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Effect of Interference on Capacity of CDMA Technology

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Abstract: Past some decade, mobile communication system has developed from 1G, 2G and 3G and now it has to enter into 4G.CDMA is most eminent multiple access scheme used in 3G.The number of us count in CDMA network exponentially rises and it limits the Capacity of CDMA network. In this article, the performance of CDMA network in wireless environment has been analyzed, using the parameters including the number of users, spreading gain, thermal noise,Multiple Access Interference and BER of CDMA with user count.

Keywords:CDMA,Spreading gain, BER, Multiple User Interference.

1. INTRODUCTION

Frequency and time are two resources for radio communication system. Division by frequency, so that each pair of communicators is allocated part of the spectrum for all of the time, results in Frequency Division Multiple Access (FDMA). Division by time, so that each pair of communicators is allocated all (or at least a large part) of the spectrum of part of the

Time results in Time Division Multiple Access (TDMA). In Code Division Multiple Access (CDMA), every user will be allocated the entire spectrum for all the time shown in Figure 1.1. CDMA uses codes to identify connections. The performance of the CDMA scheme is mainly limited by multiple access interference (MAI) and inter-symbol interference (ISI). In this paper We analyze the BER of CDAM with user count, spreading gain, and signal-to-noise ratio, and The effect of how interference grows as the number of users increases.

For an economical point of view capacity of any mobile communication is one of the important concerns to the designer. The measure of economic usefulness is not depending upon the maximum number of users which can be serviced at any specific time, but the peak load that supported by the given quality and with the availability of service [1]

This article organized in 7 sections. Section 2 shows The basic CDAM operation, Section 3 represents the system model with Rayleigh fading, section 4 represents the calculation if BER in CDMA, section 5 represents the interference effect, section 6 represents result discussion and last concluded the paper.

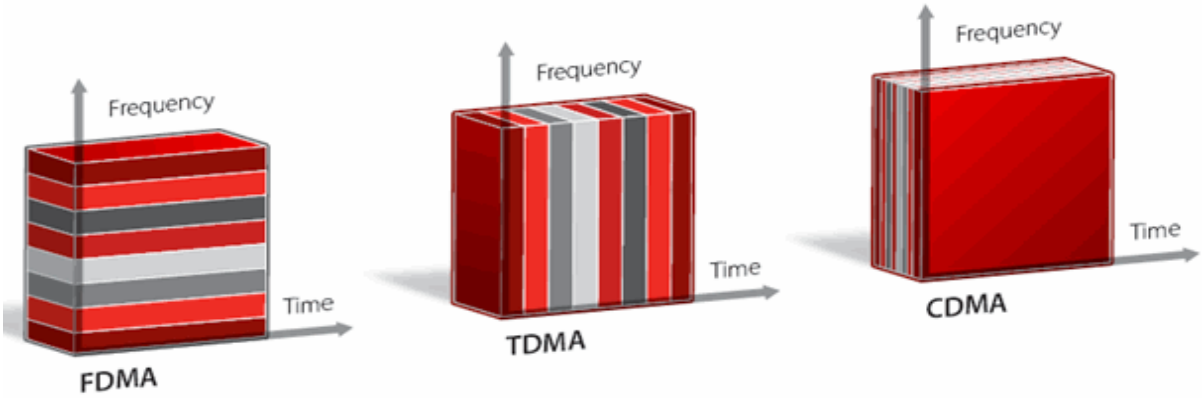

Figure 1.1

2.CDMA BASIC OPERATION

CDMA is known as Code Division Multiple Access. Multiplexing is Technique by using this we can transmits multiple signal or burst of information signal over a common communication link at same time. By this technique a signal channel can we use by multiple users. In code division multiple access (CDMA) systems, the

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narrowband message signal is multiplied by a very large bandwidth signal called the spreading signal. The spreading signal is a pseudo noise code sequence that has a chip rate which is orders of magnitudes greater than the data rate of the message. All users in a CDMA system use the same carrier frequency may transmit simultaneously.
Each user has its own pseudorandom. Codeword which is approximately orthogonal to all other codeword. For detection of the message signal, the receiver needs to know the codeword used by the transmitter. Each user operates independently with no knowledge of the other users[1][2]. In Figure 1.2 and Figure 1.3 CDMA Transmitted and Recevied Signal shown.
Encoded Signal=(Original Data)*(Chip Code)
Decoded Signal = (Received Summed signal)*Chip code

Chip code is also known as **Spreading** Code Orthogonal Code Waslh –Hadamard Code, Pseudo Noise Code.

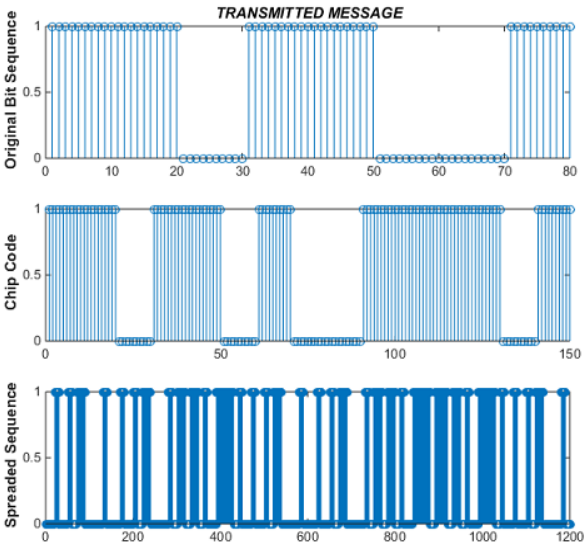

Figure 1.2 CDMA Trasmitted Signal

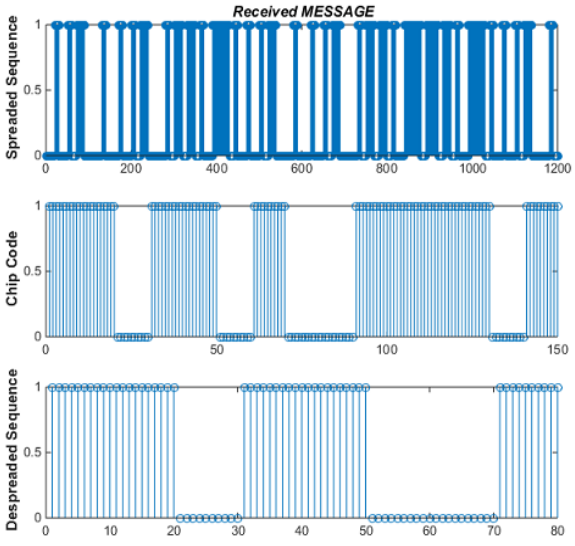

Figure 1.3 CDMA Received Signal

3. SYSTEM MODEL WITHRAYLEIGH FADING

Rayleigh Fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it reaches the Receiver. CDMA System modeling considering Rayleigh Fading Model.
Transmitted signal X(n) in CDMA is product of user signal a_0 and chip code or spreading code $c_0(n)$ each chip length is N bit long.

$$X(n) = a_0 c_0(n) \qquad (2.1)$$

Received Signal after passing through Rayeigh Fading channel is given as

$$Y(n) = hX(n) + W(n) \qquad (2.2)$$

h is channel fading coefficient, which is depends upon attenuation and delay in the signal causes by multipath, w(n) is white noise with variance $\sigma^2$and zero mean E{W(n)}=0, E{W(n).*W(m)}=0 for m≠n it means noise are independent or uncorrelated.

The value of X(n)substituted in (2.2)

$$Y(n) = ha_0 c_0(n) + W(n) \qquad (2..3)$$

During the Reception of CDMA, the receive signal correlated with user code or users spreading code, so the output of CDMA can be given as

$$\frac{1}{N}\sum_n Y(n)c_0 \qquad (2.4)$$

Y(n) value from Eq(2.3) substituted in Eq(2.4) and the result as

$$\frac{1}{N}\sum_n \big(ha_0 c_0 + W(n)\big)c_0(n) \qquad (2.5)$$

Eq(2.5) further can be expended as

$$\frac{1}{N}\sum_n ha_0 c2_0(n) + \frac{1}{N}\sum_n W(n)c_0(n) \qquad (2.6)$$

Equation (2.6) contain both signal power and noise power, the first part is signal power and 2nd part is noise power. $c_0(n)$having value +1 or -1 therefore$c_0^2(n)$ is +1 hence Equation (2.6) can be simplified as

$$ha_0 + \frac{1}{N}\sum_N^{N-1} W(n)\, c_0(n) \qquad (2.7)$$

The noise power is given as

$$\varpi = \frac{1}{N}\sum_n W(n)\, c_0(n) \qquad (2.8)$$

Since noise is independent and its means is zero,its expected vale given as

$$E\{\varpi) = E\{\frac{1}{N}\sum_n W(n)\, c_0(n)\} = 0 \qquad (2.9)$$

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Signal power = $E\{|h|^2\ |a_0|^2\}$ (2.10)

The above equation can be written as,signal power expresses as below

$|h|^2\ E\{|a_0|^2\}$ (2.11)

$E\{|a_0|^2\}$ is considered as transmitted signal power and represented as P, hence signal power can be finally given as

$|h|^2\ P$ (2.12)

SNR at Receiver = $\frac{|h|^2\ P}{\sigma^2\ /N}$ (2.13)

$SNR_R = |h|^2\ .N.SNR_T$ (2.14)

N is known as spreading gain or processing gain of CDMA system.

4.BER OF CDMA

Bit error rate is one of the most important parameters for a digital transmission system. The Qos of any digital communication is given by this parameter. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transmitting bits during a studied time interval.

BER is a unit less performance measure, often expressed as a percentage.Bit error rate is used in accessing systems that transfer digital data from one place to another

$$BER = \frac{Numberof Error}{TotalNumberofbit}$$

BER affected by transmission channel noise, interference, distortion, bit synchronization problems, attenuation, wireless multipath fading, etc.

Signal to noise ratios and E_b/N_o figures are parameters that are more associated with radio links and radio communications systems. In terms of this, the bit error rate, BER, can also be defined in terms of the probability of error P_e.

BER of CDMA System for considering wireless channel

$$BER = \frac{1}{2}\left(1 - \sqrt{\frac{N.SNR}{2+SNR}}\right) \quad (3.1)$$

The following parameters are utilized to calculate BER Total Words = 64*10, Processing gain = 64, Number of users = 12, Number of repeation = 10, SNR = 300. The Reversel ink and multipath are used.

Figure 1.4 shows when number of user increases then BER increases and number of error also increases.

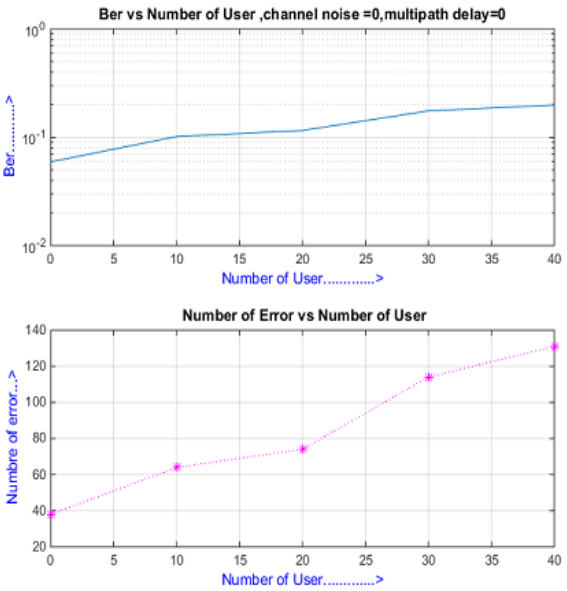

Figure 1.4 Performance of CDMA network

5. EFFECT OF INTERFERENCE ON CDMA

In CDMA communication system, there is mainly Multiple Access interference or multiuser interference. MAI limits capacity and put down the BER performance of CDMA system. Interference between different direct sequence users is referring asas MAI. When the number of the user increases in the CDMA system than MAI also rapidly increases and the whole CDMA system became interference limited.

Let assume I_I it is mean value of power spectrum density of interference noise and this noise is due to other channel.

$$I_I = \alpha(N-1)E_B/G \quad (4.1)$$

E_b is the average bit energy of any signal of the channel,
Processing gain G=$\frac{Chip\ rate}{inormation\ \ rate}$
α is a voice inactivity factor .

If N_0 stands for thermal noise of the system, then the mean total noise power spectral density is the sum of the interference noise and the thermal noise is given as

$$I_t = \frac{\alpha(N-1)E_B}{G} + N_0 \quad (4.2)$$

We can then derive the number of total CDMA channels N

$$N = 1 + \frac{G}{\alpha}\left[\left(\frac{E_b}{I_t}\right)^{-1} - \left(\frac{E_b}{N_0}\right)^{-1}\right] \quad (4.3)$$

It is the upper limit of number of user which is limit by Interference.

Figure 1.5 shows interference Vs Number of users for α'= 3/8, E_B=2dB (1.9953),G=240 using equation (4.2).

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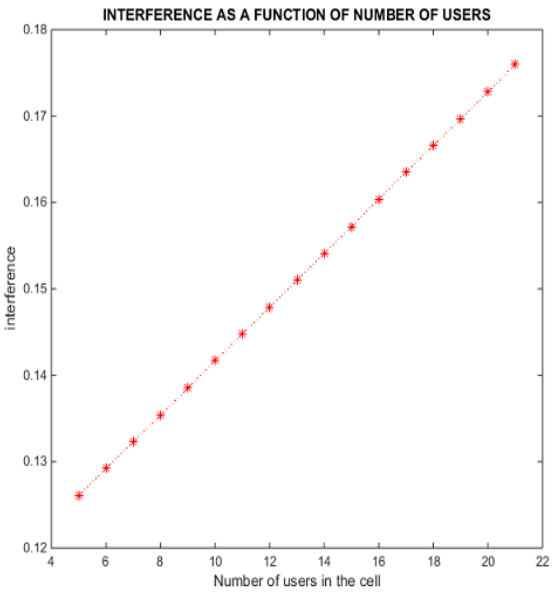

Figure 1.5 Interference Vs Number of users

6. SIMULATION RESUALT AND DISCUSSION

Figure 1.3 shows the BER performance of CDMA and it is clear that BER degrade as the number of user increases, and error also increases.Equation 4.3 gives the upper limit of CDMA capacity, which is totally depends upon Interference arises due to multiple users in CDMA network. Figure 1.5 is the plot between the number of users and interference which shows that when the number of user increases the Interference increases.

7. CONCLUSION

In this paper, weanalyze BER performance with respect to the number of users, and Interference .BER Increases as number of user increases and when the number of user increases, the error also increases. Therefore CDMA communication system is interference limited,CDMA is mainly limited by MAI which causes low SNR at the receiver and it also limit the capacity of a CDMA communication system.

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