

Performance Study on Wideband Code Division Multiple Access (WCDMA) System Rake Receiver

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Abstract—This paper presents the study of Rake receiver bit error rate (BER) performance on WCDMA. The BER performance analysis were done in a WCDMA Frequency Division Duplex (FDD) downlink system by simulating on different channel types and Rake receiver spreading factor. All the simulations were done using MATLAB Simulink models. The models included a transmitter, propagation channel (Additive White Gaussian Noise (AWGN) channel and Rayleigh multipath fading channel) and Rake receiver with up to four fingers and 4 to 256 spreading factor. The functionality of each blocks in the models were verified, then the models were simulated and finally the trade-offs between parameters affecting the Rake receiver performance were investigated. The result shows that the Rake receiver work best in multipath channel and the highest number of spreading factor, which in this paper is 256.

Keywords-component; BER, WCDMA, Rake receiver, spreading factor

I. INTRODUCTION

Multipath fading is a propagation phenomenon that arises due to the reception of several signals at the receiver. These signals, arriving from different directions will necessarily be out of phase with one another when they reach the receiving antenna because they have travelled over different distance [1]. It is considered as a problem in previous mobile communications system since it cause constructive and destructive interference to the signal, but in Wideband Code Division Multiple Access (WCDMA), the effects of multipath fading can be overcome by the used of Rake receiver. Using of Rake receiver mechanism as multipath transmission and repeated transmission mechanisms as time diversity are against to fading and therefore causes performance increasing that is considered in WCDMA [2]. Rake receiver consists of “fingers,” each corresponding to one path delay of a received signal [3]. The fingers despread the received signal by correlators. Number of Rake fingers depends on channel plan and spreading factor [2].

WCDMA is a complex system and the design parameters in WCDMA can affect the performance of Rake receiver. Some of the parameters are the modulation

technique, type of channel coding, number of users, the spreading factor and the number of fingers of the Rake receiver. It is important to determine which parameters that Rake receiver can perform at its best as it can improve WCDMA performance and hence increase system capacity. This study is applicable for mobile unit or wireless LAN where lower value of bit error rate (BER) is highly important.

The objective of this study is to understand the concept of WCDMA and to study the performance of WCDMA Rake receiver in terms of bit error rate (BER) by simulation of different design parameters and study the effect of these parameters on the Rake receiver. The chosen parameters are the value of spreading factor and type of propagation channel.

The performance of Rake receiver system has been an area of research for some researchers, and there are many aspects of the performance were considered. In [4], the author has studied the performance of Rake receiver for a pulse based ultra-wideband (UWB) communications systems in a realistic channel model. Later, a new signaling and reception techniques has been developed based on a canonical representation of the wireless channel, which leads to a time-frequency generalization of the Rake receiver to counter problems on performance degrades under fast fading which is commonly found in mobile scenarios [5]. Another researcher also evaluate the throughput performance of the Rake receiver and linear chip equalizer for Direct Sequence Code Division Multiple Access (DS-SS) downlink systems using orthogonal spreading sequences using convolutional codes in the presence of multi-code interference [6].

II. METHODOLOGY

In this project, MATLAB Simulink 7.8 has been used as the platform to build and simulate the simulation models. There were two models that were used in this project. The first model a simple WCDMA model to investigate the system's

performance using Rake receiver and without using Rake receiver. The second model is a complete WCDMA Frequency Division Duplex (FDD) downlink model built to study the effect on different channel condition and spreading factor on the Rake receiver performance. Figure 1 below shows the overall simulation process for this project.

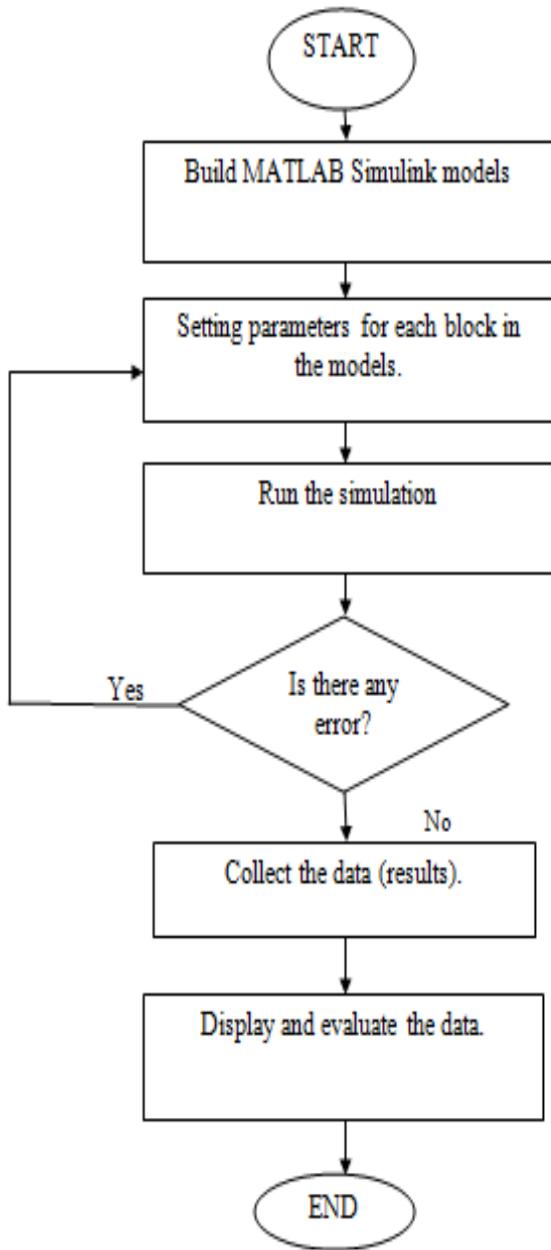


Figure 1: Flowchart for overall simulation process

A. Simple WCDMA Model with Multipath Propagation

The simple WCDMA model is shown in Figure 2 in the next page. In Figure 2, the models consider pseudo-random spreading for a single user system in multipath transmission channel. There are three-path channel in this model. In this system, no fading effects were considered since this model was built to see the performance on the receiver side with present or absence of a Rake receiver, represented by Rake Combiner block. Rake receiver that was built in this model is not a complete Rake receiver system in WCDMA system, it just perform the basic operation of a Rake receiver. As the signals were propagated in three paths, the receiver will employ a diversity reception which combines the independent paths coherently. The model was simulated with a presence of Rake Combiner, then the Rake Combiner block was removed from the model and the model was then simulated. The values for E_b/N_0 were varied from 0 dB to 12 dB.

B. WCDMA Frequency Division Duplex (FDD) Downlink Model

Figure 3 in the next page show the model for WCDMA FDD downlink system. For this model, an existing WCDMA downlink FDD model in the MATLAB Communication Blockset has been modified to be used as the simulation model. A near real time scenario with multiple users and multiple data rate has been simulated and two logical channel was dedicated to the system, control channel (Dedicated Control Channel DCCH) for the transfer of control plane information and traffic channel (Dedicated Traffic Channel DTCH) for the transfer of user plane information [7].

Two parameters that were varied for the Rake receiver performance study were the type of propagation type (Rayleigh multipath channel and AWGN channel) and the spreading factor. In downlink FDD WCDMA system, spreading factor is varied from 512 to 4 [7], but in the proposed model the spreading factor is only up to 256 and the number of fingers for the Rake receiver is one to four fingers.

There were four conditions under channel type, one is the channel type is Additive White Gaussian Noise (AWGN) channel only. The other conditions were AWGN and Rayleigh fading channel with 2 path delay, AWGN and Rayleigh fading channel with 3 path delay and AWGN and Rayleigh fading channel with 4 path delay. For the spreading factor, the spreading factor size chosen were 8, 16, 32, 64, 128 and 256. For both simulation, the value for E_b/N_0 is 12dB.

III. RESULT AND DISCUSSION

A. BER performance analysis with present and present of Rake receiver in simple WCDMA system.

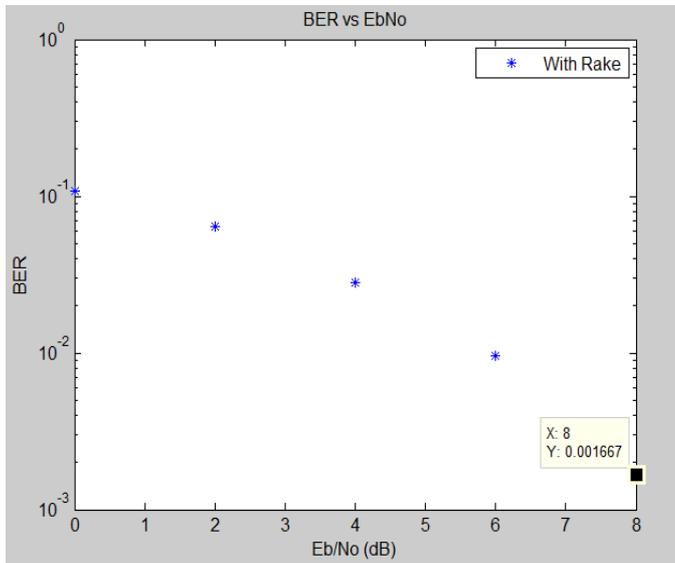


Figure 4: BER versus Eb/No graph with presence of Rake receiver

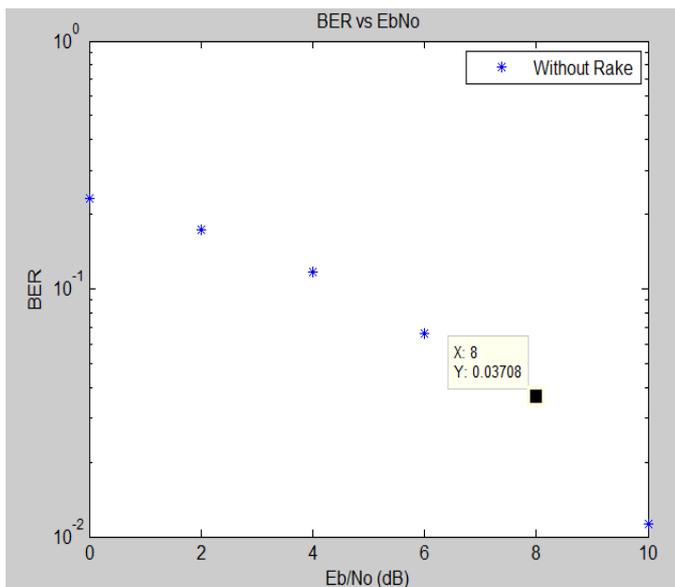


Figure 5: BER versus Eb/No graph without presence of Rake receiver

Figure 4 and figure 5 above show the value of BER in the system as the value of Eb/No varied from 0 dB to 12 dB, with presence and absence of Rake receiver in the system. Comparing both figures, note that the values for BER for figure 4 are less than in figure 5. Taking value at Eb/No at 8 dB, the value for BER in figure 4 is 0.001667 and for figure 5 is 0.03708. The value of BER decreased significantly when using Rake receiver as expected, thus proving the system

performance increase with the presence of Rake receiver, as it combines all the three signals thus produces a better receive signal. However, in both simulations, the value for Eb/No is set from 0dB until 12dB, but the graph in figure 4 only show until 8Db and 10dB in figure 5. This might cause by the setting of parameters in the Random Integer block, but it did not affect the simulation result.

B. BER performance analysis on Rake receiver in different type of channel.

TABLE 1. BER PERFORMANCE ANALYSIS ON RAKE RECEIVER IN AWGN AND RAYLEIGH MULTIPATH CHANNEL

Multipath Profile	Type Of Propagation Channel	BER Value
Profile 1	AWGN	0.5024
Profile 2	AWGN + Rayleigh Multipath (2 path)	0.5161
Profile 3	AWGN + Rayleigh Multipath (3 path)	0.5079
Profile 4	AWGN + Rayleigh Multipath (4 path)	0.5024

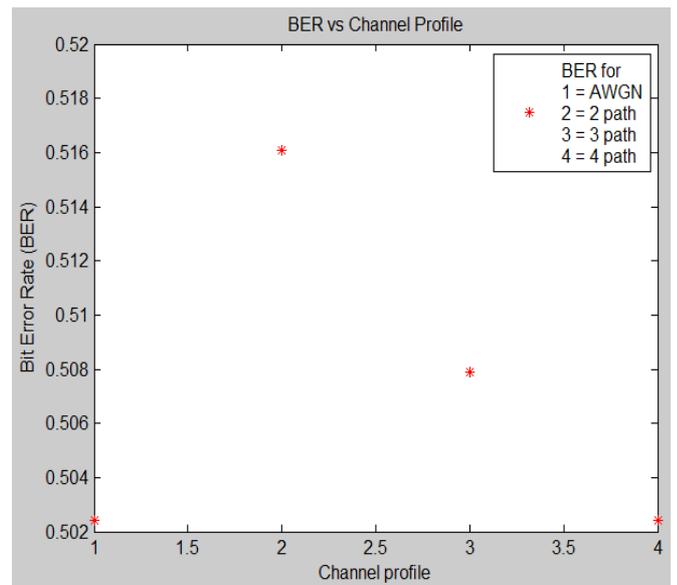


Figure 6: BER graph for in AWGN and Rayleigh fading channel

For analysis of Rake receiver in different types of transmission channel, the result is shown as in table 1. In a system which used AWGN channel only, the value of BER is 0.5024, which is the same as in channel profile 4. BER reduced as the number of multipath fading(profile 2 to 4) transmission increase. This show that the performance of Rake receiver increase as the number of multipath signals increase. Since the available finger in the model is four, then the maximum signal paths is set to four, as each finger despread

one path delay for the received signal. In channel profile 1, with four fingers available and only one signal path (AWGN channel), there was no fading effect so the performance of the system is good compared to profile 1 and 3.. In the multipath profile, there were four enable fingers and the total received signal was the sum of all signal despread by the Rake receiver finger. With four path signal, all the available Rake receiver is occupied thus producing a better signal, the same as in AWGN channel.

C. BER performance analysis on Rake receiver in different number of spreading factor.

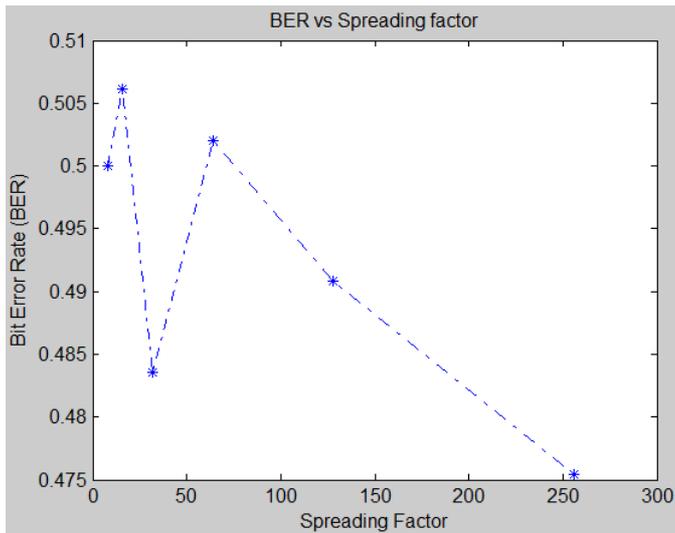


Figure 7: BER versus Eb/No graph for different value of spreading factor (Number of finger = 4, Multipath channel)

Figure 7 above shows the Rake receiver BER performance by varying the Rake receiver spreading factor. The simulation was performed with size of spreading factor was 256, and then reduced to 128, 64, 32, 16 and 8 with number of finger enable is four and in multipath channel. The value of Eb/No is fixed to 12 dB.

Based on the figure, the BER value for 256 spreading factor is less than 128, and 128 is less than 64 spreading factor. At 32 spreading factor, the value for BER is much lower than 128, and the BER value for spreading factor less than 32 is decreasing and decreasing. The result for this spreading factor (32, 16 and 8) cannot be taken into consideration in this project. This may cause by the Gaussian approximate in the AWGN channel, which is in theory is not suitable for short spreading factor. In WCDMA system, spreading factor of 16 in downlink system is considered short and 32 spreading factor is still considered as not high enough spreading factor. For low spreading factors, the Rake receiver performance supposedly degrades since the spreading sequences have bad autocorrelation and intercorrelation properties.

Comparing the BER performance for 256, 128 and 64 spreading factor, it shows that as spreading factor increased, the performance of the receiver also increase as expected. Thus, it proved that the higher the spreading factor, the better the performance of Rake receiver.

IV. CONCLUSION

As a conclusion, this project is successful based on the simulation result. There are some inconclusive data but it is explainable and there were valid factors that affect the result. From the result, we can conclude that in a system with multipath signals, the systems performance can be improved with the used of Rake receiver at the receiver side. Rake receiver also work best in multipath channel compared to normal channel and when all the available Rake receiver fingers are fully utilized by the entire path delay signals whereas in this model the total number of fingers is four. As for the spreading factor, Rake receiver is at its highest performance at the highest number of spreading factor, which is 256.

For future recommendations, it is suggested that other parameters that could affected the performance of Rake receiver can be considered in the simulation. Some examples of the parameters are speed of the terminal and data rates. The simulation could also be done under conditions when the transmit and received power are not equal, in multi-user scenario apart from only as white additive noise or use a new modulation techniques such as OFDM in the simulation model.

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