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Analysis of Space Time Codes Using Modulation Techniques

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Abstract: *In this Paper, Analysis of channel codes for improving the data rate and reliability of communication over fading channels using multiple transmit antennas has been considered. The codes, namely 'Space Time Codes' render full diversity and amend coding gain. Performance criteria for designing such codes, under this assumption that the fading is slow and nonselective frequency, is also analysed. Under this research, Study of Frame Error Rate(FER) and outage capacity is compared for different no. Of transmit and receive antennas as well as for different modulation techniques. According to theoretical results FER decreases with increasing SNR and No. Of receiving antennas. Numerical and practical result shows that FER decreases with increasing SNR and no. Of receiving antennas.*
Keywords*: Space time Block Codes ,Space time trellis Codes,Frame Error Rate(FER),Outage capacity,Pairwise Error Probability*

I. Introduction

The next generation of broadband wireless communication systems is expected to pro- vide users with wireless multimedia services such as high speed Internet access, wire- less television and mobile computing. The rapidly growing demand for these services is driving the communication technology towards higher data rates, higher mobility, and higher carrier frequencies that are needed to enable reliable transmissions over mobile radio channels. But fading is main concern with this problem as radio eave propagates from transmittiong antenna nad travel through different paths and having absorption,diffraction,scattering and many more problems.The main need of wireless communication is high speed at high data rate services.This galvanize the researchers toward developing efficient coding
Schemewhich enhance the quality and bandwidth efficiency of broadband wirelss services.For this zpurpose Space Time codes are adequate for neglecting the fading effect by using multiple transmitters and multiple recivers antennas.[2][3].
Space time codes are of two types[1]
1.Space Time Block Code(STBC)
2. Space time trellis Code (STTC)
Recently transmit diversity has been studied[1]. Fer and Outage capacity is also compared for N=2 and M=1,5.[4]

The main objective of this paper is to study the STTC for transmission using multiple antennas and compare the performance of STTC in terms of FER keeping power spectral efficiency and no. Of trellis fixed.Also compare the FER and outage Capacity for different no. Of transmitters and different no. Of receivers (more than 5).using different modulation techniques.
The outline of this Research paper is as follows. In Section II,we provide System Model of space for multiple antenna systems.In section III Block diagram of STBC and STTC is explained.PEP and Fer is studied in Section IV.Then Outage Capacity is explained In Section V.In Section VI ,FER and Outage capacity is analyzed with N=2,and M=6,8,10 and 12 for 4-PSK and 8-PSK.In Last Section VII reprents our conclusion and future scope.

II. System Model-Space Time Coding

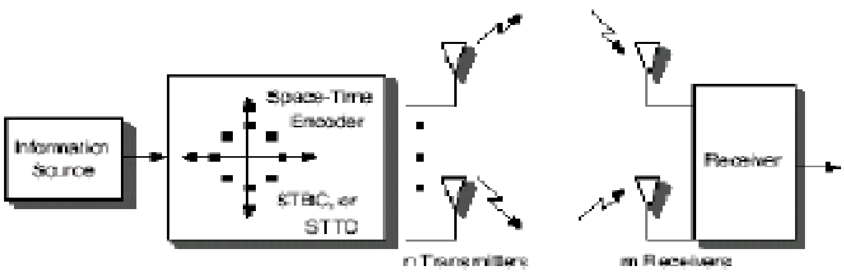

Figure1: System Block Diagram

Consider a mobile communications system where the base station is equipped with n with m receive antennas at each time slot t, signals c_t^i, $i =$ antennas and the remote unit is equipped $1, 2, ., n$ are transmitted simultaneously from the n transmit antennas. The channel is flat-fading and the path gain from transmit antenna i to receive antenna j is denoted by h_{ij}. The path gains are modeled as samples of independent complex Gaussian random variables with variance 0.5 per real dimension, i.e., $h_{ij} \sim N$ (0, 1), as we assume that signals received at different antennas experience independent fading. In this report, we will consider modelling the path gins in slow Rayleigh fading. For slow fading, it is assumed that the path gains are constant during a frame of length L and vary from one frame to another, i.e., channel is *quasi-static*.

At time t, the signal r_t^j received at antenna j is given by

$$r_t^j = \sum_{i=1}^{n} h_{ij} c_t^i + \eta_t^j \qquad \text{...........1}$$

where the noise samples η_t^j are zero mean complex Gaussian with variance

$$\sigma^2 = \frac{1}{(2E_s/N_o)} = \frac{1}{2SNR} \qquad \text{..........2}$$

per dimension. The average energy of the symbols transmitted from each antenna is normalized to one, so that the average power of the received signal at each receive antenna is n.
It is assumed that channel state information is only available at the receiver, who uses it to compute the decision metric

$$\sum_{t=1}^{l} \sum_{j=1}^{m} \left| r_t^j - \sum_{i=1}^{n} h_{ij} c_t^i \right|^2 \qquad \text{........3}$$

over all code words $c_1^1 c_1^2 \cdots c_1^n c_2^1 \cdots c_2^n c_l^n \cdots c_l^n$ and decide in favor of the code word that minimizes the sum.

III. Block diagram STBC

In 1998, Alamouti proposed a simple transmit diversity scheme [5], which improves the signal quality at the receiver on one side of the link by simple processing across two transmit antennas at the opposite end.

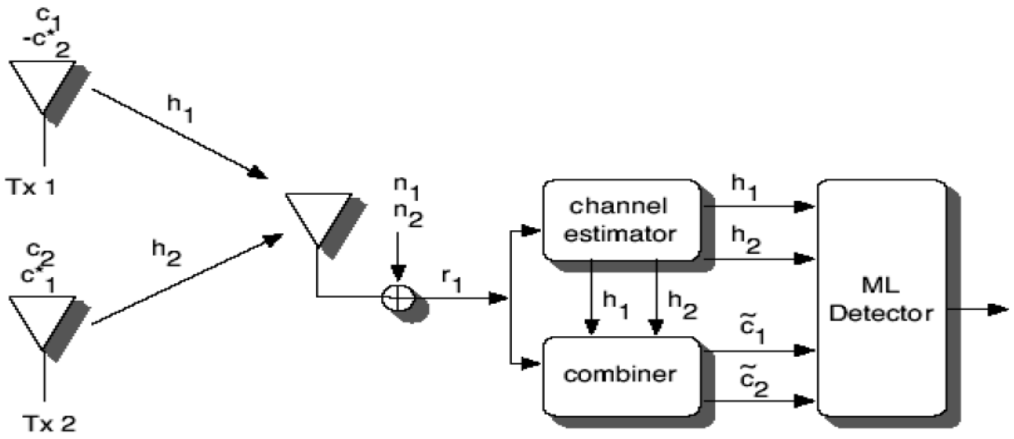

Fig. 2 Two transmit Diversity Scheme

At a given symbol period, two signals are simultaneously transmitted from the two antennas, namely c_1 from the first antenna, Tx1, and c_2 from the second antenna, Tx2. In the next symbol period, signal $-c_2^{?}$ is transmitted from Tx1 and signal $c_1^{?}$ is transmitted from Tx2, where ? denotes complex conjugation.

3.2 Black Daigram STTC

Space-time trellis codes encode the input symbol stream into an output vector symbol stream. Unlike space-time block codes, space-time trellis codes map one input symbol at a time to an $M_t \times 1$ vector output. Since the encoder has memory, these vector codewords are correlated in time. Decoding is performed via maximum likelihood [6]- [7] sequence estimation.

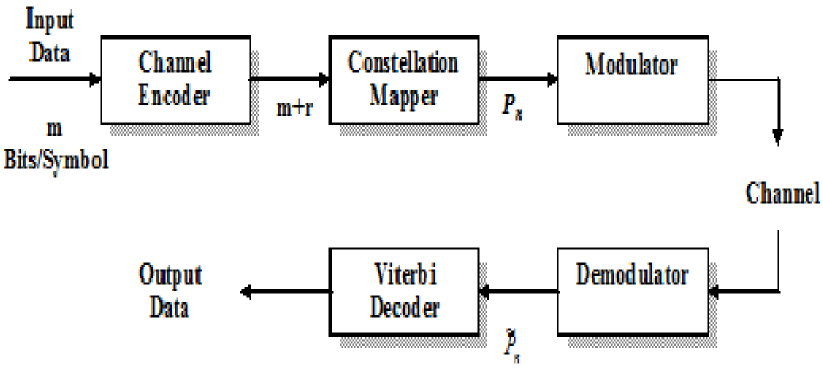

Fig.3 Block diagram of STTC

Shown above is a general block diagram for a STTC system. The input data bits coming at the rate of m bits/symbol are encoded by a channel (convolutional) encoder, to produce m + r bits which are mapped with the help of a constellation mapper to give on of the possible states of the encoder. This is then further modulated using techniques like PSK, FSK, QAM etc. and transmitted through N_t transmit antennas to the channel, where the signal gets corrupted by noise. At the receiving end, N_r receive antennas are used to receive the transmitted signal which is then demodulated and the resultant noise affected signal is feed to a Viterbi Decoder. It is a maximum likelihood (ML) decoder that gets back the original signal by construction a trellis structure. The decoder is designed such as to minimize the error due to noise or any other factors.

4.1 Pairwise error Probability(PEP)

It is assumed that each element of the signal constellation is contracted by a scale factor, chosen so that the average energy of the constellation elements is $\sqrt{E_s}$. The pairwise error probability is the probability that a maximum-likelihood receiver decides erroneously in favor of a signal.

$$e = e_1^1 e_1^2 \cdots e_1^n e_2^1 e_2^2 \cdots e_{21}^n e_3^1 \cdots e_3^n \cdots e_l^1 e_l^2 \cdots e_l^n \quad .....4$$

Assuming that

$$c = c_1^1 c_1^2 \cdots c_1^n c_2^1 c_2^2 \cdots c_{21}^n c_3^1 \cdots c_3^n \cdots c_l^1 c_l^2 \cdots c_l^n \quad ....5$$

Was transmitted.

4.2 Frame Erroe Rate(FER)

Frame error rate is the number of frame errors divided by the total number of transferred frame during a studied time interval. Ratio of data received with errors to the total data received.It is used to determine the quality of signal connection.If FER is too high connection may be dropped.

$$P(c \longrightarrow e) \leq \left[\prod_{i=1}^{r} \lambda_i\right]^{-m} (E_s/N_0)^{-rm} \quad ....6$$

This is the expression of FER.

IV. Outage Capacity

In slow fading channel, the key event of interest is outage: it is the situation when the channel is so poor that no scheme can communicate reliably at a certain fixed data rate.The largest rate of reliable communication at a certain outage probability is known outage capacity.

It is also defined [4] in terms of mutual information between input and output, I (input, output). When the output is composed of independent additive noise, and multiple of the transmitted signals, then I (input, output) = ε(output) − ε(noise). Here ε() represents entropy. Since ε(output) and ε(noise) are each expressed as the sum of N_T conditional entropies.

$$I(input, output) = \frac{1}{N_T}\sum_{i=1}^{N_T}\left[\varepsilon(output|i^{th}outcome) - \varepsilon(noise|i^{th}outcome)\right] \quad ....7$$

The Rayleigh Channel model for H ($M_R \times N_T$ channel matrix) has complex zero mean unit variance entries:

$$H_{ij} = Normal(0, 1/\sqrt{2}) + \sqrt{-1}(Normal(0, 1/\sqrt{2}) \quad ....8$$

V. Simulation and Results

In this section simulation of STTC under study is carried out using MATLAB application package.The simulation is carried out with 4-PSK and 8-PSK. The following parameters are considered:

N=2

M=6,8,10,12

Frame length=99

Frames=20

Initial SNR=1 db

After setting this configuration, FER is calculated and plotted against SNR. Then FER is compared for different no. Of transmitters and different No. Of receivers as well as for 4-PSK and 8-PSK.It has been observed that FER decreases as SNR increased and also FER decreases as rapidly as increasing No. Of receivers.FER decreases more fast for 8-PSK than 4-PSK.

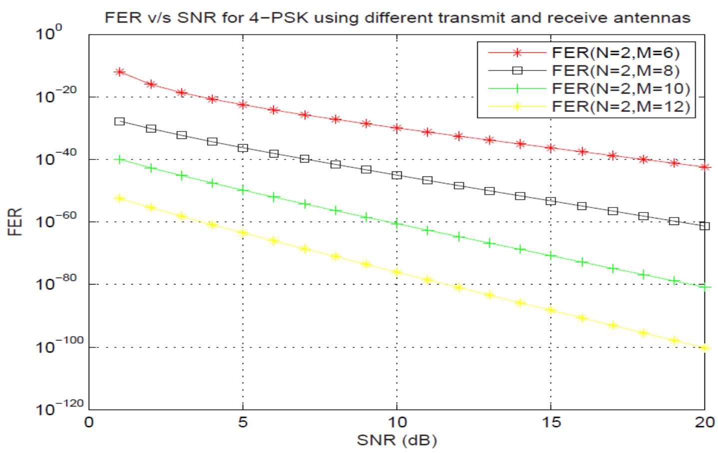

Fig 4. FERv/s SNR for 4-PSK using different no. Of Transmit and Recieve antennas

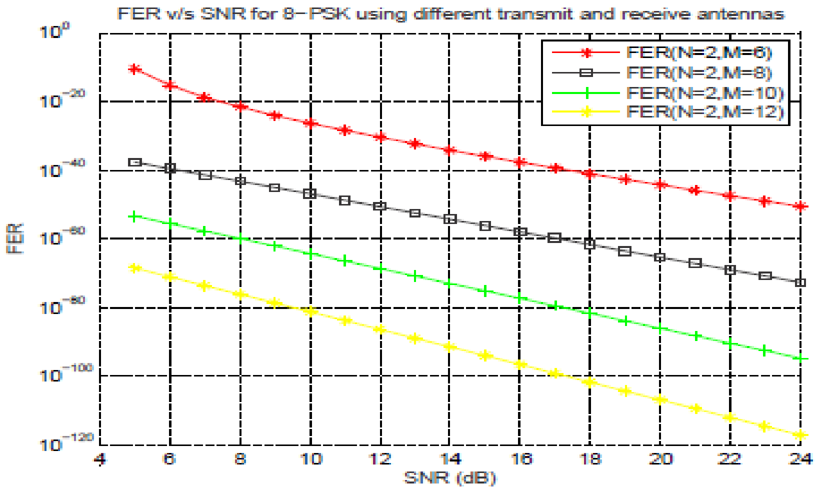

Fig 5. FER v/s SNR for 8-PSK using different transmit and receive

Outage capacity performance is plotted as a function of frame error rate (FER). Then the plot of outage capacity and frame error rate (FER) is drawn for different number of transmit and receive antenna. We repeat this experiment for N = 2 and for M = 6, 8, 10, 12. Outage Capacity increases exponentially as SNR is increased, for 2 transmit and 6 receive antennas.

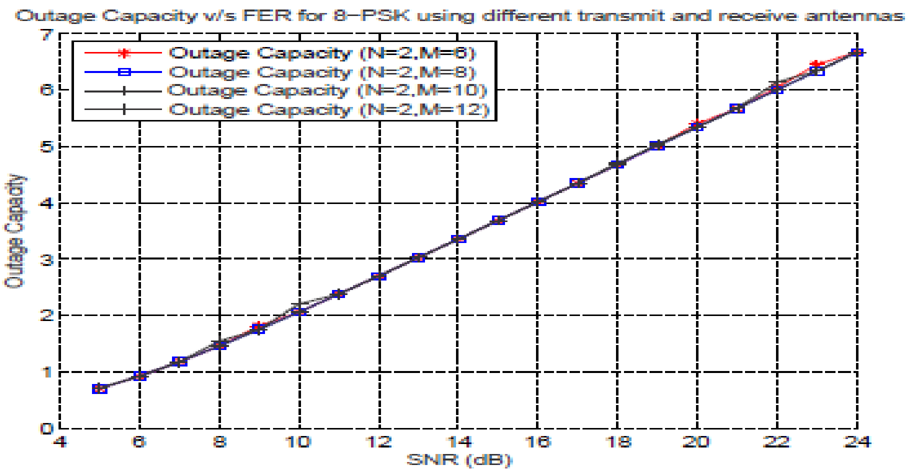

Fig. 7 Outage Capcity v/s SNR for 4-PSK using different transmit and recive antenna

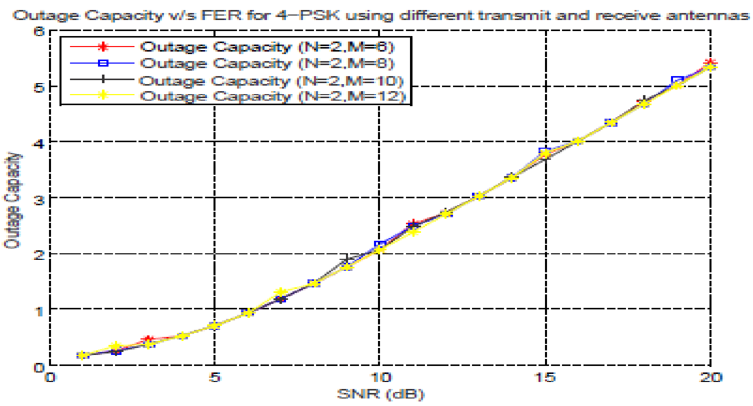

Fig. 8. Outages Capacity v/s SNR for 8-PSK using different transmit and receive antenna

VI. Conclusion

This thesis defined the analysis and evaluation of Space-Time Trellis Coding (STTC) using PSK modulation in digital communication. We provided examples of spacetime trellis codes for transmission using multiple transmit antennas. we compare the per- formance of STTC in terms of frame error rate keeping the transmit power, spectral efficiency and number of trellis states fixed. We discover that a simple concatenation of space time block codes with traditional AWGN (additive white Gaussian noise) trellis codes outperforms some of the best known space-time trellis codes at SNRs (signal to noise ratios) of interest. Our result holds for a small number of trellis states with one or two receive antennas, and is useful for the design and implementation of multiple- antenna wireless systems. But for higher number of receiver space time trellis code are used. In this thesis simulations have been conducted to study the Frame Error Rate (FER) performance and outage capacity in wireless communication for different number of transmit (N=2) and receive antennas (M=6,8,10,12) with 4-PSK and 8-PSK modulation Scheme.

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