Differential Space Time Frequency Codes with Multiplexing Demultiplexing in OFDM for wireless communication

SardarKhame Singh[1], Dr. Shah Aqueel Ahmed[2]
[1]*Research Scholar, Dept. of Electronics, Rayalaseema University, Kurnool, AP, India*
[2]*Principal, MaulanaMukhtar Ahmad Nadvi Technical Campus, Malegaon, Dist. Nasik, INDIA*

Abstract**—**Multiple-input multiple-output (MIMO) exposurealgorithms have the immensesignificance for high-performance mobilecommunications and future waveforms need to be MIMO capable.MIMO decoders have been conferred thatcan surpass Orthogonal Frequency Division Multiplexing(OFDM) in intensely frequency-selective channels in-forms ofcoded frame error rate (FER). This paper proposes space time frequency coding method with multiplexing de-multiplexing (STFC-MDX)for MIMO OFDM systems. In general coherent detection, channel estimation requires huge number of symbols for transmission in space time frequency(STF) due to which efficiency of bandwidth reduces. The proposed system for MIMO OFDM systems will increases the efficiency of bandwidth. The proposed STFC-MDXs are derived both multiplexing and de-multiplexing algorithms for 64 QAM (quadrate amplitude modulation). The simulation outcome shows that the use of STFC-MDXs can improve the performance of coherent STF bit error. The performance of STFC-MDXs is better than STF even in the absence of channel state information.

Keywords**—***OFDM, Fading Channels, Space Time Frequency, QAM, STFC-MDX*

I. INTRODUCTION

The major driver for broadband wireless communicationshas been reliable high-data-rate services (e.g., real-timemultimedia services). These, together with the scarcity of bandwidth resources, provoke research toward implementationof adequatecoding and modulation schemes that advances the quality andbandwidth efficiency of wireless systems. In wireless links,multipath fading creates performance decline and constitutesthe congestion for growing data rates. Generally,the most popular technique to combat fading has been theexploitation of diversity.Space-time (ST) coding has been proved effective in combatingfading, and enhancing data rates; see e.g., [6], [11],and references therein. Exploiting the presence of spatial diversityoffered by multiple transmit and/or receive antennas, STcoding relies on simultaneous coding across space and time toachieve diversity gain without necessarily sacrificing preciousbandwidth. Two typical examples of ST codes are ST trelliscodes [19] and ST block codes [18], [16]. In ST coding, the maximumachievable diversity advantage is equal to the product of the number of transmit and receive antennas; therefore, it is constrainedby the size and cost a system can afford. The latter motivesfor exploitation of extra diversity dimensionslike multipathdiversity.Multipath diversity becomes available when frequency selectivityis present, which is the typical situation for broadbandwireless channels [6]. Among them, [5] and [8] rely oncombining ST codes with redundant or non-redundant linear pre-coders.Maximum diversity gain is achieved in [5] and [8] atthe expense of bandwidth efficiency [5] or increased decodingcomplexity [5], [8]. On the other hand, [7], [9], [3], [15], and[14] are based on space-frequency (SF) coding, which amountsto simultaneously coding over space and frequency. However,due to the prohibitive complexity in constructing the codes, noSF codes have been designed in [17], [9], [15], or [10]. Instead,[17], [20], [15], and [10] simply adopt existing codes [ST blockcodes in [15] and trellis-coded modulation (TCM) codes in [17],[20], [15], [10], without maximum diversity gain guarantees.In [3], an SF code is proposed to achieve maximum diversitygain at the expense of bandwidth efficiency. Moreover, issuespertaining to maximizing the coding gain of ST-coded transmissionsover frequency-selective channels have yet to be addressed.Focusing on multi-antenna orthogonal frequency-divisionmultiplexing (OFDM) transmissions through frequency-selectiveRayleigh fading channels, this paper pursues a novel path:joint space-time-frequency (STF) coding over space, time, andfrequency. Resorting to sub-channel grouping [14], [7], [12]and by choosing proper system parameters, we first divide theset of generally correlated OFDM sub-channels into groups ofsub-channels. We thus convert our system into a set of what weterm group STF (GSTF) subsystems, within which STF codingis considered. By deriving design criteria for STF codes, weprovide a link between STF codes and existing ST codes.

II. SPACE TIME FREQUENCY CODED OFDM SYSTEM

We consider a STF-coded MIMO-OFDM system with M_t transmit antennas;$M_r$receive antennas and N sub carriers. Suppose that the frequency selective fading channels between each pair of transmit and receive antennas have L independent delay paths and the same power delay profile. The MIMO channel is assumed to be constant over each OFDM block period, but it may vary from one OFDM block to another. The Space Time Frequency (STF)coding scheme [1] [20] [21] [13] is used to improve thesystem performance by taking advantage of diversity in space, time and frequency inherence inMIMO-OFDM system. In the STF coded OFDMsystem the input data sequence is convolutionencoded and interleaved by a block interleaver.After the symbol mapping is performed by themodulator, the tones enter the STF encoder andthen are applied to OFDM transmitters of thedifferent antennas. Each antenna of the OFDMsystem consists of M subcarriers. The M tones ateach antenna are passed through Inverse FastFourier Transform blocks (IFFT) with a cyclicprefix added to each of the signal components. Toavoid the inter-symbol interference, the guard timeis chosen to be longer than the channel delayspread. The resultant signal is frequency up convertedto the desired transmission frequency andtransmitted through the wireless channel. The coderate of the STF encoder is p/n where the encodertakes p sequences of M tones and outputs nsequences of M tones.

A. *Design of STF coding*

In this section, we will derive design criteria for our STFcoding while keeping in mind the importance of simplifying thecode design as much as possible without sacrificing system performance.Our derivations are based on the following assumptions.

- Maximum likelihood (ML) detection is performedwith channel state information (CSI) that is known at thereceiver. CSI can be acquired either via preamble trainingor via inserted pilots, as in [15] and [2].
- High SNR is observed at the receiver.
- The $N_t(L+1)\times 1$ channel vector $h_v = [h_{1v}^T, \dots, h_{N_t v}^T]^T$is zero-mean, complex Gaussian with full-rank correlation matrix$E(h_v h_v^{\mathcal{H}}) = (1/L+1)R_h$.

However, $h_v s$for different are statistically independent,which can be satisfied by well separating the multiplereceive antennas.Notice that in as3) allows for correlated wireless channeltaps with, e.g., an exponential power profile. However, as weprove later, our design of STF coding will turn out to be independentof as long as has full rank. Note that channel taps are assumed independent in [21], [4], and[10], which is quite idealistic for frequency-selective channels.The noise isassumed to be fading channel while being additive.Suppose (s_1, s_2) represent a set of 2 consecutivesymbols in the input data stream to be transmitted.During the first symbol period t_1, T_x antenna 1transmits symbol s_1 and T_x antenna 2 transmitssymbols_2.Next, during second symbol periodt_2,T_x antenna 1 transmits symbol s_2* and T_x antenna2 transmits symbols_1*. Let h_1 be the channelresponse from T_x antenna 1 to the receiver and $h_2$be the channel response from T_x Antenna2 to thereceiver.

a) Case 1:- 2T_x antennas, 1 R_x antennas

The received signal sampler$r_1$and r_2 correspondto symbol periods$t_1$and t_2.

$$r_1 = h_1 s_1 + h_2 s_2 + n_1 \quad (1)$$

$$r_2 = h_1 s_2^* - h_2 s_1^* + n_2 \quad (2)$$

Where $n_1$and n_2 are the noise terms.

The receiver does the following computations to estimate $s_1$and s_2.

$$x_1 = h_1^* r_1 + h_2 r_2^* = (|h_1|^2 + |h_2|^2)s_1 + h_1^* n_2 - h_2 n_2^* \quad (3)$$

$$x_2 = h_2^* r_1 + h_1 r_2^* = (|h_1|^2 + |h_2|^2)s_2 + h_2^* n_1 - h_1 n_2^* \quad (4)$$

b) Case2: 2 T_x antennas, 2R_x antennas for receiver antenna 1

$$r_{11} = h_{11} s_1 + h_{12} s_2 + n_{11} \quad (5)$$

$$r_{12} = h_{21} s_2^* + h_{22} s_1^* + n_{12} \quad (6)$$

For receiver antenna 2

$$r_{21} = h_{21} s_1 + h_{22} s_2 + n_{21} \quad (7)$$

$$r_{22} = h_{21} s_2^* + h_{22} s_1^* + n_{22} \quad (8)$$

Receiver estimates the symbols s1 and s2 using

$$x_1 = h_{11}^* r_{11} - h_{12} r_{12}^* + h_{21}^* r_{21} - h_{22} r_{22}^* = (|h_{11}|^2 + |h_{12}|^2 + |h_{21}|^2 + |h_{22}|^2)s_1 + h_{11}^* n_{11} - h_{12} n_{12}^* + h_{21}^* n_{21} - h_{22} n_{22}^* \quad (9)$$

$$x_2 = h_{12}^* r_{11} - h_{11} r_{12}^* + h_{22}^* r_{21} - h_{21} r_{22}^* = (|h_{11}|^2 + |h_{12}|^2 + |h_{21}|^2 + |h_{22}|^2)s_2 + h_{12}^* n_{11} + h_{11} n_{12}^* + h_{22}^* n_{21} - h_{21} n_{22}^* \quad (10)$$

These equations clearly show that the receiver fully receives the fourth order diversity of 2*2Systems. The primary aim of using multiple antennas is to reduce the bit error rate.

III. PROPOSED FRAMEWORK

STFC-MDX system is not essential channel estimation symbols for transmission is depicted in Figure.1, two novel blocks are introduced one is multiplexing and demultiplexing. These two novel blocks are transparent if the constant envelop modulation schemes are used, but in DCM scheme the novel blocks are not transparent. Multiplexing is the process in which data streams, coming from different sources, are combined and transmitted over a single data channel. It is done by equipment called Multiplexer. It is placed at the transmitting end of the communication link. At the receiving end, the composite signal is separated by equipment called Demultiplexer. The demultiplexer performs the reverse process of multiplexing and routes the separated signals their corresponding destination.

The process of proposed system starts from MIMO nodes it showing in Figure.1. Here initial transmission occurs then goes for OFDM system, in this divide the channels into sub channels. Consider the data and divide into multiple units. In this particularly space time frequency coding applicable and multiplexing the data. Here transmission over multiple sub channels based on system performance. The receiving side of system de-multiplexing the data and improves the system level.

A. 64-QAM Modulation

The proposed algorithm is the technique used to develop the power and capacity of the mobile communication system. Quadrature amplitude modulation is a modulation having two carriers shifted by 90 degrees in phase is modulated and the ensuing output consists of phase variations and amplitude. In R-array QAM, the data bits opt for amplitude and phase shifts, one of R combinations that are apply to the carrier. 64-QAM modulation is having 6bits per symbol. Diversity techniques are the efficient way for combating channel fading and improve reliable system.

TABLE I. DIFFERENCE BETWEEN BPSK, QPSK, 8PSK, 16QAM, 32QAM, 64QAM

Modulation (R)	**Symbol rate**	**BER**
BPSK	1/1 bit rate	1
QPSK	½ bit rate	2
8PSK	1/3 bir rate	3
16QAM	¼ bit rate	4
32QAM	1/5 bi rate	5
64QAM	1/6 bit rate	6

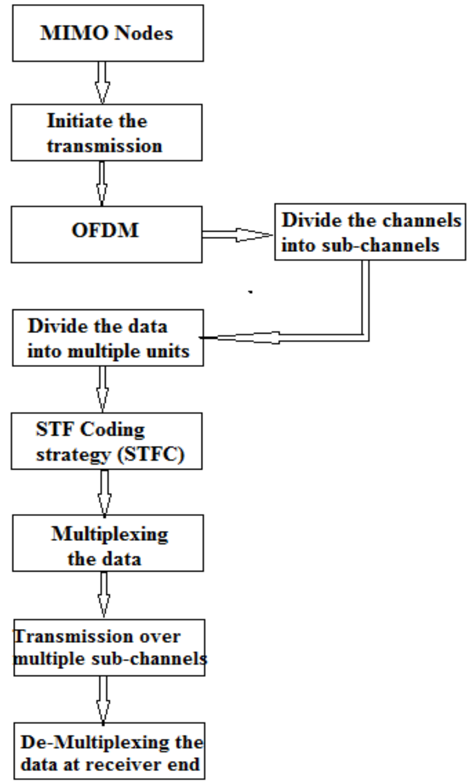

Fig. 1. Proposed Flowchart

The combination with limited interleaving and channel coding will provide time diversity. Various replicas of the transmitted signal are spaced in time and the time spacing among transmissions exceeds the coherence time of the channel.

B. Steps of process in modulation

The number of points in the constellation is defined as $R=2^b$ where b is the number of bits in each constellation symbol. In this analysis, it is desirable to restrict b to be an even number for the following reasons:

- Half of the bits are represented on the real axis and half the bits are represented on imaginary axis. The in-phase and quadrature signals are independent $b/2$ level pulse amplitude modulationsignals.
- For decoding, symbol decisions may be applied independently on the real and imaginary axis, simplifying the receiver implementation.

$$\alpha_{RQAM} = \{\pm(2r-1) \pm (2r-1)j\} \quad (11)$$

Where $r \in \{1, \dots, \frac{\sqrt{R}}{2}\}$, for 64QAM change the value based on 'R'

IV. SIMULATION ENVIRONMENT

The simulation process starts with the network process with OFDM system. Here MIMO nodes indicate how to request for a channel and share the data with possible ways support of methodology. The process of simulation begins through some parameters and library files with object files. The simulation carried out in a network simulator (NS2). Here AODV protocol used and compares STF with STFC-MDX.

In this paper, we can simulate the process of network should be taking as different objects and library files support of effective protocol and shows the process is good way. Here we can compare different systems like Space time(ST), Space frequency(SF), Space time frequency coding(STFC) and Space time frequency coding with multiplexing de-multiplexing. We compare these all but performance wise STFC-MDX is more efficient than remaining three.

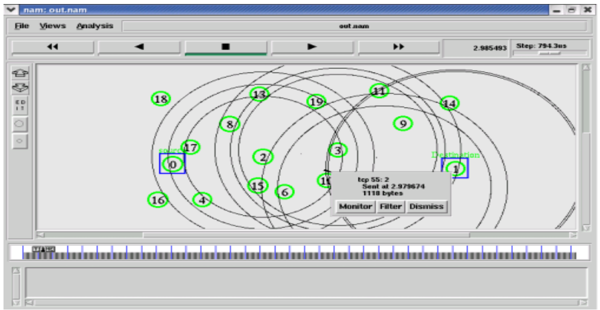

Fig. 2. Multiple data transmitting through TCP

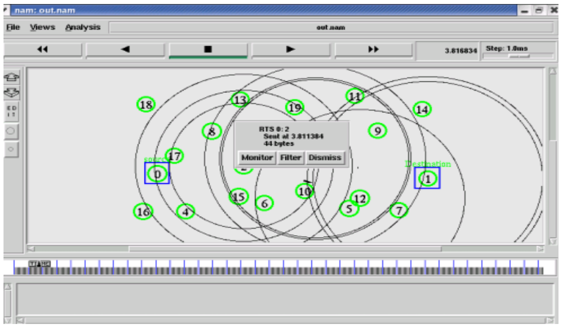

Fig. 3. Request send information fromsource to detstination

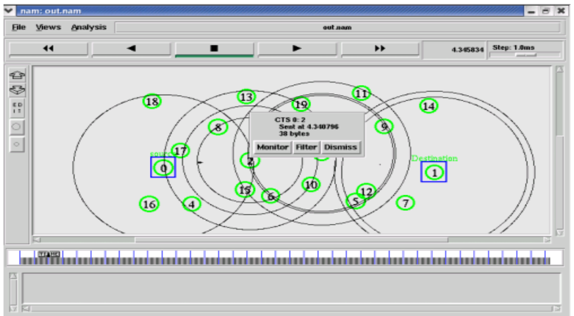

Fig. 4. Clear to send information from source to destination

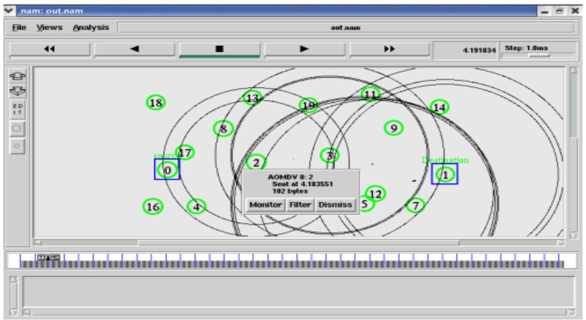

Fig. 5. Data send through multiple routings based on AOMDV

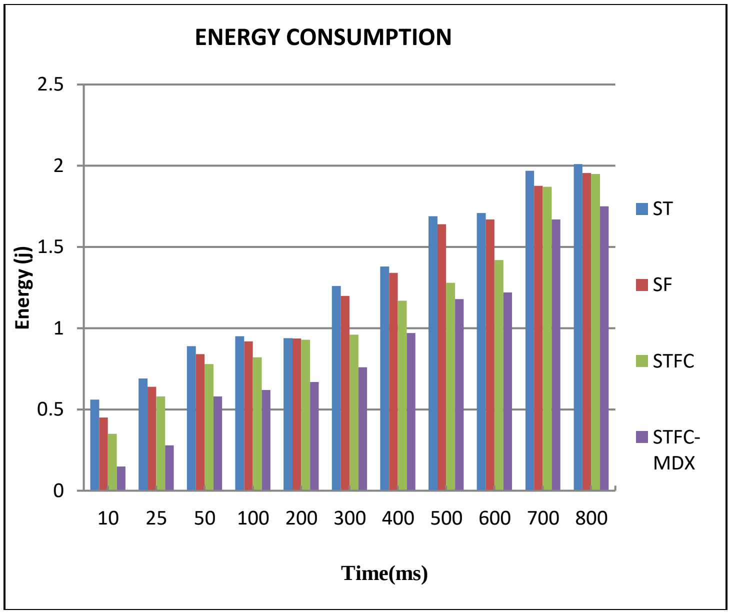

Fig. 6. Energy Consumption

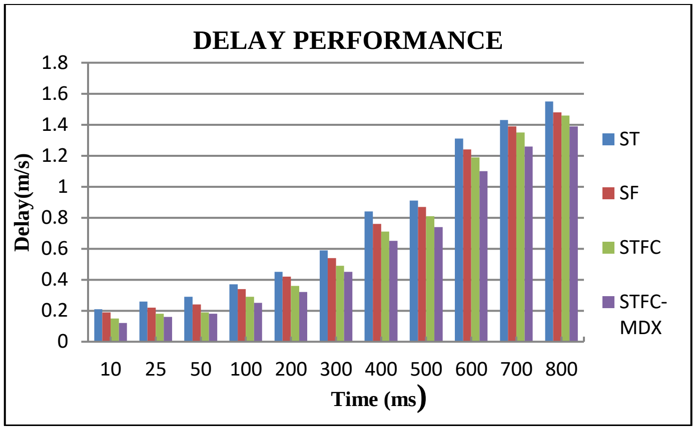

Fig. 7. Delay Performance

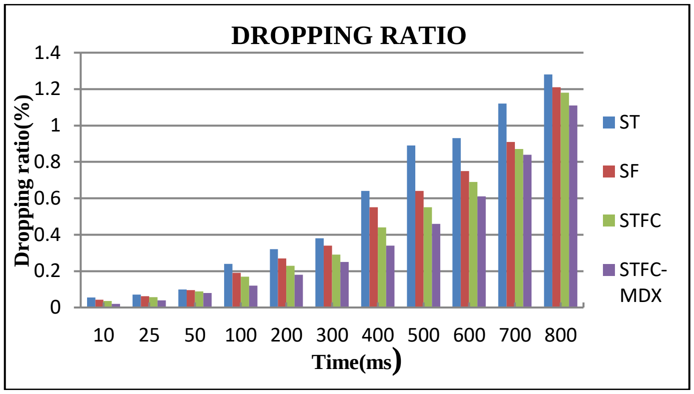

Fig. 8. Dropping Ratio

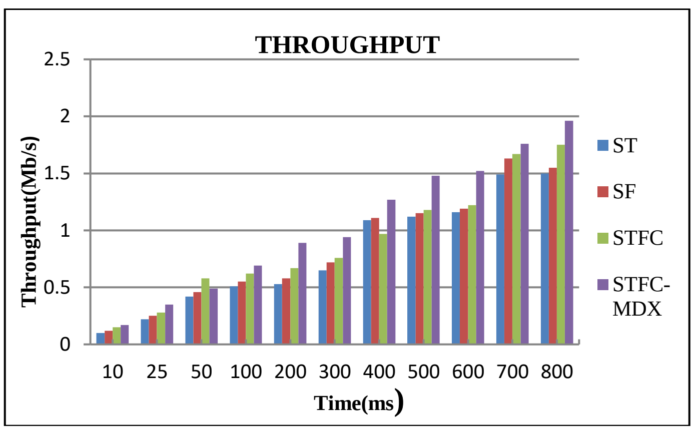

Fig. 9. THROUGHPUT

To evaluate the proposed approach compare with existing approach, four performance metrics are considered in the experiments: 1) Energy consumption: Individual energy levels of node calculate based on time interval. 2) Delay: The nodes travelling some distance based on time functionality. 3) Packet dropping ratio: how much data loss in network process based on communication levels and 4) Throughput: total data transmission based on simulation time by measuring the bit per sec process. Figure (6), (7), (8), and (9) represents the energy consumption, delay, packet dropping ratio, and throughput parameters with respect to time.

These graphs measure the system process and compared with the existing algorithm and showed that our proposed system has more effective performance than STFC.

TABLE I. SIMULATION TABLE

Parameter	Value
Application traffic	FTP
Transmission rate	15packets/sec
Radio range	250m
Packet size	1024bytes
Channel date rate	20Mbps
Maximum speed	50m/s
Simulation time	800ms
Number of nodes	20
Area	500x500
Methods	STFC,STFC-MDX
Routing protocol	AOMDV

V. CONCLUSION

In this paper designing of STF codes for multiantenna OFDM transmissionsover frequency-selective Rayleigh fading channels are described. The scheme of STF coding can be extremely usefulfor transmitting information which needs highsecurity. This scheme has a very high potentialcommercially, because of the security and high datarates which will serve the interests of the futuremobile customers who demand high bandwidths.MIMO scheme is used to provide high capacitywith the same bandwidth.Space time frequency coding method with multiplexing de-multiplexing (STFC-MDX) based on 64-QAM for OFDM communications have been used effectively for increasing the system bandwidth efficiency. Without any increase of total transmission power this development is achieved. The performance of wireless communication systems can be improved significantly by adopting space time frequency coding technique with multiplexing de-multiplexing. The proposed STFC-MDX principle may be applied to further wireless systems such as Wi-Max-MIMO.

VI. REFERENCES

[1] Zhiqiang Liu, Yan Xin and Georgios B. Giannakis,"Space-time-frequency coded OFDM over frequency-selective fading channels", Vol.50.pp. 1053-587, Oct. 2002.

[2] S. Ohno and G.B. Giannakis, ‘Optimal training and redundant precoding for block transmissions with application to wireless OFDM,” IEEE Trans. Commun. 2002. To be published.

[3] H. Bolcskei and A. Paulraj, “Space-frequency codes for broadband fading channels,” in Proc. IEEE Int. Symp. Inform. Theory, Washington, DC, June 2001.

[4] Y. Liu, M. P. Fitz, and O. Y. Takeshita, “Space-time codes performance criteria and design for frequency selective fading channels,” in Proc. Int. Conf. Commun. Helsinki, Finland. June 11-15-2001, pp. 2800-2804.

[5] Z. Liu and G.B. Giannakis, “Space-time block coded multiple access through frequency-selective fading channels,” IEEE Trans. Commun, vol.49,pp. 1033-1044, June 2001.

[6] Z. Liu, G.B. Giannakis, B. Muquet, and S. Zhou, “Space-time coding for broadband wireless communications, “ Wireless Syst. Mobile Comput., vol. 1, no. 1,pp.33-53, Jan-Mar. 2001.

[7] Z. Liu, Y. Xin, and G.B. Giannakis, Linear constellation precoding for OFDM with maximum multipath diversity and coding gains.” In Proc. 35th Asilomar Conf. Signals, Syst., Comput,. Pacific Grove, CA, Nov 4-7,2001, pp. 1445-1449.

[8] S. Zhou and G.B. Giannakis,”Space-time coding with maximum diversity gains over frequency-selective fading channels,” IEEE Signal Processing Lett., vol. 8, pp. 269-272, Oct. 2001.

[9] H. Bolcskei and A. Paulraj, “Space-frequency coded broadband OFDM systems, “ in Proc.of Wireless Commun Networking Conf., Chicago, IL, Sept. 23-28. 2000.pp. 1-6.

[10] B. Lu and X. Wang, “Space-time code design in OFDM systems,” in Proc, Global Telecommun. Conf., vol.2. San Francisco, CA. NOV-Dec. 27-1, 2000, pp. 1000-1004.

[11] A.F. Naguib, N. Seshadri, and R. Calderbank, “Increasing date rate over wireless channels,” IEEE Signal Processing Mag., vol. 17, pp. 76-92, May 2000.

[12] Z. Wang and G.B. Giannakis, “Wireless multicarrier communications: Where fourier meets Shannon,” IEEE Signal Processing Mag., 17, pp. 29-48, May 2000.

[13] Vn Nee Richard, Prasad Ramjee. OFM for Wireless Multimedia Communications, Artech House, Boston 2000.

[14] D.L. Goeckel,”Coded modulation with nonstandard signal sets for wireless ofdm systems,” in Proc.Int,Conf,Commun, Vancouver, BC, Canada, June 1999, pp.791-795.

[15] Y. Li, J.C. Chung, and N.R. Sollenberger, “Transmitter diversity for OFDM systems and its impact on high-rate data wireless networks,” IEEE J. Select. Areas Commun, vol.17,pp.1233-1243, July 1999.

[16] V. Tarok, H. jafarkhani, and A.R. Calderbank, “Space-time block coes from orthogonal designs, “IEEE Trans. Inform. Theory, vol. 45, pp. 1456-1467, July 1999.

[17] D. Agarwal, V. Tarokh, A. Naguib, and N. Seshadri, “Space-time coded OFDM high data-rate wireless communication over wideband channels,” in Proc. Veh. Technol. Conf., Ottawa, ON, Canada, May18-21, 1998, pp. 2232-2236.

[18] S.M. Alamouti, “A simple transmit diversity technique for wireless communications, “IEEE J. select areas Commun. Vol.116,pp. 1451-1458, Oct. 1998.

[19] V. Tarokh, N. Seshadri, and A.R. Clderbank, “Space-time codes for high data rate wireless communication: performance criterion and code construction,” IEEE Trans. Inform. Theory, vol.44, pp. 744-765, Mar, 1998.

[20] Vahid Trokh, Nambi Seshadri, Calderbank. Space time codes for high data rate wireless communication; Performance criterion and code construction. IEEE Transaction on Information theory 1998:44:744-765.

[21] SM Alamouti. A simple transmitter diversity scheme for wireless communication. IEEE Journal on selected Areas in communication 1998: 16:1451-1458.