Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Closed Loop MIMO Precoding with Minimal Feedback for MIMO OFDMA Systems**
Date Submitted	**2004-11-4**
Source(s)	Chan-Byoung Chae, Wonil Roh, Cheol Mun, Kyunbyoung Ko, JeongTae Oh, Hongsil Jeong, Sung-Ryul Yun, Seungjoo Maeng, Panyuh Joo, Jaeho Jeon, Jaeyeol Kim, Soonyoung Yoon, Jin-Kyu Han, Donghee Kim **Samsung Electronics Co., Ltd.** Young-Ho Jung, Seung Hoon Nam , Jaehak Chung, Yungsoo Kim, Sung-Jin Kim, Hojin Kim **Samsung Advanced Institute of Technology** cb.chae@samsung.com Voice: +82-31-279-4828
Re:	
Abstract	Closed Loop MIMO Precoding with Minimal Feedback for MIMO OFDMA Systems
Purpose	Adoption of proposed changes into P802.16e ~~Crossed-out indicates deleted text,~~ underlined blue indicates new text change to the Standard
Notice	
Release	
Patent Policy and Procedures	

Closed Loop MIMO Precoding with Minimal Feedback for MIMO OFDMA Systems

Chan-Byoung Chae, Wonil Roh, Cheol Mun, Kyunbyoung Ko, JeongTae Oh, Hongsil Jeong, Sung-Ryul Yun, Seungjoo Maeng, Panyuh Joo, Jaeho Jeon, Jaeyeol Kim, Soonyoung Yoon, Jin-Kyu Han, Donghee Kim

Samsung Electronics Co., Ltd.

Young-Ho Jung, Seung Hoon Nam , Jaehak Chung, Yungsoo Kim, Sung-Jin Kim, Hojin Kim

Samsung Advanced Institute of Technology

1. Introduction

It is well known that multiple input multiple output (MIMO) antenna systems improve spectral efficiency by allowing multiple parallel streams transmitted on the same physical resources. The current standard [1] provides this technique indicated by transmission matrix B for 2-antenna BS and C for 3- and 4-antenna BS. The performance gain, however, is known to heavily depend on the correlation property of the MIMO channel. In this contribution, a novel scheme is proposed for MIMO OFDMA so that, with the help from a minimal feedback from SS, performance degradation due to antenna correlation can be significantly reduced. To achieve this goal a unitary basis set is introduced which is common for all users and the amount of required feedback is merely a few indexing bits regardless of the number of allocated data subcarriers.

2. System Model

The block diagram of our proposed scheme that employs n_T transmit and n_R receive antennas is illustrated in Fig. 1. These sub-streams are separately coded and mapped to symbols. The coding and modulation are subject to the feedback information. Let M_i denote a specific MCS of the *i*th sub-stream. The corresponding spectral efficiency is denoted by $R(M_i)$. With total transmission power P_T, we allocate the equal power across the active bases and define the power allocation vector as $\mathbf{P} = diag(P_1, P_2, \cdots, P_{n_T})$ such that $P_T = \sum_{i=1}^{n_T} P_i$.

The signal at the receiver is given by

$$\mathbf{y} = \mathbf{HEx} + \mathbf{n} \tag{1}$$

where $\mathbf{x}$ is an $n_T \times 1$ vector whose *i*th element represents the symbol transmitted from the *i*th basis. $\mathbf{E} = \lfloor \mathbf{e}_1 \mathbf{e}_2 \cdots \mathbf{e}_{n_T} \rfloor$ is the $n_T \times n_T$ common basis matrix. The channel is represented by a matrix $\mathbf{H}$ ($n_R \times n_T$). In the ideal rich scattering environment, the entries of $\mathbf{H}$ are mutually uncorrelated. However, in real scenarios, they may exhibit certain correlations.

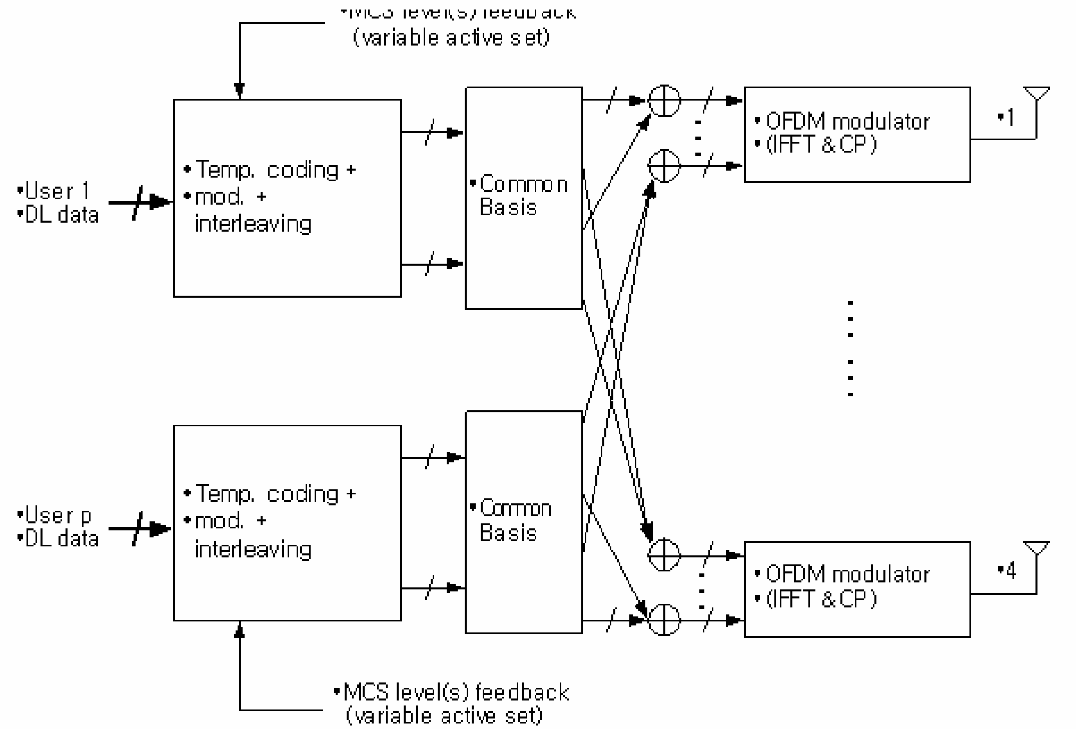

Fig 1. Transmitter Block Diagram of Proposed Scheme

3. Proposed Scheme

To maximize capacity in correlated channels, we propose unitary transform of correlated channels by a common basis matrix. Let us introduce unitary transform

$$\widetilde{\mathbf{H}} = \mathbf{HE} = \begin{bmatrix} \mathbf{h}_1\mathbf{e}_1 & \mathbf{h}_1\mathbf{e}_2 & \cdots & \mathbf{h}_1\mathbf{e}_{n_T} \\ \mathbf{h}_2\mathbf{e}_1 & \mathbf{h}_2\mathbf{e}_2 & \cdots & \mathbf{h}_2\mathbf{e}_{n_T} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{h}_{n_R}\mathbf{e}_1 & \mathbf{h}_{n_R}\mathbf{e}_2 & \cdots & \mathbf{h}_{n_R}\mathbf{e}_{n_T} \end{bmatrix} \tag{2}$$

where $\mathbf{h}_j$ is the receive channel vector at the jth antenna. Thus, $\mathbf{h}_j\mathbf{e}_k$ represents the channel by transmit beamforming via the basis $\mathbf{e}_k$ and receiving the jth antenna. By substituting (2) into (1), we have

$$\mathbf{y} = \widetilde{\mathbf{H}}\mathbf{x} + \mathbf{n} \tag{3}$$

The transformed channel matrix $\widetilde{\mathbf{H}}$ represents the channel by beamforming in fixed direction. Based on the unitary transform by the common bases, the number of active bases is determined according to the fading environments.

Let us define $\widetilde{\mathbf{h}}_\mathbf{i}$ as the ith column of $\widetilde{\mathbf{H}}$. Let us further define $\widetilde{\mathbf{H}}_i = \left[\widetilde{\mathbf{h}}_{i+1} \quad \widetilde{\mathbf{h}}_{i+2} \quad \cdots \quad \widetilde{\mathbf{h}}_{n_T}\right]$. The achievable capacity by a basis i is given by

$$C_i = \log_2\left(1 + P_i\widetilde{\mathbf{h}}_i^H\left(\widetilde{\mathbf{H}}_i\mathbf{P}_i\widetilde{\mathbf{H}}_i^H + \mathbf{I}_{n_R}\right)^{-1}\widetilde{\mathbf{h}}_i\right). \tag{4}$$

In correlated channels, proposed scheme increases disparity of spatial channel's quality, selects good spatial channels, and allocates transmit power only on the good channels, which leads to an increasing in the total rate with a given target BER.

Moreover, the proposed schemes can be easily extensible to multi-user environment. In this case, multi-users are mapped onto each unitary basis in the same frequency sub-channel based on multi-user precoding concept.

Note that in this case, the required feedback information for MSS is the index of the pre-determined unitary matrix instead of the full MIMO channel matrix that is a general requirement for multi-user precoding.

4. Simulation Results

We consider a MMSE-SIC spatial multiplexing with proposed scheme. MMSE-SIC with optimal ordering and selection algorithm is adopted at receiver. For comparison purposes, the capacity of the SM-SIC with antenna rate control with optimal ordering and selection is also presented. Linear arrangement of the antenna array is assumed at both the transmitter and receiver with spacing $d_T = 4\lambda, d_R = 0.5\lambda$. We assume uniform angular spectrum at both the transmitter and receiver with angle spread Δ_T and Δ_R, respectively. We assume that the receive antennas are uncorrelated by letting $\Delta_R = 60^\circ$, while the correlation between transmit antennas varies with the angle spread Δ_T.

Fig 2. shows the capacity comparison between proposed scheme and SM-SIC with antenna rate control when $n_T = n_R = 2$ in correlated channels. A shown in figure, proposed scheme outperforms SM-SIC with antenna rate control over a entire SNR region.

The effect of fixed beamforming on the rate at 10dB SNR in correlated channels is depicted in Fig. 3. For most receiver directions proposed scheme outperforms SM-SIC with antenna rate control. This effect of fixed beamforming is quite acceptable, considering the significant reduction in the amount of feedback information or complexity required for adaptive beamforming.

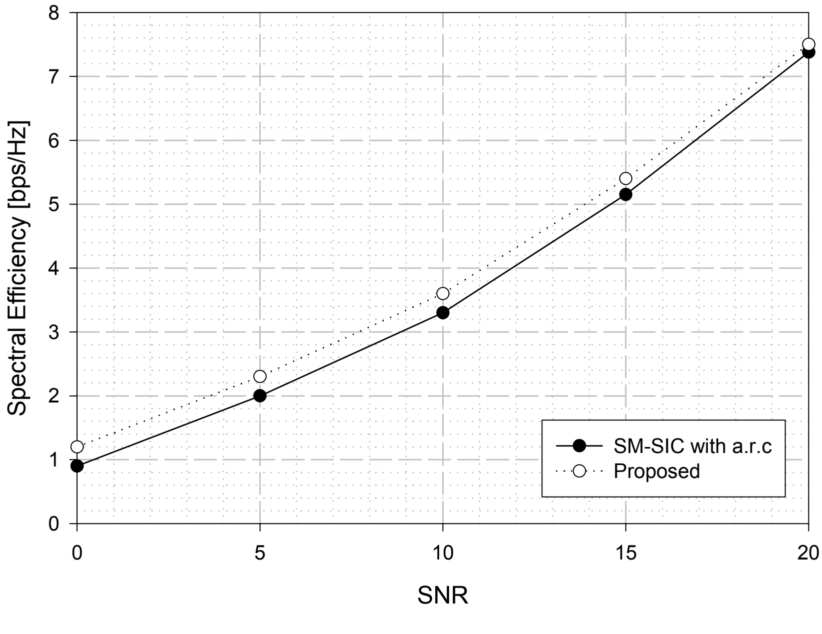

Fig 2. Capacity comparison between proposed scheme and SM-SIC with antenna rate control at the transmitter when $n_T = n_R = 2$ (Angular spread = 5^o).

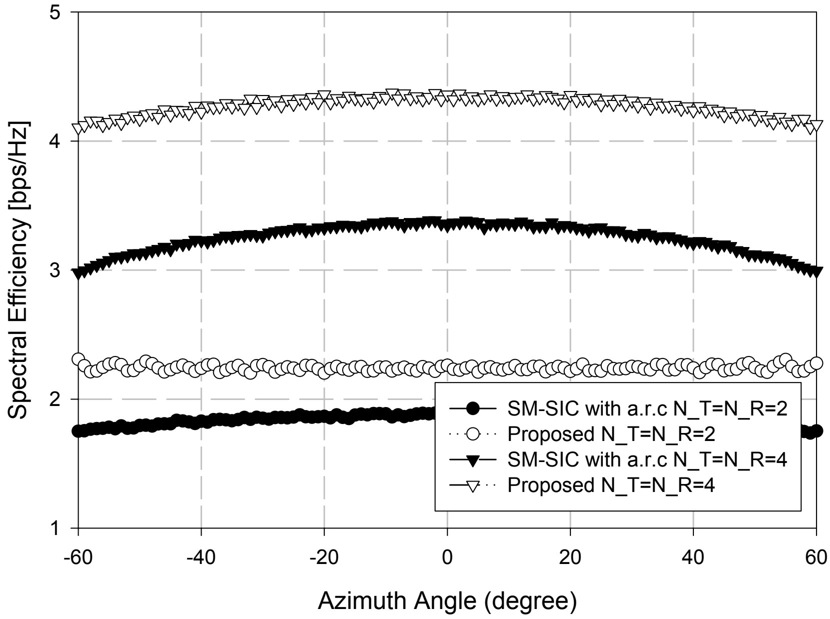

Fig 3. Effect of fixed beamforming on the rate at 10dB SNR in correlated channels.

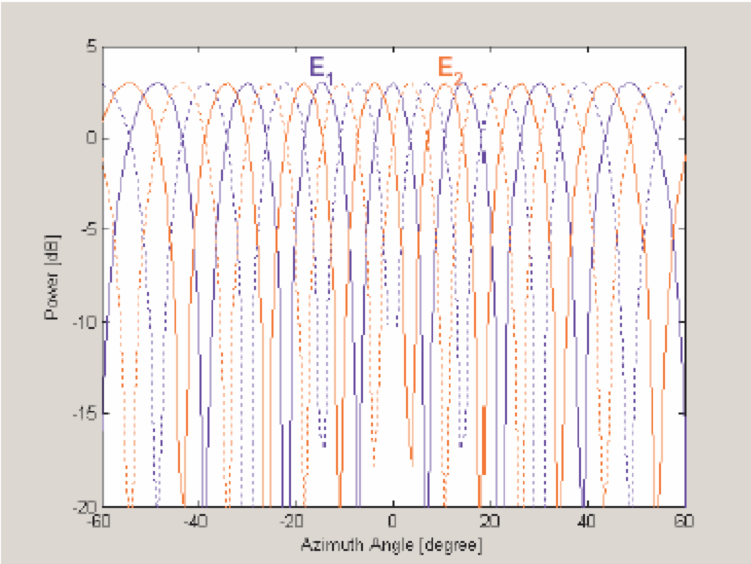

Fig 4. Beam Pattern of Common Basis

5. Specific Text Changes

8.4.8.3.6 MIMO Precoding

TBD by Closed loop MIMO Harmonization Group

References:

[1] IEEE P802.16-REVd/D5-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems