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To Compare The Linear And Non-Linear Equalizer Performance On MUI In CDMA System

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Abstract-

Code Division Multiple Access (CDMA) is one of the most flexible multiple access methods suitable for supporting many new services such as speech, video, multimedia applications and soon, which are becoming increasingly important for mobile communications. Besides supporting multiple data rates, future systems will also need to enhance the performance and capacity demands.

Direct Sequence Code Division Multiple Access (DS-CDMA) is the most commonly proposed CDMA system for the third generation of wireless mobile systems. A DS-CDMA system using conventional receiver techniques is limited in capacity because the multiple access interference (MAI) and the near-far effect will substantially degrade its performance. These problems, however, can be mitigated by employing multi user detection techniques, including optimum detectors and suboptimum ones. Although optimum detectors offer high performance and high capacity, It is very difficult to implement them because of excessive computational complexity, which grows exponentially increased with the number of users. The MMSE d etector, however, has low complexity and yet provides acceptable performance.

Keywords –

Linear Receiver, Minimum Mean Square Error (MMSE), Non-linear Receiver, Signal to Noise Ratio (SNR).

I. INTRODUCTION

Code-division multiple access (CDMA) system support multi-media services in mobile communications due to its ability to cope with the asynchronous nature of multi-media data traffic. The propagation of maximum number of users through the wireless channel results in multi-user interference from non-orthogonal users. This exhibits a user capacity limit on the CDMA systems. Different multi-user detection methods are proposed in the recent years to eliminate the adverse effects of multi-user interference. The Common methods used to suppress the multiple path interference in CDMA systems are Linear CDMA detectors viz., Matched filter, Decorrelator, and MMSE adaptive filter. G.L.Turin [1] in1980 has used the simplest scheme of conventional matched filter detector to demodulate CDMA signal. This detector though optimal in additive white Gaussian noise (AWGN) is sub-optimal because the MAI does not necessarily resemble white Gaussian noise. The optimal multiuser detector for CDMA systems based on maximum likelihood (ML) detection technique using Viterbi's algorithm is proposed by Verdu in the mid of 1980's in [2]. Unfortunately the ML method suffers from the fact that its complexity grows exponentially with the number of users and the length of the sequence. On the other hand, the decorrelator detector can completely cancel all MAI signals at the output of the detector [3]. But the structure of the decorrelator detector is quiet complex than the Matched filter detector where the detector should know all the signatures codes of all system users. The Minimum Mean Square Error (MMSE) detector compromises between the matched filter detector and the decorrelator detector using an adaptive algorithm [4]. The important references to MMSE detectors implemented in 1990 used tapped delay lines [5]. These detectors have computational complexities per detected bit which are linear in K, and are thus much simpler than the optimum detector. The disadvantage is the practical problems associated with estimating the parameters of the system and adapting the structure of the detector regardless of the decision rule adopted. A receiver that uses a chip matched filter followed by an adaptive equalizer structure is used in combating the near-far problem [6]. The receiver offer a two-fold increase in capacity relative to a conventional receiver with perfect power control. However the adaptive equalizers have a difficult time in channels that are rapidly changing causing frequent errors. A structure-wise and performance-wise comparison of MMSE is presented for MUI cancellation in uplink OFDMA system [7]. The complexity is $2N^2$ per iteration for MMSE detector. The performance of a joint rake and MMSE equalizer receiver is studied in [8]. For an MMSE equalizer at low to medium SNR's, the number of rake fingers is the dominant factor to improve system performance, while at high SNR's the number of equalizer taps plays a more significant role in reducing error rates. The reduction of estimation error variance is achieved at the cost of power and bandwidth. The performance of channel overloading schemes based on two sets of orthogonal signal waveforms is investigated on a Rayleigh fading channel [9]. This channel overloading techniques offer substantial channel overloads when used in conjunction with soft iterative interference cancellation. This paper proposes a linear MMSE technique and a non-linear MMSE-Decision Feedback Equalizer (MMSEDFE) for overloaded CDMA system to accommodate more number of users than the processing gain of the system. The paper is organized as follows. In Section II, the system model is briefly described. Synchronous and Asynchronous Model is presented in section III. Section IV describes Probability of Error. Simulation results are presented in section V and the paper is completed by some concluding remarks.

2. **System Model:**

We will consider BPSK transmission through a common Additive White Gaussian Noise (AWGN) channel shared by K simultaneous users employing a DS-CDMA system. As mentioned earlier, each user is assigned aunique signature waveform $s_k(t)$ of duration T, where T is the symbol duration. A signature waveform can be expressed as

$$s_k(t) = \sum_{n=0}^{N-1} a_k(n)h(t - nT_c), \quad 0 \le t \le T \text{ ....(1.1)}$$

Where $[a_k(n) \in \{+1,-1\}, 0 \le n \le N-1]$ is a pseudo-noise (PN) code sequence of the k[th] user consisting of N chips, h(t) is the spreading chip whose duration is $T_c = T/N$. The signature waveforms are assumed to be zero outside the interval [0,T], and, therefore, there is no inter symbol interference (ISI).

In general, one can assume with out loss of generality that all K signature wave forms are normalized so as to have unit energy, i.e.

$$\mathbf{S_k = \int_0 \|s_k\|^2 (t)\, dt^T \text{...............(1.2)}}$$

The corresponding base-band transmitted signal of each user can be expressed as

$$g_k(t) = A_k \sum_{i=1}^{M} b_k(i) s_k(t - iT) \text{ ....(1.3)}$$

Where A_k is the received amplitude of the k[th] user's signal user such that A_k^2 is referred to as the energy of the k[th] user. Figure1.1illustrates the received waveform, y(t), comprising the sum of K transmitted waveforms in AWGN which can be expressed as

$$y(t) = \sum_{k=1}^{k} A_k \sum_{i=1}^{m} b_k(i) s_k(t - iT - \tau_k) + \sigma n(t) \text{ ....(1.4)}$$

Where τ_k is the transmission delay and n(t) is white Gaussain noise with unit power spectral density. Note that the noise power in a frequency band with bandwidth B is $2\sigma^2$ B (the noise one - sided spectral density level $2\sigma^2$ is often denoted by N_0).

Without loss of generality, we can assume that the delays τ_k are smaller than the bit period time T ($0 \le \tau_k \le T$ for $1 \le k \le K$) and $0 \le \tau_1 \le \tau_2 \le \ldots \le \tau_k < T$. Additionally, we shall assume that the data rate 1/T is identical for all users.

3. **Synchronous and Asynchronous Model:**

Multi user detectors basically have a front-end whose objective is to convert the received continuous-time waveform, y(t), into a discrete-time process. The matched filter output is then given by:-

$$y_K = \int_0^T y(t) s_K(t) dt \quad \text{.................(1.5)}$$

In the synchronous case, it is sufficient to restrict our attention to a one-shot model. There fore, one can express the output of the k[th] matched filter as:

$$y_k = A_k + \sum_{j \ne k} A_j b_j \rho_{kj} + n_k \text{........................(1.6)}$$

y_K = (y,S_K) = Desired Information + MAI+Noise

4. **Probability of Error**

As derived before for the synchronous case, the k-th user matched filter output is

$$y_k = A_k b_k + \sum_{j \ne k}^{k} A_j b_j \int_0 s_j(t)\; s_k(t)\, dt + n_k$$

The probability of error scan be expressed as follows, with change of integration variable and symmetry:

$$P = \frac{1}{2}\int_0^{\infty} f_{Y/-1}(v)dv + \frac{1}{2}\int_{-\infty}^{0} f_{Y/1}(v)dv$$
$$= Q\left(\frac{A < s,h >}{\sigma|h|}\right)$$
$$= Q\left(\frac{A}{\sigma}\right)$$

The analysis in the asynchronous case can be done in a similar fashion. The major difference is that each bit is affected by 2K-2 interfering bits in stead of K-1 bits a sin the synchronous case. Probability of error for the k-th user is

$$P_k^c(\sigma) = \frac{1}{2^{2K-2}} \sum_{1} \ldots \sum_{j \ne k} \ldots \sum_{K} Q\left(\frac{A_k}{\sigma} + \sum_{j \ne k} \frac{A_j}{\sigma}(e_j \rho_{jk} + d_j \rho_{kj})\right)$$

Where e_j and d_j □ {-1,+1} the asynchronous cross correlations in the above equation depend on the off sets between the users' symbol periods. As a result, those parameters are random variable that may actually be time varying.

5. Simulation Results

From fig: 1.1 we find that direct detection algorithms results in more BER whereas CDMA will result in less BER. From above figure we find that for the less value of SNR performance of direct detection and CDMA detection there is no difference. But for higher SNR conditions CDMA shows better performance the range of error in CDMA in this case is 10^{-4}.In fig: 1.2 we find the loaded performance value of MUI in chip length of 128.

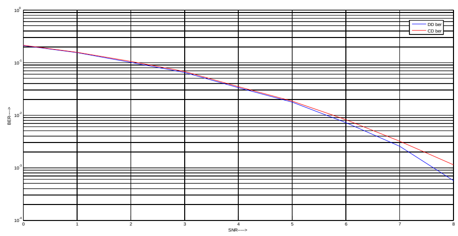

Figure:-1.1: BER performance of linear and non-linear detector

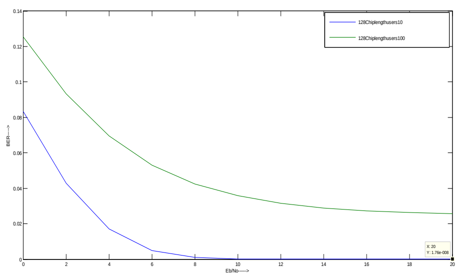

Figure:-1.2: BER performance of linear and non-linear detector

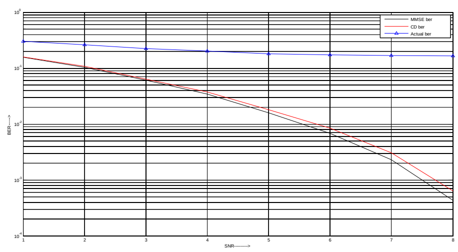

Figure:-1.3: BER performance of linear and non-linear detector

In Fig 1.3 we see that the direct sequence with multiuser detection and with MMSE equalizer we are able to fight with the multiple accessing that result in multi access interference (MAI). From above figure it is clearly visible that DS-CDMA with Multiuser detection and with MMSE equalizer our BER range can be improved drastically. Now in this case we find the improvement in BER that is in the range of 10^{-8} with the chip length of 128.

6. Conclusion:

DS-CDMA is the most commonly proposed CDMA system for the third generation of mobile systems. It has many advantages as explained earlier. However, its performance is mainly degraded by the near-far problem and the multiple access interference. One way to circumvent these difficulties is to utilize a multiuser detector.

There are many optimum multiuser detectors for a DS-CDMA system, but they practically require a high computational complexity which grows exponentially with the number of users. To reduce the computational complexity, linear detectors may be employed because their complexity increases linearly with the number of users. We found that the nonlinear equalizer give better performance as compare in linear equalizer.

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