HYBRID INTERFERENCE CANCELLATION RECEIVER FOR DS-CDMA SYSTEMS

L.Nithyanandan and P.Dananjayan
Department of Electronics and Communication Engineering
Pondicherry College of Engineering
Pondicherry – 605014
Email- pdananjayan@hotmail.com

ABSTRACT
In a CDMA system, the performance of channel matched filter receivers are limited by the presence of multi-user interference. Hence receivers must be capable of suppressing these interferences. Interference suppression or interference cancellation works by subtracting the interfering users from the received signal, thus allowing an improved error rate for the user of interest. In this paper a hybrid interference cancellation receiver is designed by combining the successive and parallel interference cancellation algorithms, so that the advantages of both the schemes are utilized effectively. The hybrid interference cancellation scheme results in a simple, faster and reliable receiver. With the help of simulations, it is shown that this hybrid approach outperforms the other multi-user detection schemes.

1. INTRODUCTION
One of the fastest growing technologies in the recent past is the Wireless personal communication technology. The most widely available media for commercial wireless personal communication is the Cellular mobile telephony. The goal of personal communication Services (PCS) industry is to expand the capabilities of the current second generation cellular system to provide enhanced services like wireless facsimile, e-mail, wireless video services, bank transactions etc. While there is still some distance to cover before reaching this point, many developing PCS technologies are key in achieving ultimate third generation goals. These technologies include adaptive antenna arrays (smart antennas), adaptive equalization, speech coding, propagation prediction, and advanced signal processing techniques for mitigating interference effects.

The first radio systems were designed to transmit and receive information on a single frequency or channel but are usually very inefficient in terms of traffic throughput. In contrast, the multiple access wireless system allows the sharing of available channels by various users with a well defined method to access these channels. Out of the multiple access schemes available like TDMA, FDMA and CDMA ITU-T has identified CDMA 2000 as the wireless access standard for third generation wireless communication due to its advantages.

The most challenging part in any of these kinds of wireless technologies is that of the receivers. The receiver design decides the size, weight and cost of a mobile unit. Hence a receiver should be of petite size, with a reduction of weight and yet at an affordable cost. At the same time, the receiver should be efficient and must perform well under all circumstances. A novel hybrid interference cancellation receiver has been proposed and the performance is analyzed in this paper.

2. CDMA RECEIVER
The change from a single user environment to a multiuser environment necessarily entails a modification in receiver design if high performance is to
be maintained. Fig. 1 is a general model of a CDMA communication system. It is comprised of K single user DS-SS transmitters simultaneously transmitting over a linear AWGN channel. The channel attenuates and delays each signal and corrupts the aggregate transmission with AWGN. This noisy composite of delayed and attenuated signals $r(t)$ arrives at the CDMA receiver whose job is to recover each user’s data stream. Single user detectors are not optimal for CDMA because they process other user interference, termed multiple access interference (MAI), as unstructured channel noise, hence multi-user detectors are required for CDMA reception[1,2].

To design better CDMA receivers, the specific structure of MAI needs to be more fully exploited. To such an end, novel receiver structures have been proposed over the years that take advantage of knowledge of MAI signal parameters. Such multi user receivers are more complex than conventional ones because of their capability of using MAI signal information to help recover the desired user. For the foreseeable future, multiuser receiver structures like interference cancellation receivers are only suitable for use at the base station where additional complexity may be supported.

**3. HYBRID INTERFERENCE CANCELLATION RECEIVERS**

The proposed HIC combines both SIC [3,4] and PIC [5] to the correct proportion so that the receiver performance is enhanced to reach the near optimal level. The successive interference cancellation receiver is the simple, but requires high computational time, whereas the parallel interference cancellation receiver is more complex, but computational time is less. The best solution to get the desired improvement in performance is to have a perfect trade off between the computational time and receiver complexity, so that with minimum number of iterations, with minimum complexity, a better performance can be achieved. The proposed receiver has the PIC as the first stage of cancellation, where a few number of users who have the decision statistic above a certain threshold, are cancelled in parallel. The remaining users are given to the second stage of cancellation i.e SIC. The SIC cancel users, one at a time, until the desired user’s signal is separated. Finally, the subtracted signal is given to a conventional receiver to get the users’ information. The performance of the proposed HIC receiver solely depends on the threshold or decision static.

To derive the threshold, first it is required to get the conditional probability of error. The conditional probability density functions of the decision statistic magnitude $y_k$, given the input data $x_k = -1$ or $+1$ are Gaussian centered at $-1$ and $+1$ respectively. The conditional probability of error, given the decision statistic $y_k$ derived and as this will be symmetric, the analysis can be simplified to consider only positive values of $y_k$.

Using Bayes’ rule, the conditional probability of error is

$$p_e(y_k) = p(x \neq 1 \mid y_k)$$

$$= \frac{p(y_k \mid x_k = -1)}{p(y_k \mid x = 1) + p(y_k \mid x_k = -1)}$$
This very well indicates that for small magnitudes of $y_k$, the probability of error is high and therefore these tentative decisions cannot be relied upon. Hence, using null-zone cancellation, where only users with decision statistic above a threshold are cancelled, should improve performance. This result also supports the use of decision statistic ordered SIC, as the user with the highest decision statistic is also likely to have the most reliable tentative data estimate. Hence the threshold can easily obtained from the previous equation as

$$th = \frac{\delta^2}{2} \ln \left( \frac{1-p_e}{p_e} \right)$$

The decision statistic for each user is calculated and is compared with the threshold. All users having a decision statistic greater than that threshold are given to the parallel Interference cancellation stage. This process is repeated until no user has a decision statistic greater than the threshold. Then the remaining users are passed on to the successive interference cancellation stage. Here all MAI signals are cancelled and finally the desired users signal is obtained. The complete flow diagram of the HIC algorithm is shown in Fig. 2.

4. SIMULATION RESULTS

The hybrid interference cancellation receiver was simulated using MATLAB. The simulation was run under different conditions and the error performance of the receiver is obtained. In order to compare the receiver performance with that to the other schemes, the SIC and PIC receivers were also simulated and their error performances were obtained.

To keep the simulation time practical, a processing gain of 15 was chosen. The simulation was run by assuming that there are 15 users operating simultaneously and each user having either 1000 bits or 10000 bits.

The error performances thus obtained for each receiver type are compared. Also the plot between the number of users and Bit error rate was also obtained and compared.

Fig. 2 Flow Diagram of hybrid interference cancellation receiver

Fig. 3 portrays the plot between signal to noise ratio and bit error rate. As it is seen the conventional receiver has the highest error rate. The Parallel interference cancellation receiver performs better when compared to the conventional receiver, but has high error rates due to imperfect cancellation. Even-though the computation time is large the successive interference cancellation technique provides the best possible error performance. The hybrid interference cancellation receiver, as seen from the Fig.3, nearly matches the performance of the SIC receiver.
Fig. 4 shows the plot between Number of users and Bit error rate. As the number of users increase, the error rate also increases. Here again, the performance of the conventional receiver and the PIC receiver are poor whereas the performance of HIC nearly approaches the performance of SIC.

Fig. 6 shows the plot between the number of users and the bit error rate. Here again, the number of bits per user is assumed to be 10000. As the number of users increase, the bit error rate also increases.

Fig. 7 portrays the error performance of the various receivers. Here the simulation is done by assuming that each user has different power levels of transmission. Here the performance of the PIC receiver is better than when the users had equal power. This is used effectively to produce better error performance in the case of HIC receiver. The SIC receiver performs poorly in this kind of an environment. Fig. 8 analyses the computational complexity of the SIC receiver and the HIC receiver.

Fig. 5 is a plot much similar to Fig 3. Here the number of bits per user is assumed to be 10000. This is to increase the resolution of the performance characteristic achieved. As the resolution is increased, it is seen that, the performance of the HIC receiver closely matches and even outperforms the SIC receiver.
The number of correlations required in SIC increases exponentially as the number of users increase. In case of HIC, the number of correlations required is much lesser when compared to that of the SIC.

5 CONCLUSION

In this paper, a hybrid interference cancellation receiver has been proposed and the performance of the receiver was obtained using simulations. The performance of the proposed receiver was compared with the other interference cancellation receivers. From the results obtained, it is concluded that, the performance of the hybrid interference cancellation receiver matches the successive interference cancellation scheme with much lesser number of correlations and hence with less computational time. But the complexity of the HIC receiver is comparatively greater than that of the SIC receiver, lesser than that of the PIC receiver. Hence a perfect trade off between the computation time and receiver complexity is achieved.

ACKNOWLEDGEMENT

The authors sincerely acknowledge G.Balamurugan, G.Magesh, V.N.sathish and S.Manickavasagam for their help in completion of this paper.

REFERENCES


