DESIGN AND ANALYSIS OF PARALLEL INTERFERENCE CANCELLER RAKE SYSTEM FOR WIRELESS COMMUNICATION

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ABSTRACT

This paper proposed a software wireless communication simulator which simulates Code Division Multiple Accesses (CDMA) with rake fingers. CDMA is a popular technology in cellular systems due to its superior capacity and performance. The simulator is a tool to evaluate these design options and trades in deferent scenarios. The backbone of this system is a wireless CDMA multiple user link built using MATLAB. An efficient method of system modeling is used to speed up the simulations. This simulator can be used to study the performance of a CDMA wireless link with variation in system parameters and channel conditions with multiple user data. In the proposed method we have studied the performance of Parallel Interference Canceller (PIC) receiver and analyzed the Bit Error Rate and Signal to Noise Ratio Performance.

1. INTRODUCTION

Wireless cellular telephony has been growing at a faster rate than wired-line telephone networks. The main factor driving this tremendous growth in wireless coverage is that it does not need the setting up of expensive infrastructure like copper or fiber lines and switching equipment. This growth has also been fueled by the recent improvements in the capacity of wireless links due to the use of multiple access techniques (which allow many users to share the same channel for transmission) in association with advanced signal processing algorithms. Code Division Multiple Access (CDMA) is becoming a popular technology for cellular communications [5].

Unlike other multiple access techniques such as Frequency Division Multiple Access (FDMA) and Time-Division Multiple Access (TDMA) [7], which are limited in frequency band and time duration respectively, CDMA uses all of the available time-frequency space. One form of CDMA called Direct Sequence CDMA (DS-CDMA) uses a set of unique signature sequence or spreading codes to modulate the data bits of different users. With the knowledge of these spreading codes, the receiver can isolate the data corresponding to each user by the process of Channel estimation and detection. This process spreads the bandwidth of the underlying data signal; hence CDMA is called a spread spectrum technique. Standards such as IS-95 and the proposed W-CDMA are based on CDMA technology [7].

Here in this paper we have introduced a new technique called Parallel Interference Canceller [1-3] for Rake system which will simulate the DS-CDMA wireless technology for multiple paths without interfering each other and also analyzed the simulation results.

2. RAKE RECEIVER

If in a mobile radio channel reflected waves arrive with small relative time delays, self-interference occurs. Direct Sequence (DS) Spread Spectrum is often claimed to have particular properties that makes it less vulnerable to multipath reception. In particular, the rake receiver architecture allows an optimal combining of energy received over paths with different [10]. It avoids wave cancellation (fades). If delayed paths arrive with phase differences and appropriately weighs signals coming in with different signal-to-noise ratios [6].

The rake receiver consists of multiple correlators, in which the receive signal is multiplied by time-shifted versions of a locally generated code sequence. The intention is to separate signals such that each finger only sees signals coming in over a single (resolvable) path. The spreading code is chosen to have a very
small autocorrelation value for any nonzero time offset. This avoids crosstalk between fingers. In practice, the situation is less ideal. It is not the full periodic autocorrelation that determines the crosstalk between signals in different fingers, but rather two partial correlations with contributions from two consecutive bits or symbols. It has been attempted to find sequences that have satisfactory partial correlation values, but the crosstalk due to partial (non-periodic) correlations remains substantially more difficult to reduce than the effects of periodic correlations the rake receiver is designed to optimally detect a DS-CDMA signal transmitted over a dispersive multipath channel. It is an extension of the concept of the matched filter [6,9].

In the matched filter receiver, the signal is correlated with a locally generated copy of the signal waveform. If, however, the signal is distorted by the channel, the receiver should correlate the incoming signal by a copy of the expected received signal, rather than by a copy of transmitted waveform. Thus the receiver should estimate the delay profile of channel, and adapt its locally generated copy according to this estimate [10, 7].

In a multipath channel, delayed reflections interfere with the direct signal. However, a DS-CDMA signal suffering from multipath dispersion can be detected by a rake receiver. This receiver optimally combines signals received over multiple paths:

Like a garden rake, the rake receiver gathers the energy received over the various delayed propagation paths. According to the maximum ratio combining principle, the SNR at the output is the sum of the SNRs in the individual branches, provided that:

1. We assume that a random channel is present (with interference)
2. Codes with a time offset are truly orthogonal Signals arriving with the same excess propagation delay as the time offset in the receiver are retrieved accurately, because

$$\sum_{n=1}^{N} c^2_1 (n\tau) + c^2_2 (n\tau) = \sum_{n=1}^{N} c^2_1 (n\tau) = N$$

(1)

This reception concept is repeated for every delayed path that is received with relevant power. Considering a single correlator branch, multipath self-interference from other paths is attenuated here, because one can choose codes such that [4].
3. MULTIPATH AND RAKE RECEIVER

One of the main advantages of CDMA systems is the capability of using signals that arrive in the receivers with different time delays. This phenomenon is called multipath. FDMA and TDMA, which are narrow band systems, cannot discriminate between the multipath arrivals, and resort to equalization to mitigate the negative effects of multipath [5, 10]. Due to its wide bandwidth and rake receivers, CDMA uses the multipath signals and combines them to make an even stronger signal at the receivers. CDMA subscriber units use rake receivers. This is essentially a set of several receivers. One of the receivers (fingers) constantly searches for different multipath and feeds the information to the other three fingers. Each finger then demodulates the signal corresponding to a strong multipath. The results are then combined together to make the signal stronger [6].

3.1 Multipath reception

Experiments with mobile communication were done at VHF frequencies, near 50 MHz, already in the 1920s. Results of these tests revealed a very hostile propagation environment, particularly in urban centers. The signal quality varied from "excellent" to "no signal". Moving the vehicle over a few meters resulted in dramatic changes of the received field strength [11].

4. PURPOSE OF SIMULATOR

The objective of this research is to simulate and evaluate the performance of different parameters and RAKE receiver performance for the CDMA. It is well known that CDMA simulator and the simulation software developed for this research implements RAKE and without RAKE methods in combination with CDMA standard. This work will provide crucial information leading to the implementation of CDMA simulator in a real-world system. RAKE to multiple stages of parallel interference cancellation. RAKE was used in this work along with receivers that used the information in the channel. For both Conventional and proposed rake system, we compare them in multipath environment. It will be shown that the use of number of bit error in received data by the RAKE receiver is less than the received data of without RAKE receiver advantages of RAKE receivers [8, 10].

The multipath link developed in the software simulation system is intended as a backbone for developing more complex systems. This flexible link has a multipath interface which allows a system designed to test different scenarios by changing the parameters (such as number of users, paths, channel properties and attenuation factor). A library of .m file for all parts of the system is developed. The different configurations of a CDMA wireless link can be studied using the components of the library. The modular design of the simulation system allows easy addition of new algorithms to the library.

5. ALGORITHM AND IMPLEMENTATION

Proposed algorithm will be as follows

- Generate a random input data which is to be transmitted
- Perform IQ modulation to the input bit stream
- Generate the Channel Coefficients and PN sequence by using Pseudo Random generator
- Then transmit through the channel by using

\[ Y = x \cdot h + n \]  

(1)

- Calculate the Probability
\[ A = \left\lfloor \log \left( \frac{P_1}{P_2} \right) \right\rfloor \]

Where \( P_1 = R_1 \) and \( P_2 = R_2 \)

\[ n_1 = \text{no. of ones after modulation} \]
\[ n_2 = \text{no. of zeros after modulation} \]

If \( \lambda(Y(x,y)) \leq 2 \)

\[ D(x, y) = \frac{\lambda(Y(x,y))}{2} \]

else

\[ D(x, y) = \text{signum} \left( \lambda(Y(x,y)) \right) \]

- Then apply the Kronecker tensor product of \( D \) and 1. The result is a large array formed by taking all possible products between the elements of \( X \) and those of \( Y \).
- Finally Calculate the Bit error Rate and draw the performance of BER vs SNR.

6. SIMULATION RESULTS

In the result of this project we will show the Performance of difference between transmit data and received data which is referred to as Bit Error rate Signal to Noise Ratio and also compared the conventional method with the Proposed PIC rake system.

![Fig 3: Performance of BER Vs SNR of PIC Rake system for 4 different paths](image)

7. SUMMARY OF RESEARCH

We have developed a simulator made in our paper work, we have shown in this paper that how PIC (Parallel Interference Canceller) rake receiver in used for CDMA to decrease bit error due to multipath interferences. it can simulate a CDMA encoding and decoding process, the data is assumed to be traveled through different path, the effect of different path and CDMA is considered to generate the multipath effect the data is pass through the different path and assumed at receiver end just before the decoder to avoid the multipath effect RAKE receiver is used the RAKE receiver concept is introduced in the decoding process.

REFERENCES


