Adaptive DS/CDMA Non-Coherent Receiver using MULTIUSER DETECTION Technique

V.Rakesh[1], S.Prashanth[2], V.Revathi[3], M.Satish[4], Ch.Gayatri[5]

Abstract— In this paper, we propose and analyze a new non-coherent receiver with PN code tracking for direct sequence code division multiple access (DS-CDMA) communication systems in Multipath channels. We employ the decision-feedback differential detection method to detect MDPSK signals. An "error signal" is used to update the tap weights and the estimated code delay. Increasing the number of feedback symbols can improve the Performance of the proposed non-coherent receiver. For an infinite number of feedback symbols, the optimum weight can be derived analytically, and the performance of the proposed non-coherent receiver approaches to that of the conventional coherent receiver.

Index Terms— **DS/CDMA, Code Tracking, LMS (Least Mean Square error), MAI (Multiple Access Interference), and MUD (Multiuser Detector)**

I. INTRODUCTION

Communication system has challenge of accommodating many users in a small area. The wireless domain is the current area of interest. The conventional systems used either frequency spectrum sharing or timesharing and hence there was the limitation on the capacity. With the advent of spread spectrum and hence CDMA, fixed bandwidth was used to accommodate many users by making use of certain coding properties over the bandwidth. But this system suffers from MAI (Multiple Access Interference) caused by direct sequence users.

Manuscript received Jan, 2014.

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Multi-User Detection Technique is going to be the key to this problem. These detection schemes were introduced to detect the users' data in the presence of Multiple Access Interference

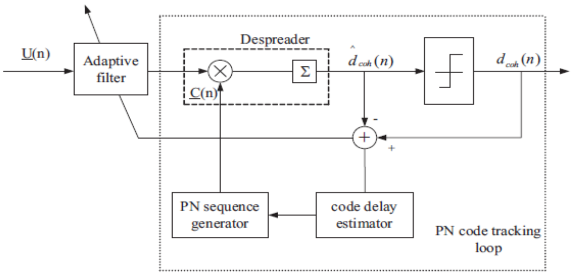

Figure1. The conventional coherent receiver - joint detection and PN code tracking.

(MAI), Inter Symbol Interference and noise. Spread spectrum CDMA systems (DS/CDMA) are becoming widely accepted and promise to play a key role in the future of wireless communications applications because of their efficient use of the channel and there allow ness for nonscheduled user transmissions. Hence recent interests are in techniques, which can improve the capacity of CDMA systems. The CDMA system originally proposed by QUALCOMM for cellular phone applications has been adopted by the Tele- Communication industry association TR-45 committee as TIA/EIAIS-95standardforcellularcommunications.As mobile communication systems based on CDMA are inherently subject to Multiple-Access Interference (MAI), since it is impossible to maintain orthogonal spreading codes in mobile environments. MAI (Multiple Access Interference) limits the capacity of Conventional detectors and brings on strict power control requirements to alleviate the Near-Far problem. Multi-user Detector (MUD) techniques exploit the character of the MAI by removal of the Multi-User Interference from each user's received signal before making data decision, and thus offer significant gains in capacity and Near-Far Resistance over the conventional receiver .

II. SYSTEM MODEL

The DS/CDMA receivers are divided into Single-User and Multi-User detectors. A single user receiver detects the data of one user at a time whereas a multi-user receiver jointly detects several users' information. Single user and multi user receivers are also sometimes called as decentralized and centralized receivers respectively. At the receiver, the aim is to restore the signal, which is corrupted by the channel back to its original form. In its simplest form, the Single-User detector is a matched filter to the desired signal. Other users' signals are treated as noise (self noise). These self-noise limit the system's capacity and can jam out all communications in the presence of a strong nearby signal (Near-Far Problem). The capacity is optimized when all users enter the base station at the same power level forcing the use of power control circuits in the terminal transmitters. Early work on multi-user detectors assumed that the receiver has the knowledge of the codes of all users. These detectors can be used only for the uplink transmission.

There have been great interests in finding sub optimum detectors with acceptable complexity and marginal performance degradation compared with the optimum detector. Sub optimum detectors can be classified into two categories, namely linear multi-user detectors and subtractive interference canceller. Two of the most cited linear multi-user detectors are Decor relating detector and MMSE detector. In Subtractive Interference Cancellation, estimates of the interference are generated and subtracted out. For Decor relating detector there is need to compute the inverse of a cross-correlation matrix, which makes it unacceptable for practical implementation. On the other hand, Subtractive Interference Cancellers are much easier to implement compared with linear multi-user detectors, but the performance gap between them is quite obvious. Another disadvantage of subtractive interference cancellation is that they usually need to estimate the amplitude and carrier phase of all active users. Further research is going on the improvement of more efficient schemes. Earlier multi-user detection techniques are either too complicates to implement in order to achieve near optimum performance, or there is too much compromise in performance to maintain the simplicity of the system. Recently, there has been considerable interest in linear multi-user detection based on Minimum Mean Square Error (MMSE) criterion.

It is shown that MMSE detector, relative to other detection schemes has the advantage that explicit knowledge of interference parameters is not required, since filter parameters can be adapted to achieve the MMSE solution. Although it does not achieve minimum bit-error rate, MMSE detector has been proved to achieve the optimal near-far resistance. This paper deals with simulation of linear multi-user detectors methods for varying parameters. In this paper, simulation results are presented to demonstrate the performance of linear detectors viz., Decor relating detector and Subspace MMSE detector. Their performance is also compared with that of conventional detectors. It can be seen that the BER performance is significantly influenced by the number of users, number of paths and length of signature code used. An attempt at reaching certain conclusions has also been carried out. Figure 1 shows the general structure of multi-user detector.

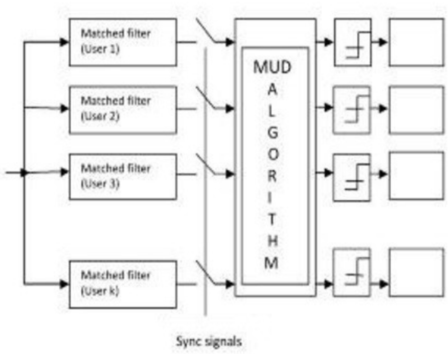

Figure2. General structure of multi-user detector

III. CONVENTIONAL NON-COHERENT RECEIVER

The below figure shows the block diagram of the proposed non-coherent receiver that combines the differential detection with PN code tracking for DS-CDMA systems. The ibid. information sequence $\{a_k(n)\}$ is first differentially encoded. The resulting MDPSK symbols b_k (n) are given by $b_k(n) = a_k(n) b_k(n-1)$

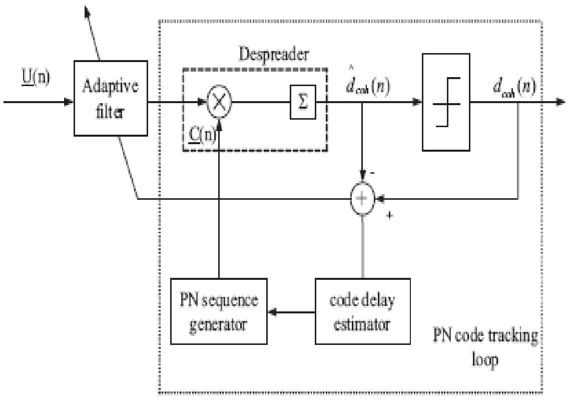

Figure.3. The proposed non coherent differential detection receiver with PN code tracking.

And the transmitted signal model is the same as (1). The received sample sequence {rib} is also expressed as (2). Here, the constant phase shift Θ is unknown. At the receiver, the sampled signals are first passed through the transversal filter and then degraded by the local PN sequence. The tap weight vector W(n), local PN code vector C(n), and the received sample matrix U(n) can be described as equations (3), (4), and (5), respectively. The normalized desperate output q(n) is the same as (7), and can be represented as q(n) = WH(n)U(n)C(n)/β. In the next stage, the differential detection is necessary to recover the MDPSK information sequence. The decision variable ddif (n) is obtained by non-coherent processing of the desperate output q(n), ddif (n)

= q(n)q∗ref (n − 1) where the reference symbol qref (n − 1) is generated as follows

$$q_{ref}(n-1) = \frac{1}{N-1}\sum_{L=1}^{N-1} q\,(n-1)\prod_{m=1}^{l-1} d_{dif}\,(n-m)$$

where N,N ≥ 2, is the number of despreader output symbols used to calculate ddif (n). ddif (n) is the hard decision result of ddif (n). Note that for *N* = 2, *qref* (*n* − 1) = *q*(*n* − 1)*, ddif* (*n*) is the decision variable of a conventional differential detection. However, for *N* >2, a significant performance improvement can be obtained. We can use the cost function

$$J_{dif} = E \quad |d_{dif}(n) - \hat{d_{dif}}(n)|^{2}$$

The error signal can be defined as edif (n) def = ddif (n) − ˆ ddif (n). Here, edif (n) at the n-th symbol time also depends on past tap weight vectors W(n−ν), ν ≥ 1. For the derivation of the adaptive algorithm, these past tap weight vectors are treated as constants since |edif (n)|2 is differentiated only with respect to W(n). The cost function of differential detection Jdif can be written as

$$J_{dif} = E\ [\,d_{dif}(n)\dot{d}_{dif}(n)$$

$$-d_{dif}(n)\,\frac{q_{ref}(n-1)}{\beta}\,C^{T}(n)U^{H}(n)W(n)$$

$$-\dot{d}_{dif}(n)\,\frac{q_{ref}(\dot{n}-1)}{\beta}\,W^{H}(n)U(n)C(n)$$

$$+\frac{|q_{ref}(n-1)\ 2}{\beta 2}W^{H}(n)U(n)C(n)C^{T}(n)U^{H}(n)W(n)]$$

The gradient of the cost function with respect to the tap weight vector is

$$\partial\frac{J_{dif}}{\partial W} = -\frac{2}{\beta}\,\dot{Q_{ref}}(n-1)\dot{d_{dif}}(n)U(n)C(n)$$

$$+\frac{2}{\beta^{2}}|q_{ref}(n-$$
$$1)|2\ U(n)C(n)C^{T}(n)U^{H}(n)W(n)$$

$$= -\frac{2}{\beta}\,\dot{q}_{ref}(n-1)e_{\dot{d}if}(n)U(n)C(n)$$

and the gradient of the cost function with respect to the code delay is

The gradient vector ∂C(n) ∂τ is the same as (10). The tap weight of the noncoherent adaptive filter is updated by

$$W(n+1) = W(n) + \mu\left[\frac{2}{\beta}\dot{q_{ref}}(n-1)e_{\dot{d}if}(n)U(n)C(n)\right]$$

$$\textit{and the code delay } \tau \textit{ is updated by } \tau(n+1) = \tau(n) - \lambda\,\partial\frac{J_{dif}}{\partial\tau}$$

IV. STIMULATION RESULTS

From the above discussion, we know that the selection of the chip waveform and the sample number D are the factors to control the performance of the system. The effect of the gradient of chip waveform about the code delay as in (11) on the performance of the system can be large. However, as the dependence of the system performance on the chip waveform is usually very complicated, it is generally difficult to evaluate this effect. Therefore, we use simulation to compare the effectiveness of different chip waveforms. In this section, the following time-limited chip waveforms are considered:

1) Raised-Cosine (rct) :

$$\varphi(t) = \sqrt{\frac{2}{3}}\,\left[1-\cos\left(\frac{2\pi t}{T_c}\right)\right]\delta_c(t)$$

2) Blackman (bm) :

$$\varphi(t) = \epsilon\left[\epsilon_1 - \epsilon_2\cos\left(\frac{2\pi t}{T_c}\right) + \epsilon_3\cos\left(\frac{4\pi t}{T_c}\right)\right]\delta_c(t)$$

$$where\ \ \epsilon^{2} = \left(\epsilon_1^{2} + \frac{\epsilon_2^{2}}{2} + \frac{\epsilon_3^{2}}{2}\right)^{-1} and\ \ \epsilon_1 = 0.42, \epsilon_2 = 0.5, and\ \ \epsilon_3 = 0.08$$

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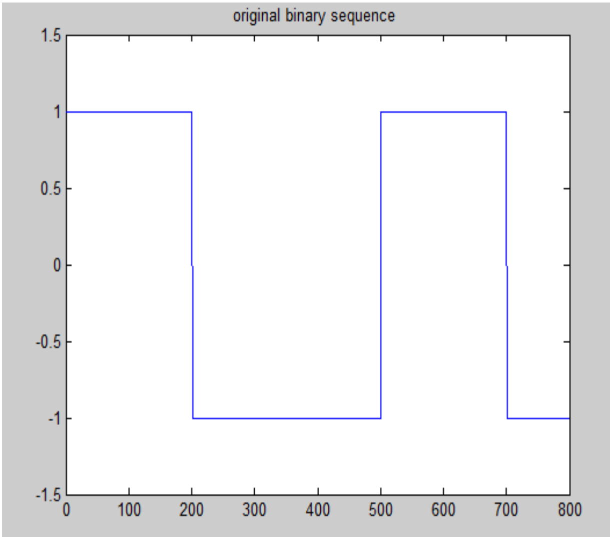
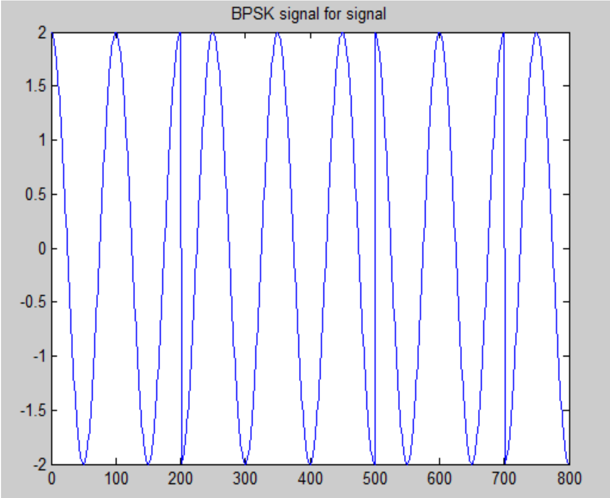
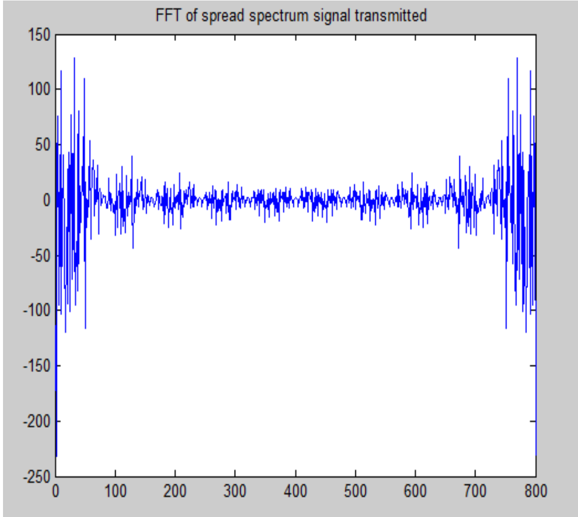
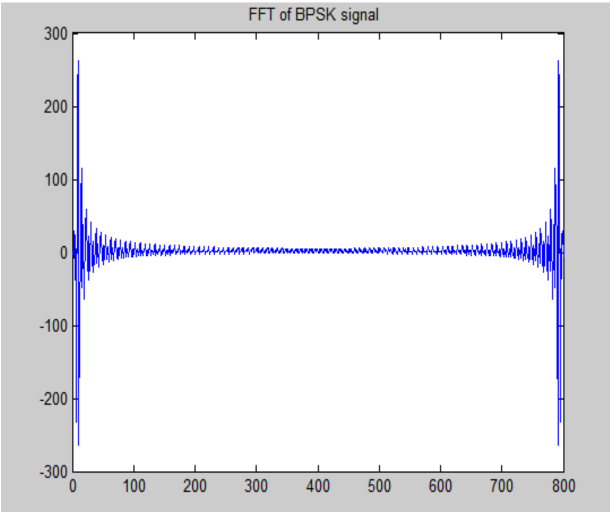
V. RESULTS

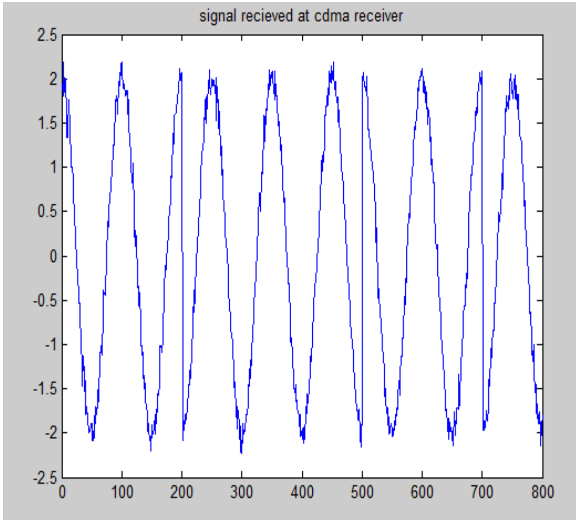
A. Figures and Tables

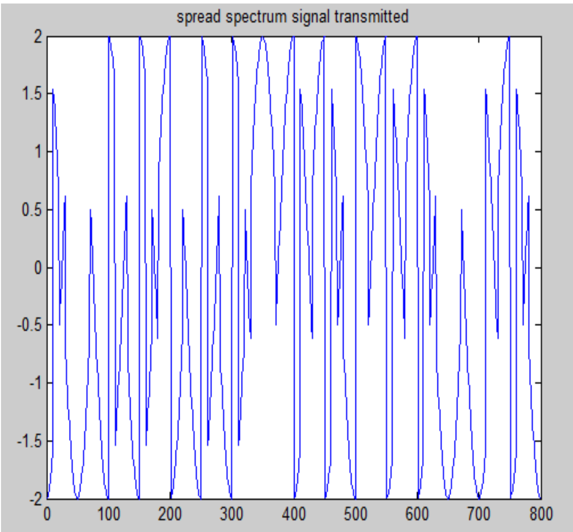


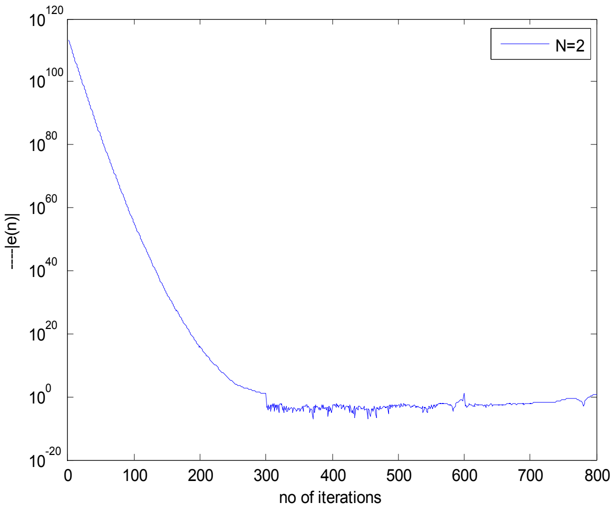

BPSK signal for signal

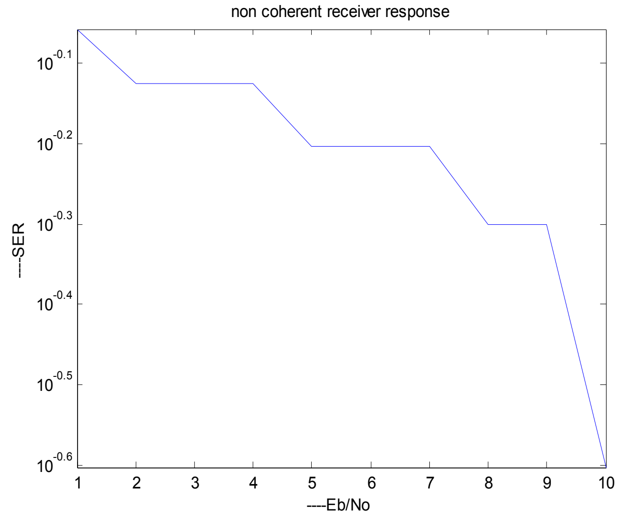

FFT of spread spectrum signal transmitted


FFT of BPSK signal


signal recieved at cdma receiver


spread spectrum signal transmitted


N=2
---|e(n)|
no of iterations



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VI. CONCLUSION

A novel non-coherent receiver for joint timing recovery and data detection in DS-CDMA systems is proposed in this work. It estimates the desired signal and code delay by LMS algorithm at the same time. The MMSE solution of the proposed receiver is analyzed theoretically and by computer simulations. Three different chip waveforms are simulated in two different multipath channels with different numbers of active users. It is shown that the timing offset can be rapidly tracked even if the mismatch is up to half chip time interval. The loss of non-coherent detection compared with conventional coherent detection is limited and can be adjusted via the generation of the reference symbol for the decision-feedback differential detection. The performance of the non-coherent receiver can approach the performance of the conventional coherent receiver if an infinite number of feedback symbols are used, as has been shown analytically. Furthermore, simulations show that the proposed receiver in an asynchronous situation approaches the performance as that of the receivers with perfect synchronization.

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