based on long term CSI.

To illustrate the effect of \( \alpha \) value on the system performance, Fig. 1 illustrates the ergodic sum capacity of SCC for various \( \alpha \) choices at different signal-to-noise ratio (SNR) levels. Clearly, the choice of \( \alpha \) influences the scheduling performance. One interesting phenomenon is that the optimum value of \( \alpha \) that achieves the largest ergodic capacity appears to be relatively insensitive to the SNR level.

Because of the complex nonlinear relationship between \( \alpha \) and the ergodic capacity, finding optimum \( \alpha \) in a closed form is very difficult. Instead, in practical scenario, we would like to give some good guidelines on the selection of \( \alpha \) a priori in order for SCC to be practical. Our approach is to find an \( \alpha \) that will lead to an average number of users with \( I_k = 1 \) to equal a predetermined number \( L \). We let \( L > K_S \) but \( L \) cannot be too large without making it difficult to select \( K_S \) users out of \( L \) users to achieve good quality of service (QoS) requirement.

Let \( p_k \) be the probability of user \( k \) sending back \( I_k = 1 \), i.e.,
\[
p_k = \Pr\{\text{tr}([R_k H_k^H H_k] \geq \alpha)\}. \tag{20}
\]

The mean number of users with \( I_k = 1 \) is simply
\[
\mathbb{E}\{L\} = \sum_{k=1}^{K} p_k. \tag{21}
\]

Thus, our problem is to find an \( \alpha \) to achieve \( \mathbb{E}\{L\} = L \). To make this problem more tractable, we further assume that these are homogeneous users and \( R_k = I \). Under these assumptions, the probability in (20) reduces to
\[
p_k = \Pr\{\text{tr}(H_k^H H_k) \geq \alpha\}
= e^{-\alpha} \sum_{i=0}^{MN-1} \frac{\alpha^i}{i!} \tag{22}
\]
where (22) is given by [21, Eq. (2.114)]. With the definition of normalized incomplete gamma function \( \Gamma(n, x) = \frac{1}{[n-1]!} \int_x^\infty t^{n-1} e^{-t} dt \), the probability can be further written as
\[
p_k = \Gamma(MN, \alpha). \tag{23}
\]

From (21) and (23), the solution of \( \alpha \) can be obtained by
Fig. 2. Ergodic sum capacity (obtained by DPC) comparison of round-robin scheduling, scheduling with scalar feedback (SSF), scheduling with channel correlation (SCC), and the optimal scheduling by exhaustive searching method.

Fig. 3. Ergodic sum capacity (obtained by ZF precoding) comparison of round-robin scheduling, scheduling with scalar feedback (SSF), and scheduling with channel correlation (SCC). Precoding using both full CSI and quantized CSI with fixed $B = 4$ bits/mobile are tested.

Fig. 4. Ergodic sum capacity (obtained by ZF precoding) comparison of round-robin scheduling, scheduling with scalar feedback (SSF), and scheduling with channel correlation (SCC). Precoding using both full CSI and quantized CSI with scaled $B = \frac{M-1}{3}$ SNR bits/mobile are tested.

solving $E\{L\} = T$. Thus, we have

$$\alpha = \Gamma^{-1} \left( MN, \frac{T}{K} \right).$$

(24)

Without loss of generality, we can set $T = 3K_S$ in our system. Numerical results indicate that the value of $\alpha$ is not very sensitive to the precise value of $T$. And in the following simulation section, results will show only a negligible capacity degradation by using $\alpha$ obtained from the guideline of (24) instead of the optimal one.

V. SIMULATION RESULTS

In this section, our proposed scheduling schemes are tested in computer simulations. We consider the case of $M = 4$ antennas located at BS whereas each user has a single antenna ($N = 1$). The total number of active users in a cell is set to $K = 40$ and the number of scheduled users during each timeslot is $K_S = 4$. We randomly generated a single fixed channel correlation matrix $R_k$ for each user.

In Fig. 2, we evaluate the ergodic sum capacity obtained by DPC with different scheduling schemes. Ergodic sum capacity achieved by our SSF, our SCC, the round-robin scheduling schemes, and the optimal scheduling (exhaustive search) are given. The result shows that the proposed schemes can achieve a scheduling gain of approximately 2–3 dB over round-robin. Compared with the optimal one, the sum capacity achieved with our methods has little capacity loss in the low SNR region. However, this capacity gap grows with increasing SNR. Moreover, we can also see that the performance of SCC is almost the same as SSF, even though the former one requires less feedback information for scheduling.

Fig. 2 also compares the sum capacity achieved by SCC under different values of $\alpha$: optimal versus the approximation of (24). It can be seen that the sum capacity loss due to the suboptimal $\alpha$ is negligible. Note that we obtained $\alpha = 5.42$ from (24) with the system configurations stated before.

Fig. 3 and Fig. 4 depict the sum capacity obtained through zero-forcing (ZF) precoding under different scheduling schemes. Since ZF is a transmission strategy that eliminates multiuser interference by precoding, the channel orthogonality of users contributes to a better performance. Meanwhile, SCC is designed to fully explore the spatial correlation information of users. Therefore, unlike DPC, the proposed SCC scheme can outperform the SSF scheme when zero-forcing precoding technique is exploited. And this effect becomes more pronounced when the SNR grows.

Even though this work only focuses on the reduction of feedback information during the scheduling stage, it is still useful to consider the total required feedback information for scheduling and transmission. Since $K_S$ users will be scheduled at a time, all schemes require the feedback of their CSI for transmission by DPC and many precoding techniques. Such information is often reduced through quantization. In Figs. 3–
4, the sum capacity obtained by ZF with finite-rate feedback (FRF) is also provided. In the case of FRF, we use \( B \) bits to quantize the CSI of each user. \( B = 4 \) bits/mobile is tested. The results are not very promising, as pointed out by [16] that \( B \) should increase linearly with the SNR in order to achieve the full multiplexing gain of \( M \). Thus, we further tested the system with a scaled \( B = \frac{M}{K} \) bits/mobile according to [16]. From the labeled results in both figures, we witness the loss of scheduling gain due to the CSI quantization. Still, SCC provides a more noticeable scheduling gain because its main information source is the (unquantized) long-term information.

Finally in Table I, the required feedback information of different scheduling schemes are listed in detail. This information shows that, except for the arbitrary round-robin scheduling, SCC requires the least amount of feedback information. In this table, we included the total feedback information required by both scheduling and transmission strategies in different cases. When ZF is used with FRF, \( B \) can be fixed or scaled according to SNR to achieve full multiplexing gain.

<table>
<thead>
<tr>
<th>Scheduling</th>
<th>Info. for Scheduling</th>
<th>Info. for Transmission</th>
<th>Overall Feedback Info.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DPC or ZF</td>
<td>ZF with FRF</td>
</tr>
<tr>
<td>Round-Robin</td>
<td>No</td>
<td>CSI of ( K_S ) users</td>
<td>( K_S ) CSI</td>
</tr>
<tr>
<td>Optimal Scheduling</td>
<td></td>
<td>( K ) scalars</td>
<td>( K ) bits</td>
</tr>
<tr>
<td>SSF</td>
<td>full CSI of ( K ) users</td>
<td>B bits/mobile</td>
<td>( K_S ) CSI</td>
</tr>
<tr>
<td>SCC</td>
<td>( K ) bits</td>
<td>( K ) scalars + ( K_S ) CSI</td>
<td>( K ) bits</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

We present two scheduling schemes for multiuser MIMO under spatially correlated channels. Aimed at maximizing a sum capacity bound, a scalar channel quality measure is defined for feedback to BS. Based on the feedback information, a multiuser scheduling scheme is proposed using only 1-bit feedback information. Furthermore, by jointly exploring the long-term channel correlation information with the 1-bit feedback, this scheduling scheme can effectively improve the ergodic sum capacity of our system. Finally, we evaluate our scheduling scheme under quantized CSI feedback. Our results demonstrate the effectiveness of our SCC algorithm in achieving much of the scheduling gain achievable by optimum scheduling with only limited feedback for scheduling.

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REFERENCES