Chapter XII
Soft Decision Parallel Interference Cancellation for Multi-Carrier DS-CDMA

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ABSTRACT

In this chapter, we propose a new scheme for Multi User Detection (MUD) using 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 Multi-Carrier (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 subcarrier, 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) 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).
**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).

Multi-carrier modulation is currently used in many wireless systems for transmission of data for telephone network and cellular radio (Bingham, 1990). MC-DSCDMA technique offers many advantages like robustness in fading interference, spectral efficiency, down link Bit Error Rate (BER) and non-contiguous bandwidth operations (Shinusuke Hara & Prasad, 1997). 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 multi-carrier 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. Much of the research is aimed at finding an appropriate trade off between complexity and performance. Important linear sub optimum multi-user detectors including decorrelating detector and MMSE detectors were tried to remove the MAI (Shimon Moshavi & Bellcore, 1996; Sergio Verdu, 1998). The major disadvantages of the linear sub optimal detection were (i) The number of large computations needed to invert the matrix especially for asynchronous case (ii) Need to estimate the recovered amplitude or phase.

Owing to the large complexity involved in the optimum detection, several sub optimal approaches had been studied (Zhenuhua Xie et al, 1990; Proakis, 1995; Alexandra Duel Hallen et al, 1995; Verdu, 1998). 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.

SIC cancels the interference estimate one after another whereas PIC cancels the interference simultaneously (Tero Ojanpera, 1997; Sergio Verdu, 1998). The performance of SIC will be better if unequal received power of the user is available at the receiver and PIC was better if the user with equal power (Jefery G. Andrews & Meng, 2004). 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 (Ginnakis, Hua, Stoica, & Tong, 2000; Kondo & Milstein, 1996).

In recent years, there has been an increased interest in the subtractive type interference cancellers, SIC and PIC was the two important detectors in the group.