Title:

DEVELOPMENT OF ANTI-JAMMING TURBO CODED OFDM SYSTEM FOR WIRELESS COMMUNICATION UNDER OPTIMAL (PARTIAL/FULL) BAND JAMMING ENVIRONMENT

By

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ABSTRACT:

This thesis is aimed to study and develop a robust, efficient and adaptive anti-jamming (AJ) scheme for wideband noise jamming environments in wireless communication (WCM) systems. Wideband noise jamming impacts the whole spectrum of communication and requires innovative solutions that can quickly adapt to changing conditions while ensuring communication integrity and reliability. Various forms of noise jamming such as spot, sweep, multiple-tone, pulsed and partial-band noise jamming necessitate specific countermeasures. The focus of this research is on the channel coding approach along with the spatial diversity (SD) for mitigating the disruptive effect of wideband noise jamming. Particularly, this study explores the combination of Turbo coding and orthogonal frequency-division multiplexing (OFDM) as an AJ strategy which is particularly effective in high-speed WCM systems where reliable data transmission is crucial. It enhances the system's performance by providing both spectral efficiency (via OFDM) and error-correcting capabilities (via Turbo coding). Turbo codes have been reported to provide excellent error-correcting capabilities, which is vital in noisy or fading channels encountered in WCM systems. Similarly, the OFDM scheme has also been reported to be least affected by noise and interference due to the orthogonality property of its subcarriers. Therefore, by employing Turbo coding combined with OFDM, the resulting system can effectively detect and correct errors, while enhancing the overall transmission reliability and robustness of the WCM system, under wideband noise jamming environment.

Specifically, this research study proposes and investigates the bit error performance of a multi-relay distributed symmetric Turbo-coded OFDM (DSTC-OFDM) scheme in terms of its capability to reduce the bit error rate (BER) introduced by a noise jamming source. Moreover, the proposed scheme has been improved to work in coded-cooperative (CCP) WCM scenarios over the additive white Gaussian noise (AWGN) channel as well as the frequency-selective Rayleigh fading (FSRF) channel models under wideband noise jamming environment. The Turbo coded system is well-known for showing remarkable performance in a typical cooperative communication framework. Therefore, the proposed scheme based on distributed Turbo codes is efficiently implemented in the CCP WCM system. As a suitable benchmark for comparison, a conventional symmetric Turbo coded OFDM (STC-OFDM) scheme is also developed for non-cooperative (NCP) WCM system and the BER performance comparison of the proposed distributed scheme has been made with the STC-OFDM scheme to assess its effectiveness for the WCM model under the same jamming environment. In this research, binary phase-shift keying (BPSK) modulation is used as the prime modulation technique while the decoding algorithm employed is

the log maximum a-posteriori probability (Log-MAP) algorithm. In addition to BPSK modulation, both the proposed schemes have also been analyzed for higher-order modulation techniques, namely 4-QAM and 16-QAM. For both the proposed NCP and CCP WCM models, random interleaver is considered as an optimal selection for the interleaver design and soft-demodulators are used along with a joint-iterative soft-input/soft-output (JISISO) decoding technique at the destination node for the DSTC-OFDM scheme in coded-cooperation. A comparison of the BER performance of the STC-OFDM scheme in NCP WCM with the DSTC-OFDM scheme in CCP WCM over the stated models of WCM channels is also presented. The Monte Carlo simulation results show that for code rates Rc=1/3 and data frame lengths l=512, the DSTC-OFDM scheme clearly outperforms the STC-OFDM scheme by roughly a gain that ranges between 1-7 decibels (dBs) for varying jamming-to-signal ratios under the same conditions in the case of high SNR simulated region. However, in the case of the low SNR simulated region, the STC-OFDM scheme shows almost similar performance as the DSTC-OFDM scheme, under identical conditions. Moreover, the proposed DSTC-OFDM scheme is further explored in the coded-cooperation with multiple relays and the best relay selection technique under the jamming environment over a multipath FSRF channel. Furthermore, the deployment of multiple relays in the vicinity of the destination node introduces the SD which leads to the enhancement of the information reliability of the communication link and further reduction of bit errors during data transmission.

In order to further improve the BER performance under the jamming environment, the proposed STC-OFDM and DSTC-OFDM schemes are incorporated with Alamouti space-time block coding MI-MO (2×2) antennas for the NCP and CCP WCM systems respectively. The research evaluates the bit error performance of the STC-OFDM MI-MO scheme in comparison to that of the DSTC-OFDM MI-MO scheme over the specified channel models under the same circumstances and noise jamming environment. Moreover, this study conducts a comparative analysis between the two proposed MI-MO schemes and their respective single antenna counterparts. The Monte Carlo simulation results reveal that the proposed DSTC-OFDM MI-MO (CCP) scheme with Alamouti-STBC (2×2) antennas clearly outperforms the STC-OFDM MI-MO (NCP) counterpart scheme with Alamouti-STBC (2×2) antennas by roughly a gain that ranges between 0.5-6 dB under the same conditions, in the high SNR simulated region. However, in the low SNR simulated region, the STC-OFDM MI-MO scheme shows almost similar performance as the DSTC-OFDM MI-MO scheme, under identical conditions. Moreover, soft-demodulators are employed along with the JISISO MI-MO (Turbo) decoding technique at the destination node for the DSTC-OFDM MI-MO scheme incorporating STBC MI-MO (2×2) antennas in coded-cooperation. Furthermore, both the proposed MI-MO schemes with Alamouti STBC MI-MO (2×2) antennas incorporate coding gain, diversity gain and multiplexing gain under identical conditions. The bit error performance of the proposed DSTC-OFDM-MIMO scheme in coded-cooperation can be further improved by employing multiple relays which results in a further reduction of the probability of error PE. The results showed notable improvement in the link performance with the proposed schemes validating Turbo coded OFDM to be a feasible and effective AJ approach for combating the impact of wideband noise jamming in WCM systems.