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A Review of MC-CDMA System STBC B-STTC Site Diversity Techniques

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ABSTRACT: **The combination of multiple antennas and multi-carrier code division multiple access (MC-CDMA) is a strong candidate for the downlink of future mobile communications. The advancement of such systems, in scenarios that model real life transmissions is an additional step towards an optimised achievement. Nevertheless, when transmitting over fading channel, multi-cell interference occurs and this degrades the performance of the system. Site diversity technique is applied to the system to overcome multi-cell interference. Due to non orthogonality of spreading codes multi-cell interference is not completely eradicated. To overcome this problem, space time block code (STBC) based space time trellis code (STTC) site diversity technique was introduced to reduce multi-cell interference. In this paper, balanced STTC (B-STTC) based STBC site diversity is proposed to further improve the performance of MC-CDMA system by mitigating multi-cell interference and is extended to STBC based B-STTC site diversity technique. Simulation result shows that STBC based B-STTC site diversity outperforms B-STTC based STBC site diversity technique.**

Index Terms: MC-CDMA, B-STTC based STBC, STBC based B-STTC, site diversity

I. INTRODUCTION

Broadband wireless access for evolving mobile internet and multimedia services are driving a surge of research on future wireless communication systems to support multi-user access and high data rates. Multi-carrier code division multiple access (MC-CDMA), which suits high data rate applications with multiplexing technique appears to be a promising technique in achieving high data rates [1]. MC-CDMA is robust to multi-path fading, inheriting the advantages of conventional CDMA where frequency diversity can be achieved in a broadband channel [2]. With its capability of synchronous transmission, MC-CDMA is suitable for downlink of cellular communication systems [3]. The challenge of achieving reliable data transmission over wireless link is more difficult due to the fact that received signals from multi-path add destructively causing multi-cell interference which results in serious performance degradation. To achieve reliable communication over wireless links antenna diversity [4] derived by employing spatially separated antennas at the transmitter and receiver was introduced. High data rate MC-CDMA systems additionally employ multiple input multiple output (MIMO) [5] techniques to mitigate fading.

Data transmission involves spreading operations by the use of short channelisation code and long scrambling code. Short channelisation code helps in separating the signals of different users present within the cell and long scrambling code mitigates the effects of interference produced by users belonging to other cells. However, the system faces multi-cell interference due to fading channel resulting in degradation of bit-error rate (BER).

Site diversity technique has been proposed for realising CDMA and orthogonal frequency division multiplexing (OFDM) systems to minimise multi-cell interference [5-7], where STBC is used to gain diversity effect among several base stations. STBC site diversity system transmits the encoded signals from several base stations and these signals are combined at the receiver with STBC decoding operation. STBC branches and the scrambling codes are assigned to each base station to maintain orthogonality of signals between the cells and to reduce interference among them. The same technique is extended to MC-CDMA system. However, the scrambling codes assigned are generally non orthogonal among cells and hence multi-cell interference still exists. Using STBC with multiple antennas at each base station, site diversity was achieved with further reduction in multi-cell interference [8]. STBC does not provide coding gain and in view of this it is worthwhile to consider a joint design of error control coding, modulation, transmit and receive diversity to develop an effective signalling scheme called space time trellis code (STTC), which combats the effects of fading [9]. STTC became extremely popular as it can simultaneously offer coding gain with spectral efficiency and full diversity over fading channels. STTC was used to obtain site diversity with multiple antennas at base station and it outperformed STBC based site diversity in terms of error rates [10]. A new class of 4-phase shift keying (4-PSK) STTC using points of constellation with same probability called as balanced STTC (B-STTC) [11] was proposed.

B-STTC with equal probable of constellation points achieves reduced error rate [11] and it is used to achieve site diversity for MC-CDMA system to enhance its performance. STBC based STTC codes [12] built with set partitioning [13], achieves more diversity gain and achieves better error rates and improves the performance of MC-CDMA system. To further enhance the performance of MC-CDMA system, in this work, B-STTC based STBC site diversity is proposed and analysed. The use of B-STTC in STTC based STBC reduces the error rate and pave way for improvement in performance. Furthermore, it is extended to STBC based B-STTC to attain site diversity.

II. B-STTC BASED STBC SITE DIVERSITY TECHNIQUE FOR MC-CDMA SYSTEM

B-STTC based STBC site diversity is proposed to improve the performance of MC-CDMA system in multi-path fading environment. B-STTC based STBC code exploits diversity gain and channel efficiency simultaneously without aggravating a bandwidth expansion similar to STTC based STBC codes, with decreased error rate in view of the fact that B-STTC is used in replacement to STTC block.

Fig. 1 represents the block diagram of B-STTC based STBC site diversity transmitter for MC-CDMA system with M_T transmitting antennas. The input symbol vectors are modulated by a B-STTC and STBC encoder and transmitted as in conventional MC-CDMA system. The receiver model provided for STBC site diversity [8] can be used here as it involves normal STBC decoding operation.

In the transmitter, input bits are fed to the encoder with the help of memory less source $S_R = \{0, 1\}$ with equally probable symbols [11], the modulation for a given state is denoted as

$$X = (x_1, x_2, \ldots\ldots, x_u)^T \in Z_4^{i_T} \quad (1)$$

where $Z_4^{i_T}$ represents the index of quadrature phase shift keying (Q-PSK) symbols at transmitting antenna of the shift register realized by $(v + 1)$ blocks of u bits and $x_1\ x_2, \ldots, x_u$ are the modulated symbols. The B-STTC generated by the STTC encoder with Q-PSK is given by

$$F = S_B\, X \quad (2)$$

where S_B is the generator matrix given by

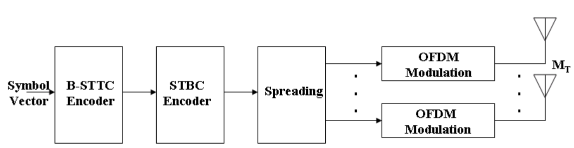

Fig. 1. Block diagram of B-STTC based STBC site diversity transmitter for MC-CDMA system.

$$S_B = \begin{pmatrix} s_{1,1}^1 \ldots s_{u,1}^1 \ldots s_{1,v+1}^1 \ldots s_{u,v+1}^1 \\ s_{1,1}^2 \ldots s_{u,1}^2 \ldots s_{1,v+1}^2 \ldots s_{u,v+1}^2 \\ s_{1,1}^{M_T} \ldots s_{u,1}^{M_T} \ldots s_{1,v+1}^{M_T} \ldots s_{u,v+1}^{M_T} \end{pmatrix} \quad (3)$$

For three transmit and receive antenna case, the encoder with a help of three constellation symbols s_1, s_2 and s_3 generates blocks $s_1, s_2, s_3, -s_1^*, s_2^*$ and $-s_3^*$. Signal s_1 is transmitted from first antenna, s_2 is transmitted from second antenna and s_3 is transmitted from third antenna at time $t = 1$. Signals $-s_1^*$, s_2^* and $-s_3^*$ are transmitted from first, second and third antenna respectively at time $t = 2$.

Assuming that the fading remains constant, the received signals from three different antennas are denoted as

$$\begin{aligned} y_1 &= h_1 s_1 + h_2 s_2 + h_3 s_3 + n_1 \\ y_2 &= -h_1 s_1^* + h_2 s_2^* - h_3 s_3^* + n_2 \\ y_3 &= h_1 s_1 - h_2 s_2^* + h_3 s_3 + n_3 \end{aligned} \quad (4)$$

where

h_1, h_2 and h_3 are the path gains modelled as independent samples of a zero mean complex Gaussian random variable

n_1, n_2 and n_3 are random Gaussian variables with zero mean and variance σ^2.

The receiver generates soft estimates with the assistance of perfect channel state information (CSI) [10] as follows

$$\begin{aligned} \tilde{s}_1 &= h_1^* y_1 + h_2 y_2 + h_3 y_3^* \\ &= \left(|h_1|^2 + |h_2|^2 + |h_3|^2\right) s_2 + h_1^* n_1 + h_2 n_2 + h_3 n_3^* \\ \tilde{s}_2 &= h_2 y_1 + h_1 y_2^* + h_3^* y_3 \\ &= \left(|h_1|^2 + |h_2|^2 + |h_3|^2\right) s_3 + h_2 n_1 + h_1 n_2^* + h_3^* n_3 \\ \tilde{s}_3 &= h_3 y_1^* + h_2 y_2 + h_1^* y_3 \\ &= \left(|h_1|^2 + |h_2|^2 + |h_3|^2\right) s_1 + h_3 n_1^* + h_2 n_2 + h_3^* n_3 \end{aligned} \quad (5)$$

With the first transmitted symbol s_1, the Viterbi decoder builds the following metric for the branch symbol s_{M_R}, as given below

$$m_e(\tilde{s}_1, s_{M_R}) = \left(|h_1|^2 + |h_2|^2 + |h_3|^2\right)\left|s_{M_R}\right|^2 + d_e^2(\tilde{s}_1, s_{M_R})$$

$$m_e(\tilde{s}_2, s_{M_R}) = \left(|h_1|^2 + |h_2|^2 + |h_3|^2\right)\left|s_{M_R}\right|^2 + d_e^2(\tilde{s}_2, s_{M_R}) \quad (6)$$

$$m_e(\tilde{s}_3, s_{M_R}) = \left(|h_1|^2 + |h_2|^2 + |h_3|^2\right)\left|s_{M_R}\right|^2 + d_e^2(\tilde{s}_3, s_{M_R})$$

where m_e denotes the metric of the soft estimates associated with s_{M_R}

M_R is the number of receiving antennas

$d_e^2(\tilde{s}_1, s_{M_R})$, $d_e^2(\tilde{s}_2, s_{M_R})$ and $d_e^2(\tilde{s}_3, s_{M_R})$ are the Euclidean distance obtained from $(\tilde{s}_1, s_{M_R})(\tilde{s}_1, s_{M_R})^*$, $(\tilde{s}_2, s_{M_R})(\tilde{s}_2, s_{M_R})^*$ and $(\tilde{s}_3, s_{M_R})(\tilde{s}_3, s_{M_R})^*$ respectively

Performance of the system with B-STTC based STBC site diversity under fading channel remains constant for two consecutive symbol transmission periods, $2T_p$. Analysis of the system is carried out through the decoding data E obtained from the maximum likelihood decoder in the receiver when the coded sequence S is transmitted. S and E are defined as

$$\begin{aligned} S &= [s_1, s_2, -s_2^*, s_1^*, \ldots, s_{2T_p-1}, -s_{2T_p-1}^*, s_{2T_p-2}^*] \\ E &= [e_1, e_2, -e_2^*, e_1^*, \ldots, e_{2T_p-1}, -e_{2T_p-1}^*, e_{2T_p-2}^*] \end{aligned} \quad (7)$$

where e_1 and e_2 are the decoded data of the symbols s_1 and s_2

The error probability approximation is obtained as

$$P_e(S \to E | h_1, h_2) = \exp\left\{-\frac{E_s}{4\sigma^2}\sum_{r_x=1}^{2T_p-2}\left\{\begin{matrix}\left[|s_l - e_l|^2 + |s_l - e_{l+1}|^2\right] \\ \left[|h_1|^2 + |h_2|^2\right]\end{matrix}\right\}\right\} \quad (8)$$

where

l is the symbol duration

T_p is the symbol transmission period

E_s is the average energy of the signal constellation

For an independent Rayleigh fading distribution of $r_a M_R$ and $|h_1|$ with probability density of $P(|h_1|) = 2|h_1|\exp\left(-|h_1|^2\right)$,

$$\begin{aligned} P_e(S \to E) &\le E\prod_{l=1}^{2T_p-2}\exp\left\{-\frac{E_s}{4\sigma^2}\left[|s_l - e_l|^2 + |s_l - e_{l+1}|^2\right]\left[|h_1|^2 + |h_2|^2\right]\right\} \\ &= \prod_{l=1}^{2T_p-2} E_O\left(\exp\left\{-\frac{E_s}{4\sigma^2}\left[|s_l - e_l|^2 + |s_l - e_{l+1}|^2\right]\left|h_{1,M_R}\right|^2\right\}\right) \end{aligned} \quad (9)$$

With the aid of equation (8), the error event probability, the coded sequence S is decided to E and is expressed as

$$\begin{aligned} P_e(S \to E) &\le \left(\prod_{l=1}^{r_a}\left[|s_l - e_l|^2 + |s_l - e_{l+1}|^2\right]\right)^{-M_R}\left(\frac{E_s}{4\sigma^2}\right)^{-r_a M_R} \\ &= \left(\prod_{l=1}^{r_a}\left[|s_l - e_l|^2 + |s_l - e_{l+1}|^2\right]^{1/r_a}\right)^{-r_a M_R}\left(\frac{E_s}{4\sigma^2}\right)^{-r_a M_R} \end{aligned} \quad (10)$$

where

r_a is the rank of the coded matrix

$r_a M_R$ is the diversity gain

$\prod_{l=1}^{r_a}\left[|c_l - e_l|^2 + |c_l - e_{l+1}|^2\right]^{1/r_a}$ is the coding gain

By this method B-STTC based STBC site diversity technique is realised for the system which obtains coding gain without provoking bandwidth expansion.

III. STTC BASED STBC SITE DIVERSITY TECHNIQUE FOR MC-CDMA SYSTEM

Fig. 2 depicts the block diagram of STBC based B-STTC site diversity transmitter for MC-CDMA system and the receiver can utilise STTC site diversity [10] technique. STBC based B-STTC codes are similar to STBC based STTC codes with balanced constellation points in STTC block. Like STBC based STTC codes, STBC based B-STTC codes are also built by set partitioning. The goal of set partitioning is to achieve better coding gain and is obtained through pair-wise distance. As STBC based B-STTC codes have equally probable constellation points at the decoder it reduces the error rate compared to B-STTC based STBC codes.

For STBC codes, the determinant criterion defines the pair-wise distance which is used to establish the partitioning rules. If the transmission matrix of space time code is denoted as $c_1 = G(s_1, s_2)$, $D_f(c_1, c_2) = G(s_1, s_2) - G(s_1', s_2')$ represents the difference of the transmission matrices for codewords c_1 and c_2, the diversity is defined by the minimum rank of the matrix $D_f(c_1, c_2)$. The minimum of the determinant of the matrix $B(c_1, c_2) = D_f^H(c_1, c_2)D_f(c_1, c_2)$, where $D_f^H(c_1, c_2)$ is the Hermition difference of the transmission matrix, over all possible pairs of distinct codewords c_1 and c_2 [14] corresponds to the coding gain. Using this definition CGD between codewords (c_1, c_2) is given as

$$CGD(c_1, c_2) = D_f^2(c_1, c_2) = \det(B(c_1, c_2)) \quad (11)$$

where

$$B(c_1, c_2) = \begin{bmatrix} 2|z_1|^2 & -(z_2)(z_1)^* e^{j\beta} & (z_2)^*(z_1) \\ -(z_3)^*(z_2)e^{-j\beta} & |z_2|^2 + |z_3|^2 & (z_2)^*(z_1)e^{-j\alpha} \\ (z_3)(z_1)^* & (z_3)^*(z_1)e^{j\alpha} & 2|z_3|^2 \end{bmatrix}$$

$z_1 = s_1 - s_1'$; $z_2 = s_2 - s_2'$; $z_3 = s_3 - s_3'$

The STBC orthogonal design coupled via symbol s_2 for three transmit and receive antennas is denoted as

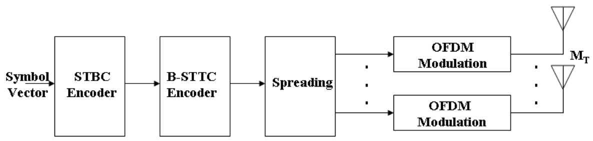

Fig. 2. Block diagram of STBC based B-STTC site diversity transmitter for MC-CDMA system.

$$G(s_1,s_2,s_3)=\begin{bmatrix} -s_2^* & s_1 & s_1^* e^{j\beta} \\ s_1^* & s_2 & -s_3^* \\ s_3^* e^{j\alpha} & s_3 & s_2^* \end{bmatrix} \quad (12)$$

where $s_1^* e^{j\beta}$ and $s_3^* e^{j\alpha}$ enable to optimise the minimum CGD within each obtained coset, angles (α,β) belong to the constellation symbol and are used to separate the triplets of symbols which share the same second symbol.

The set partitioning for Q-PSK constellation is obtained through the mathematical expression given by

$$\det(B(c_1,c_2)) = |z_1|^4 |z_3|^2 + |z_1|^2 |z_3|^4 - 2\,\mathrm{Re}\left[(z_3^*)^3 (z_1)^3 e^{j(\alpha-\beta)} \right] \quad (13)$$

The choice of (α,β), which maximises the minimum CGD within each coset, is sampled at a rate $\pi/16$. However, the obtained values for (α,β) does not correspond to Q-PSK constellation points [15] and this necessitates the need for constellation expansion to use set partitioning with maximum of minimum CGD values. Applying set partitioning for 16 cosets gives a minimum CGD values of 128 and without constellation expansion [16], using set partitioning for the same number of cosets gives minimum CGD of 8 with $(\alpha,\beta)=(0,0)$.

A simple STBC structure is used to derive a set partitioning rule. This structure will be a basis to obtain a powerful quasi orthogonal structure which will be incorporated into a trellis. The STBC matrix looks like

$$G(s_1,s_2,s_3) = \begin{bmatrix} -s_2^* & s_1 & 0 \\ s_1^* & s_2 & -s_3^* \\ 0 & s_3 & s_2^* \end{bmatrix} \quad (14)$$

The computation of the determinant of matrix $B(c_1,c_2)$ with $s_1 = e^{jp_1\omega}$, $s_2 = e^{jp_2\omega}$, $s_3 = e^{jp_3\omega}$ and $s_1' = e^{jq_1\omega}$, $s_2' = e^{jq_2\omega}$, $s_3' = e^{jq_3\omega}$ where $p_1, p_2, p_3, q_1, q_2, q_3$ are the integers, and yields the following expression

$$\det(B(c_1,c_2)) = 64\,\sin^2\left(\frac{|q_2-p_2|}{2}\omega\right) \left(\sin^2\left(\frac{|q_1-p_1|}{2}\omega\right) + \sin^2\left(\frac{|q_2-p_2|}{2}\omega\right) + \sin^2\left(\frac{|q_3-p_3|}{2}\omega\right) \right)^2 \quad (15)$$

where $\omega = 2\pi / P_c$ (P_c is the size of the transmit constellation) and $\omega = \pi/2$ for a Q-PSK constellation. Equation (15) clearly implies that symbols s_1 and s_1'; s_2 and s_2'; s_3 and s_3' have to be different in each coset to maintain a non-null CGD.

After the set partitioning step, a trellis is built affecting a particular STBC from a set of possible candidates to transitions originating from a state. The coding gain is optimised within each coset by maximising the distance between codewords. A design with full diversity is needed to use STBC code given in equation (14) into a STTC design and in fact, achieving full diversity is equivalent to showing the determinant of matrices $B(c_1,c_2)$ are nonzero over all possible codewords c_1 and c_2. As it is the case, matrices $B(c_1,c_2)$ should be checked that they do not loose the full rank value when c_1 and c_2 belong to different cosets. To solve this unit transform matrices Θ are assigned to each state to check that the minimum of det($B(c_1,c_2)$) is equal to zero when c_1 belongs to coset 1 and c_2 belongs to coset 2. In fact, unitary matrix Θ_j corresponds to a rotation and preserves distance among the constellation points i.e., the minimum CGD value is left unchanged by applying a unitary transform Θ_j to $G(s_1,s_2,s_3)$ within each coset. Search for unitary matrices are done using parameter isation [17], and along with the selected partitioning level, unit matrices whose number equal to the number of cosets with maximum separation distance are obtained. The trellis is evenly built by affecting a unitary matrix transform to each coset with each of them corresponding to a trellis state and is transmitted.

Assuming Rayleigh fading channel between each pair of transmit and receive antenna, the received signal is given as

$$Y = H\Theta_j G(s_1,s_2,s_3) + N \quad (16)$$

where
H is the channel coefficient
Θ_j is the 3 x 3 unitary matrix used in state j
N is the vector of additive white Gaussian noise (AWGN) with zero mean and variance σ^2

Received signal within three successive time slot intervals, is given by

$$
\begin{aligned}
y_1 &= -h_1 s_2^* + h_2 s_1^* + h_3 s_3^* e^{j\alpha} + n_1 \\
y_2 &= h_1 s_1 + h_2 s_2 + h_3 s_3 + n_2 \\
y_3 &= h_1 s_1^* e^{j\beta} - h_2 s_3^* + h_3 s_2^* + n_3
\end{aligned}
\quad (17)
$$

To compute branch metrics for different symbol triplets, auxiliary quantities are obtained as below

$$
\begin{aligned}
y_1' &= y_1 - h_3 s_3^* e^{j\alpha} \\
y_2' &= y_2 - h_3 s_3 \\
y_2'' &= y_2 - h_1 s_1 \\
y_3' &= y_3 - h_1 s_1^* e^{j\beta}
\end{aligned}
\quad (18)
$$

The decoding signal is obtained through combining [18] with equations (17) and (18) and is given by

$$
\begin{aligned}
y_1^* h_2^j + h_1^* y_2' &= \left(|h_1|^2 + |h_2|^2\right) s_1 + n_2 h_1^* + n_1^* h_2 \\
-y_1^* h_1^j + h_2^* y_2' &= \left(|h_1|^2 + |h_2|^2\right) s_1 + n_2 h_2^* - n_1^* h_1 \\
y_3^* h_3 + h_2^* y_2'' &= \left(|h_2|^2 + |h_3|^2\right) s_2 + n_2 h_2^* + n_3^* h_3 \\
-y_3^* h_2 + h_3^* y_2'' &= \left(|h_2|^2 + |h_3|^2\right) s_3 + n_2 h_3^* - n_3^* h_2
\end{aligned}
\quad (19)
$$

Summing the above equation yields

$$
\begin{bmatrix} y_1^* h_2 + y_2 h_1^* \\ -y_1^* h_1 + 2 y_2 h_2^* + y_3^* h_3 \\ -y_3^* h_2 + y_2 h_3^* \end{bmatrix} =
$$

$$
\begin{bmatrix} |h_1|^2 + |h_2|^2 & 0 & h_3 h_1^* + h_2 h_3^* e^{-j\alpha} \\ h_1 h_2^* + h_3 h_1^* e^{-j\beta} & |h_1|^2 + 2|h_2|^2 + |h_3|^2 & h_3 h_2^* + h_1 h_3^* e^{-j\alpha} \\ h_1 h_3^* + h_2 h_1^* e^{-j\beta} & 0 & |h_2|^2 + |h_3|^2 \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}
$$

$$
+ \begin{bmatrix} n_1^* h_2 + n_2 h_1^* \\ -n_1^* h_1 + 2 n_2 h_2^* + n_3^* h_3 \\ -n_3^* h_2 + n_2 h_3^* \end{bmatrix}
\quad (20)
$$

IV. PERFORMANCE ANALYSIS

The proposed site diversity for MC-CDMA system is simulated using MATLAB and the simulation parameters are given in Table 1. Fig. 3 shows the symbol error rate (SER) performance with bit energy to the spectral noise density (E_b/N_0) of the system with and without diversity under Rayleigh fading channel.

The diversity technique uses two antennas at the transmitter and receiver terminal. The result indicates that when multiple antennas are used there is an improvement error rate and hence the performance of the system increases due to the exploitation of diversity in the transmitter and receiver.

Table 1: Parameters.

Parameters	Descriptions
Modulation	4-PSK
Symbol length	64
Number of sub-carriers	128
Channel estimation	Perfect estimation
Channelisation code	Walsh-Hadamard code of length 63
Scrambling code	Random code of length 63
Channel	Rayleigh fading channel with AWGN floor
Number of antennas	Two, three, four and five

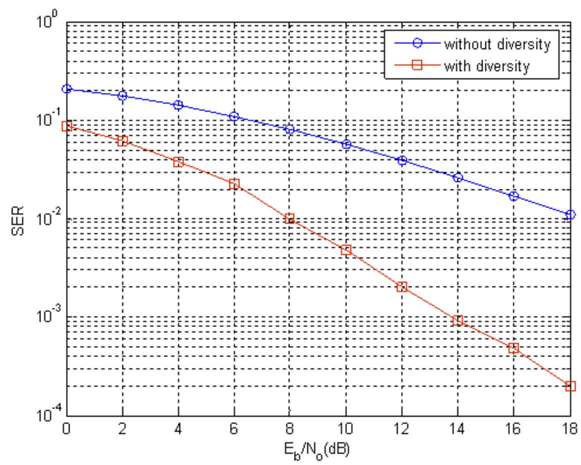

Fig. 3. Performance of the system with and without diversity.

Performance of MC-CDMA system with STBC based STTC site diversity is evaluated by varying the transmitting and receiving antennas. Fig.4 illustrates the performance of the system in terms of SER and E_b/N_0 with STBC based STTC site diversity for two, three, four and five transmit and receive antennas. It is observed from the plots that the system with five transmit and receive antennas gives better performance in SER when compared to the system with two, three and four antennas. The improvement in SER for the larger number of antennas is due to the maximum utilisation of diversity. The maximum number of antennas used for simulation is restricted to five as further increase of it introduces hardware complexity and increases the cost of the system.

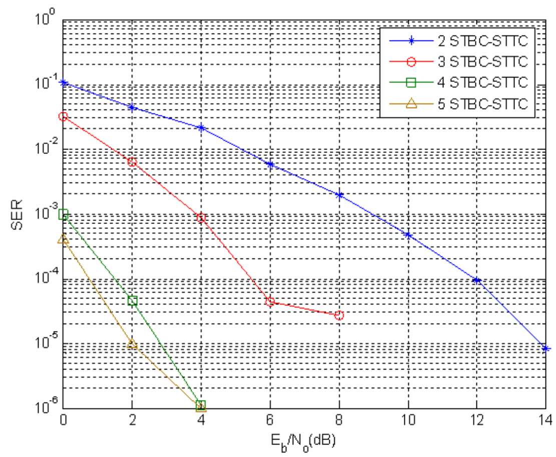

Fig. 4. Performance of the system with STBC based STTC site diversity for various antennas.

Fig.5 depicts SER versus E_b/N_0 performance of the system with B-STTC based STBC site diversity for various numbers of antennas. The result portrays that the SER of the system with five transmit and receive antennas outperforms two, three and four transmit and receive antennas. Fig.6 renders the same scenario of the system with STBC based B-STTC site diversity for different antennas. Similar conditions of diversity utilisation observed in Fig.4 and 5 are noticed here irrespective of the coding techniques used for site diversity technique i.e. improvement of SER is noticed clearly when there is increase in number of antennas.

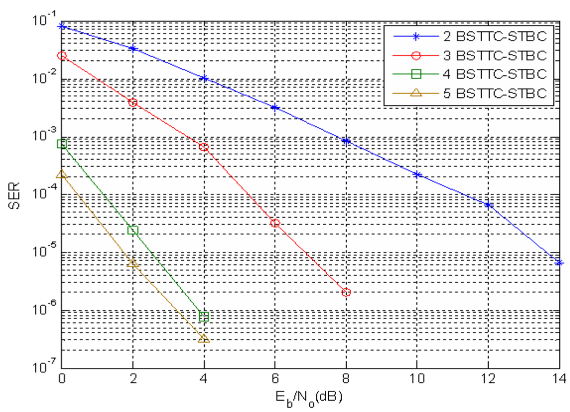

Fig. 5. Performance of the system with B-STTC based STBC site diversity for various antennas.

The SER performance of STBC based STTC site diversity is compared with the B-STTC based STBC site diversity in Fig.7.

It is clearly visible from this figure that B-STTC based STBC site diversity technique outshines STBC based STTC site diversity technique of the system.

B-STTC based STBC site diversity uses balanced codes in STTC encoder block which reduces the error rate when compared to STBC based STTC site diversity technique.

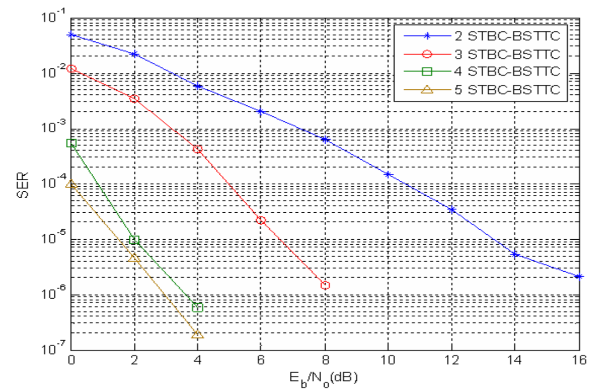

Fig. 6. Performance of the system with STBC based B-STTC sitediversity for various antennas.

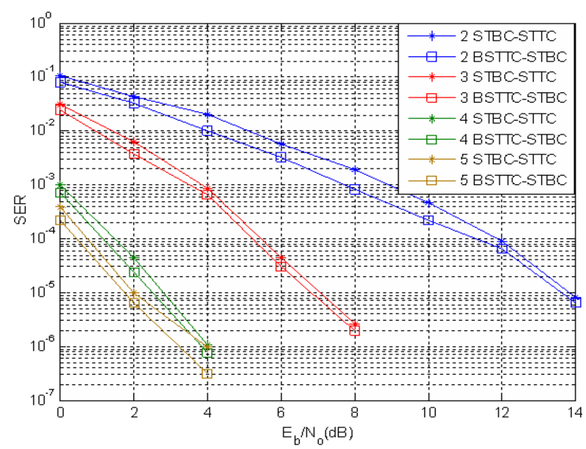

Fig. 7. Performance comparison of the system with STBC based STTC and B-STTC based STBC site diversity techniques for various antennas.

SER performance of the system is compared between B-STTC based STBC site diversity technique and STBC based B-STTC site diversity technique and is depicted in Fig.8. This figure clearly portrays that STBC based B-STTC site diversity technique surpasses B-STTC based STBC site diversity technique. As the STBC based B-STTC codes are transmitted in STTC form and moreover in balanced manner (equal probability of constellation points), significant improvement in error performance is achieved.

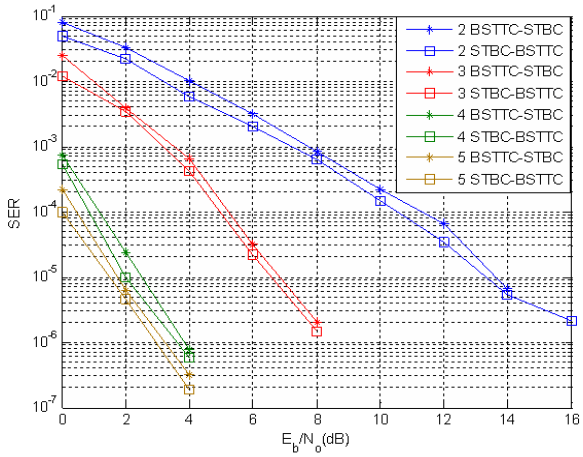

Fig. 8. Performance comparison of the system with STBC based STTC and B-STTC based STBC site diversity techniques for various antennas.

V. CONCLUSION

Site diversity scheme for MC-CDMA system is proposed using B-STTC based STBC and STBC based B-STTC to improve the performance of mobile terminals in the downlink in this paper. These methods considerably minimise multi-cell interference by jointly consuming the diversity gain and coding gain. With STBC based B-STTC site diversity technique, the performance of MC-CDMA system achieves better reduction in error rates as the transmitted codes are balanced one. Also, simulation results shows that STBC based B-STTC site diversity outperforms STBC based STTC and B-STTC based STBC site diversity techniques in terms of SER and is best opted for MC-CDMA system.

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