Simple Interference Cancellation Technique for Multicarrier DS-CDMA

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ABSTRACT

In this article, we propose a new scheme for multi user detection (MUD) using the parallel interference cancellation (PIC) technique. This technique provides a good complexity, latency, and performance compromise. Among spread-spectrum techniques, the most popular one is the direct sequence-code division multiple access (DS-CDMA), where each active user’s data is modulated (multiplied) by a unique code. This technique is suitable for multicarrier (MC) direct sequence-code division multiple access (DS-CDMA) systems. We offer a new scheme of soft detectors whose performance is superior to that of the other famous suboptimal detectors. On each sub carrier, instead of making hard bit decisions of the other users in the current stage and regenerating and cancelling the interference signal, a weighted sum of the soft outputs of the other users in the current stage is cancelled from the soft output of the desired user. This is the input to the next stage, then at the last stage, the interference cancelled outputs from all the subcarriers are combined (maximal ratio combining) to form the decision statistics. We derived expressions for the bit error rate (BER) on Rayleigh fading channels. Analytical results are found for different stages in the proposed PIC scheme. The simulation results show that the proposed scheme offers good interference cancellation than the other filter receiver. The complexity of this scheme grows linearly with the number of users. Moreover, this scheme is much faster than other receivers such as successive interference cancellation (SIC).

Keywords: bit error rate; DS-CDMA; parallel interference cancellation

INTRODUCTION

An important aspect of the air interface of a cellular telephone system is the multiple access method. Each user of the cellular system is given a separate channel, and how they are different is determined by the multiple access method. In a cellular system employing Direct Sequence-Code Division Multiple Access (DS-CDMA), all users use the same frequency at the same
time (Viterbi, 1995). Before transmission, the signal from each user is multiplied by a distinct signature waveform. The signature waveform is a signal which has a much larger bandwidth than the information bearing signal from the user. The CDMA system is thus a spread spectrum technique (Scholtz, 1982). All users use different signature waveforms to expand their signal bandwidth. At the base station, the sum of all the broadband signals is received. To demodulate a signal from a specific user, the received signal is correlated with the signature waveform of that user. To solve the problems with the conventional receiver a different type of multi-user detector has been designed (Short & Rushforth, 1990; Verdu, 1998; Xie, Short, & Rushforth, 1990). MC-CDMA is capable of supporting high data rate services over hostile radio channels. The modulated signal can be generated with the aid of the Fast Fourier Transform (FFT) at the cost of low receiver complexity.

Studies have been made to analyze the performance of multicarrier DS-CDMA systems. It is known that Multiple Access Interference (MAI) limits DS-CDMA system capacity (Cooper & Nelleton, 1978), and that any technique, which can suppress/cancel MAI, can increase the capacity of system. Multi-user detectors exploit the inherent structure in the MAI to estimate and cancel the MAI to improve detection performance. Due to the large complexity (grows exponentially with number of user) involved in the optimal detection, several sub optimal approaches have been studied (Verdu, 1998; Xie et al., 1990). Non-linear sub optimum multi-user detectors, including Successive Interference Canceller (SIC) and Parallel Interference Canceller (PIC), make tentative decisions on the bits of the users using any detector. The SIC detector imposes only modest additional complexity and has the potential of providing a significant performance over single-user detector. In contrast to the SIC based multi-user detector, the Parallel Interference Cancellation (PIC) (Viterbi, 1971) aided detector estimates and subtracts the MAI imposed by all interfering users from the signal of the desired user in parallel (Ginakis, Hua, Stoica, & Tong, 2000; Kondo & Milstein, 1996).

In this article, a new scheme of soft detectors whose performance is superior to that of the other famous suboptimal detectors is offered. On each sub carrier, instead of making hard bit decisions of the other users in the current stage and regenerating and canceling the interference signal, a weighted sum of the soft outputs of the other users in the current stage is canceled from the soft output of the desired user. This is the input to the next stage then at the last stage. The interference canceled outputs from all the subcarriers are combined (Maximal Ratio Combining-MRC) to form the decision statistics. We derived expressions for the Bit Error Rate (BER) on Rayleigh Fading channels.

Demand for wireless data services and applications is taking off around the world and this is where Multicarrier CDMA fits in. MC-CDMAconsistently provides better capacity for video and data communications than the other commercial technologies. In GPS Pseudolites transmissions are envisaged to provide better than one meter location accuracy for various applications. A main drawback with the ground-based pseudolite transmission is the effect of interference in multipath environment. We note that use of MC-CDMA for GPS Pseudolite transmission can be beneficial in combating the effect of interferences.
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