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REVIEW OF SPACE-TIME TRELLIS-CODED OFDM SYSTEMS FOR LTE ENVIRONMENT

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Abstract— *The wireless channel suffers from attenuation due to destructive multipath in the propagation media. These forms of attenuation result in the inefficient and unreliable transmission of data over many radio channels. Some possible but non-pragmatic solutions to combat this degradation are to increase the transmission power, antenna size, or antenna height. A realistic alternative to these solutions would be to transmit some less-attenuated replica of the signal to the receiver, thereby increasing the receiver's probability of receiving a less corrupted signal. This transmission and reception scheme is called diversity, and it is the most important technique used to encounter the effects of fading in wireless communications. Space-Time Trellis Codes (STTCs) were introduced for a high data rate, bandwidth, and power-efficient communication method over wireless Rayleigh and Rician fading channels. STTCs can achieve a diversity advantage by placing the diversity burden on the BS. Hence, leaving the MS to maintain its mobility and practicality, STTCs are based on well-defined trellis structures. Therefore, they can be decoded using soft-decision decoding techniques at the receiver, such as Viterbi decoding. STTC modulations proposed a joint design of coding, modulation, and transmit diversity for flat Rayleigh fading channels. OFDM is a technique introduced for combating the effects of multipath propagation in frequency selective fading channels. In wideband wireless channels, the symbol period becomes smaller relative to the channel delay spread, and because of it, the transmitted signals experience frequency-selective fading. Therefore, it is desirable to look into the effect of frequency-selective fading.*

Keywords—OFDM, LTE, STTC, PSK, SNR etc.

1.INTRODUCTION

SPACE-TIME CODING

Space-time coding has gained much interest due to its capability of achieving better performance using transmits diversity. Transmit diversity can achieve diversity gain by transmitting from multiple spatially separated antennas. A space time code is a method employed to improve data transmission reliability in a wireless communication system using multiple antennas. The space-time codes depend on transmitting multiple, redundant copies of a data stream to the receiver, hoping that some of them may survive the physical path between the transmission and reception in a good enough state to allow reliable decoding. Several space-time coding techniques have been proposed to transmit diversity. Space-time coding techniques were used to achieve lower error rates or higher data rates in narrowband systems. The family of space-time codes mainly includes space-time block code (STBC) and space-time trellis codes. These two techniques provide diversity advantage like any well known maximal ratio receive combining (MRC) technique. Space-time block coding, a significant transmit diversity technique, was first proposed by Alamouti for flat fading channels assuming the channel was constant over an ST-code-word duration (i.e., one symbol durations or two symbol durations) and the channel state information (CSI) being known at the receiver. The Alamouti STBC is generalized for a two-input–single-output (2ISO or generally MISO) diversity system utilizing a simple maximum-likelihood (SML) detector and can obtain the full-diversity advantage. Later on, Alamouti STBC was generalized for many multiple transmitting and receiving antennas (MIMO). In space-time block code (STBC), a block of input symbols producing a matrix output over antennas and time. This technique provides full diversity with simple encoding and decoding complexity but does not provide any coding gain with full-rate space-time code. The STBC code has two important properties: each symbol is decoded separately using only linear processing, a simple decoding way. The code satisfies the rank criterion, so it provides the maximum possible diversity. In the case of space-time trellis codes (STTC), a signal input symbol produces a sequence of spatial vector outputs at a given time. STTC has the advantage that they provide diversity as well as coding gain. Tarokh first proposed STTC for two transmit antennas.

SPACE TIME TRELLIS CODES

Various techniques such as adaptive antennas and space-time processing have been studied to provide high data rate transmission while efficiently combating fading effects. Many proposals use multiple antennas at the transmitter side with appropriate signal processing and offer antenna space diversity for the downlink. Among them, space-time trellis coding is an attractive and promising solution, which achieves bandwidth-efficient transmit diversity by using specially designed channels codes at the transmitter end combined with some additional signal processing at the receiver [18]. Space-Time Trellis Coded Modulation (STTCM) is obtained by combining channel coding with the Multiple Input Multiple Output (MIMO) concept to improve the data rate and wireless communications reliability. Many performance criteria have been established to maximize both the diversity and coding gain of STTC. The rank and determinant criteria for slow fading channels and the Euclidian distance and the product distance criteria for fast fading channels [2][1]. Convolution encoders with the same structure but with different weighting coefficients are assigned to transmitting multiple branches in STTC. Therefore, the state transitions of the encoders are the same, but their outputs differ, according to the past inputs. A maximum-likelihood series estimator (i.e., a Viterbi decoder) can be applied at the receiving side.

MODULATION

The choice of modulation technique has a direct impact on the capacity of a wireless communication system. It determines the bandwidth efficiency of a single physical channel in terms of the number of bits per second per Hertz (bit/s/Hz), and it is therefore important that this choice is discussed in detail. In selecting a suitable modulation scheme for a wireless communication system, consideration must be given to achieving the following,

- High bandwidth efficiency.
- High power efficiency.
- Low carrier-to-co channel interference power ratio (in case of a cellular mobile communication system)
- Low out-of-band radiation.
- Low sensitivity to multipath fading.
- Constant or near-constant envelope.
- Low cost and ease of implementation.

Many digital modulation techniques are available and extensively used in the present wireless communication system; these include phase-shift keying (PSK/BPSK), multilevel phase-shift keying (M-ary PSK), Quadrature phase-shift keying (QPSK), Frequency shift keying (FSK/BFSK), and Quadrature amplitude modulation (QAM). But one of the most efficient modulation technique is trellis coded modulation (TCM). The TCM combines both coding and modulation to achieve significant coding gains without compromising bandwidth efficiency. The TCM scheme employs redundant non-binary modulation combined with a finite state encoder that decides the modulation signal selection to generate a coded signal sequence. It uses signal state expansion to provide redundancy for coding and design coding and signal mapping function to maximize the free distance (minimum Euclidean distance) between the coded signals directly. At the receiver, the signals are decoded by a soft decision maximum likelihood sequence decoder.

ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

Orthogonal frequency division multiplexing (OFDM) is a popular method for high data rate wireless transmission. OFDM may be combined with antenna arrays at the transmitter and receiver to increase the diversity gain and enhance the system capacity on time-variant and frequency-selective channels, resulting in a multiple-input multiple-output (MIMO) configuration. Orthogonal frequency division multiplexing (OFDM) has become a popular technique for transmitting signals over wireless channels. OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB-T), the IEEE 802.11a local area network (LAN) standard, and the IEEE 802.16a metropolitan area network (MAN) standard. OFDM is also being pursued dedicated short-range communications (DSRC) for roadside to vehicle communications and as a potential candidate for fourth-generation (4G) mobile wireless systems. OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub-channels. The subcarriers have the minimum frequency separation required to maintain their corresponding time domain waveforms' orthogonality, yet the signal spectra corresponding to the different subcarriers overlap in frequency.

3. Problem Statement

The upper layers of LTE are based upon TCP/IP, which will likely result in an all-IP network similar to the current state of wired communications. LTE will support mixed data, voice, video, and messaging traffic. LTE uses OFDM (Orthogonal Frequency Division Multiplexing) and MIMO (Multiple Input Multiple Output) antenna technologies. The higher signal to noise ratio (SNR) at the receiver enabled by MIMO, along with OFDMA and SC-FDMA (Single channel orthogonal frequency division multiple access in uplink), provides improved coverage throughput, especially in dense urban areas.

4. Proposed Algorithm

This dissertation's results are based on the M-ary PSK modulation technique over a fast Rayleigh fading channel. We have simulated the proposed approach for 2-PSK (M = 2), 4-PSK (M = 4), 8-PSK (M = 8), 16-PSK (M = 16) and the number of OFDM subcarriers are assumed to be 124. Moreover, in our result, we have considered perfect channel state information (CSI) at both transmitter and receiver so that maximum diversity is confirmed. Fig 6.1. illustrates the noise reduction in balanced STTC for OFDM based Rayleigh channel with 2-PSK modulation scheme in terms of symbol error rate (SER) and signal to noise ratio (SNR) gain while Fig 6.2., Fig 6.3.and 6.4 Represent the evaluation of same codes but with 4-PSK,8 PSK and 16-PSK modulation schemes. We simulate the result with 2 transmit and 2 receive antennas, and the decoding of the signal STTC codes are simulated by using three different decoding techniques, these are MMSE (minimum mean square error), ZF (zero forcings), and ML (maximum likelihood) using soft-decision decoding with Viterbi algorithm. Our result shows that out of these three decoding techniques, the ML decoding using the Viterbi algorithm gives a much better result than MMSE and ZF decoding. Moreover, our result shows that the 16-PSK modulation scheme can reduce more noise than 2-PSK, 4-PSK, and 8-PSK for the same codes having similar antennas and a similar bit rate.

Block Diagram of Proposed Methodology

Space-Time Trellis Coded Modulation (STTCM) is obtained by combining channel coding with the Multiple Input Multiple Output (MIMO) concept to improve the data rate and wireless communications reliability. Many performance criteria have been established to maximize both the diversity and coding gain of STTC. The rank and determinant criteria for slow fading channels and the Euclidian distance and the product distance criteria for fast fading channels. Convolution encoders with the same structure but with different weighting coefficients are assigned to transmitting multiple branches in STTC.

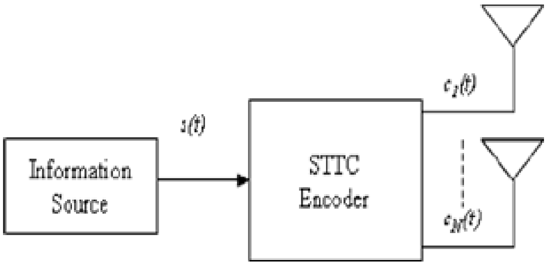

Figure 1 STTC encoder

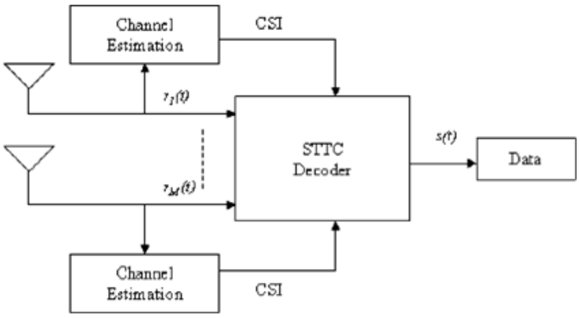

Figure 2 STTC Decoder

Conclusion

Reduced noise-based estimation schemes are widely favored as their implementation is relatively simple, and most current wireless standards already provide for their use. Training sequences for multiple transmit antennas require properties of zero (or very low) cross-correlation between sequences transmitted from different transmit antennas. Real-time optimization problem, especially for the sub-channel assignment that introduces intractable integer variables.

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