ISSN 2229-5518

Performance of DS-WCDMA/QPSK in Mobile Rayleigh Channel

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Abstract— The aim of this paper are to study, analyze and design software program to simulate the link performance of mobile communication system under the impairment of the multiple access schemes, down-link thermal noise and the multipath fading in the mobile channel. For this purpose, modeling and simulation has been used to study the effects of nonlinearities in mobile channel using spread spectrum for Direct Sequence Code Division Multiple-Access, with Quadrature Phase shift Keying Modulation (DS-CDMA/QPSK).

Index Terms— DS, QPSK, RayLeigh, Simulation WCDMA,

1 Introduction

Wide band Code Division Multiple Access was adopted as the physical layer protocol for third generation (3G) networks, which Offer higher data rates and more efficient spectrum utilization Compared to second generation networks [1]. WCDMA technology is the most widely used third generation system which is spreading over a wide bandwidth by multiplying the user information with spreading sequence in WCDMA [2].

The 3GPP (3G Partnership Project for wideband CDMA standards) body is developing WCDMA for both wide area mobile cellular coverage as well as indoor cordless type applications [3]. WCDMA requires a minimum bandwidth allocation of 5MHz, which is an important distinction from the other generation standards [4]. Packet data rates up to 2Mb/s per user in indoor or small-cell outdoor environments and at rates of up to 384 Kbit/s in wide-area coverage is supported by WCDMA [5].W-CDMA systems can employ the high order modulation (MPSK or M-QAM) to increase the transmission data rate with the link quality control.[6] . WCDMA is a promising technique for achieving the high data capacity and spectral efficiency requirements for wireless communication system of the near future [7].

Direct-Spread WCDMA Principles: PN codes have some unique properties. One of them is that any physical channel or user application, when spread by a PN code at the transmitter, can be uniquely identified at the receiver by multiplying the received baseband signal with a phase coherent copy of that PN code [8] [9].WCDMA employs coherent detection on uplink and downlink with the usage of pilot symbols and supports multiple types of handoffs between different cells including soft handoff, softer handoff and hard handoff[10].

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2 SYSTEM MODEL

The system model is depicted in Fig 1.

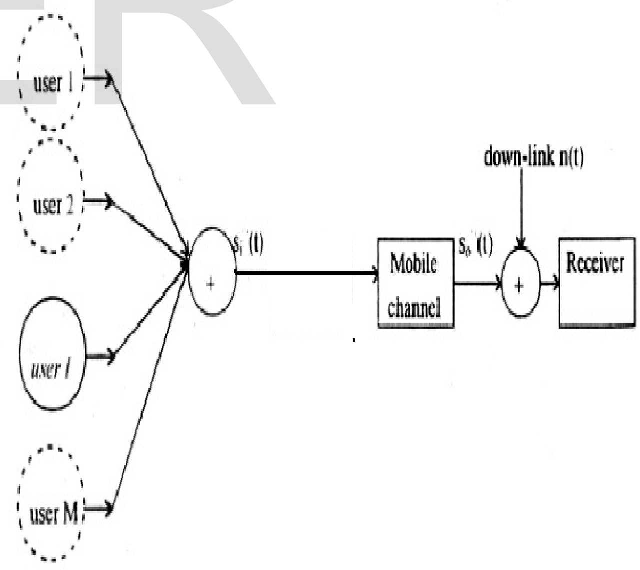

Fig (1): DS- WCDMA system model

In DS-WCDMA, users employ their own sequence to spread the information data. The information data of each user is modulated by QPSK then the first bits of modulated data is spreaded by the code sequence and the spreaded data of all users are transmitted to the base station at the same time. The base station detects

ISSN 2229-5518

the information data of each user by correlating the received signal with the code sequence allocated to each user. The transmitted data in the in-phase channel and Quadrature phase modulated by QPSK are multiplied by the code sequence used to spread the transmitted data then the transmitted signal is contaminated in a Rayleigh fading channel.

At the receiver, AWGN is added to the received data, the resample data are the data of all users. By correlating the data with the spread code used at the transmitter, the transmitted data of all users is detected.

3 SMATHEMATICAL MODEL

In this model each user sends a QPSK signal with in phase (I) and Quadrature (Q) components spread by the respective user code sequence with high power. Analytically, The general form of QPSK signal can be defined as: [11]

$$S_i = \sqrt{\frac{2E_{\min}}{T_S}} a_i \cos(2\pi f_c t) + \sqrt{\frac{2E_{\min}}{T_S}} b_i \sin(2\pi f_c t) \quad (1)$$

$$0 \le t \le T, i = 1, 2, ..., M$$

Where $E_{\min}$ is the energy of the signal with the lowest amplitude and a_i and b_i are pair of independent integers chosen according to the location of the particular signal point.

The continuous time representation of the equivalent baseband DS-CDMA signal is given by:[12]

$$S_{DS}(t) = \sum_{u=1}^{N_u} \sum_{m=-\infty}^{\infty} \sum_{n=0}^{N-1} D_m^u c_n^u g_n(t - mT) \quad (2)$$

$$g_n(t) = \begin{pmatrix} e^{j2\pi n(t-Tc)} & t \in [0,T] \\ 0 & t \notin [0,T] \end{pmatrix} \quad (3)$$

Where gn(t-mT) represents the nth sub carrier, T is the duration of the MC-WCDMA symbol and Tc is the duration of the chip. the signal is low pass filtered before transmission.

where Dmnu is the S/P output for time slot m, sub carrier n and user u , cu(t) is the Walsh code for user u and gn(t-mT) is the nth sub carrier .

The average probability of error Pp for in-phase branch can be expressed as [13].

$$\mathrm{p_p} = \frac{1}{2}\left[\mathrm{P_1}\left\{s_p > 0 \,|_{dp} = -1\right\} \mathrm{p_r}\left\{s_p < 0 \,|_{d_p} = +1\right\}\right] \quad (4)$$

Assuming that the probabilities of transmitting symbols -1 and +1 are equal (i.e.):

$$\mathrm{P_p} = \mathrm{P_r}\left\{s_p < 0 \,|_{\mathrm{d_p}} = +1\right\} \quad (5)$$

Assuming that the number of chip per bit, N is large, the decision variable sp can be approximated according to the central limit theorem by a Gaussian random variable.

The error probability in an AWGN channel for QPSK using coherent detection can be approximated by: [12]

It was shown in [7] that the BER for an AWGN channel obtained from IGA is

significantly more accurate than the BER obtained from the SGA especially for small number

of user, k. Thus by applying SIGA, overall BER can be represented as [7].

$$p_e = \frac{1}{3}\left[1 - \frac{N}{\sqrt{\mu_\xi + N^2}}\right] + \frac{1}{12}\left[1 - \frac{N}{\sqrt{\mu_\xi + \sqrt{3}\sigma_\xi + N^2}}\right] \quad (6)$$

Where:

$$\mu_\xi = \frac{2N}{3}(k-1)$$

$$\sigma_\xi = (k-1)\left[\frac{1}{45}\left(43N^2 + 18N - 18 + (k-2)\frac{N-1}{9}\right)\right] \quad (7)$$

K: number of users

N: code length

Out put of low pass filter of a synchronous system for user 1 can be represented by:

$$y_1 = \int r(t)\cos\omega_c t dt = S_1 + I_1 + n_1 \quad (8)$$

Where n is zero mean Gaussian random variable with $\sigma_{n_1}^2 = N_0 \frac{N}{4}$

S_1 is signal component $S_1 = \pm AN$ and interference term is given by:

$$I_1 = \sum_{k=2}^{k} A_k b_0^k \cos\phi_k \int a_k(t) a_1(t) dt \quad (9)$$

Since a sum of independent random variable has Guassian distribution it follows that I1 is Gaussian random variable with zero mean and variance. By symmetry and using independence I1 and n1 we have:

$$p_{e\perp A1} = Q\left[\frac{A_1 N}{\sqrt{\frac{N_0 N}{4} + \sum_{k=2}^{k} N^2 \rho_{k+1}^2}}\right] \quad (10)$$

And averaging over probability densityfunctionA1,bit error rate for Rayleigh faded user is :

$$p_e = \frac{1}{2}\left[1 - \frac{1}{\sqrt{1 + \frac{N_0}{4N} + \sum_{k=2}^{k} \rho_{k+1}^2}}\right] \quad (11)$$

For uniform random signature sequence $E\left[\rho_{k+1}^2\right] = \frac{1}{N}$

$$p_e = \frac{1}{2}\left[1 - \frac{1}{\sqrt{1 + \frac{N_0}{4N} + \frac{k-1}{N}}}\right] \quad (12)$$

4 PRINCIPLE OF MONTE CARLO SIMULATION

IJSER style is to not citations in individual brackets, followed Monte Carlo simulation for estimating the bit error rate in mobile communication system is shown in fig (2) that involves the following steps:

The signal is generated by form Inphase (I) and Quadrature (Q) data streams for all users for DS-CDMA/QPSK.

- Then the output signal encounters the degrading effects of the propagation channel.

Channel type is modeled to represent environmental conditions of Rayleigh channel.

Before detection of the signal, it is subjected to the effect of the Additive Gaussian noise (AWGN).

- The detection technique is implemented where despreading sequence signal is assumed after demodulation. Finally the decision and the estimation of error rate are performed as:

$$P_e^{\Lambda} = \frac{1}{N}\sum_{k=1}^{N} g(Y(k)) \quad (13)$$

where g(Y(k)) = 1 if Y(k) ≠ A(k) and g(Y(k)) = 0 if Y(k) = A(k) (this step is equivalent to counting errors).

The accuracy of estimates obtained via MC simulation will depend on the estimation procedure used, sample size N, the ability to reproduce sampled values of the input processes accurately, and modeling assumptions and approximations. In general, the accuracy will be proportional to large number of samples will have to be simulated in order to obtain accurate estimates via MC simulations. While the MC technique is general and can be applied to a broad range of problems, the large sample size requirements and hence the length of simulation are often limiting factors.

5 SIMULATION

A computer program using Matlab software program is implemented to simulate the BER performance in a AWGN and Rayleigh fading environments of DS-CDMA.

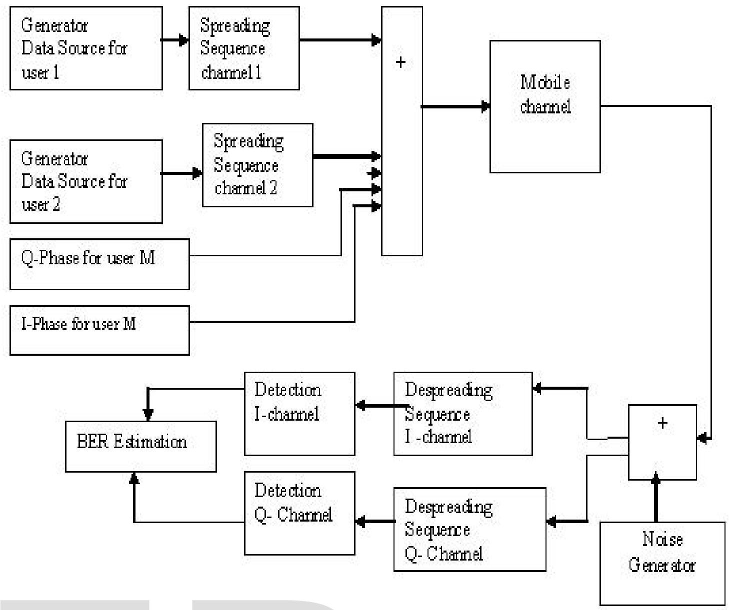

Fig. 2.Monte Carlo Model of a Mobile Channel[13]

The DS- WCDMA model is simulated for s Walsh spreading sequences code in the presence of Rayleigh channel by considering multi users and Quadrate Phase Shift Keying (QPSK) as modulation scheme. The simulation parameters used in the simulation are given in Table 1. Then the BER performance of DS-WCDMA is calculated and compared by varying the length of above mentioned sequences. The BER is the number of bit received as errors divided by the total number of transmitted bits during a studied time interval

Table.1, Simulation Parameters

Parameter	Value
Spreading code	WALSH
Code length	32,64
No.of users	1,4,7
Modulation techniques	QPSK
SNR dB	(0,2,4,6,8,10,12,14,16)
Channel	Rayleigh channel with AWGN

ISSN 2229-5518

6 Simulation Results

Matlab software program is executed for estimating the error rate at different values of the control parameters (signal to noise ratio SNR and propagation channel).

The performance results are plotted and analyzed for multi-user WCDMA/QPSK in mobile channel for different cases.

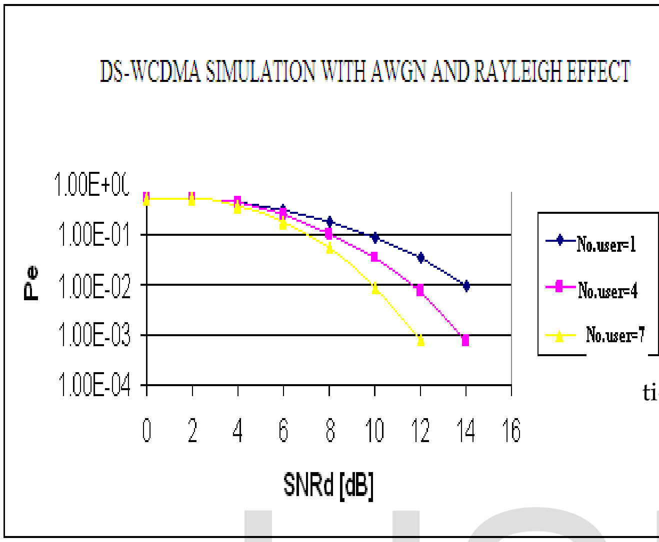

Fig. 4. Probability Of Error Performance Over A Rayleigh Channel For Different Number Of Users

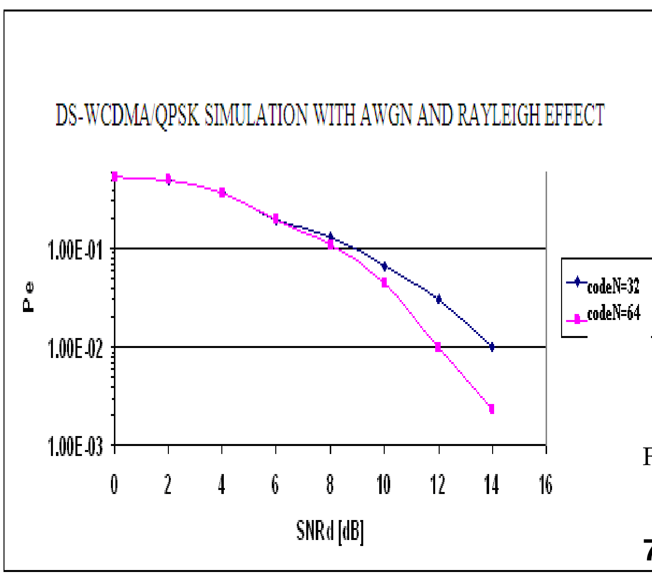

Fig 5 Performance Of Rayleigh Channel, Comparison Between Different Code Lengths

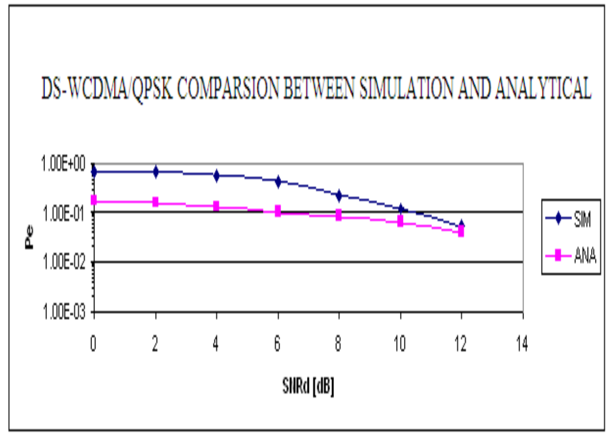

Fig. 6 Comparison Between Analytical And Simulation Performance For 7 Number Of User

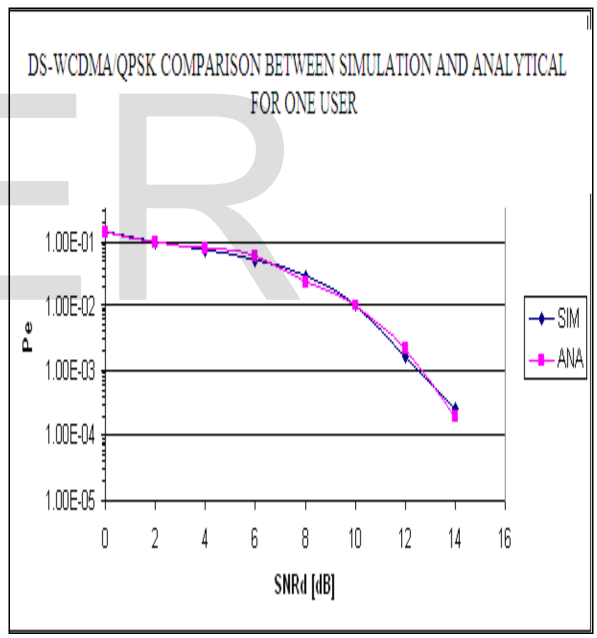

Fig 7. Comparison Between Analytical and Simulation For Rayleigh Channel Performance For One Number Of User

7 Conclusion

In this paper, the performance of DS-CDMA signal transmission through mobile channels system with QPSK mapping in the presence of AWGN and multipath fading using computer simulation model was studied and analyzed it is performance in terms of the BER was explored. The results obtained from simulation models show that:

increasing the signal to noise ratio reduces the value of bit error rate (BER).

From the obtained results increasing the code length reduces the value of bit error rate up to a certain limit.

Also, increasing the number of users increases the value of bit error rate to a certain limit depending on the SNR. Also the simulation method results show that BER depends on mobile propagation channel and noise.

The obtained results show that increasing the number of users (M), the system performance degrades because (MAI) dominate.

The obtained results show that increasing the SNR improves the performance up to a certain limit after which any further increase does not have any significant effect on the quality of the received signal.

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