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On Using Space Diversity Technique in Reducing the Effect of Multipath Fading in CDMA20001x Mobile Radio Network

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***Abstract* - In wireless communication, signal fading is the attenuation that a carrier-modulated signal experiences over a certain propagation media. The fading can be as a result of the signal undergoing multipath propagation which results in multipath fading or as a result of shadowing from obstacles affecting the wave propagation and is referred to as shadow fading and so on. One of the 3G networks, CDMA 20001x is prone to multipath fading. Thus, this paper present space diversity technique as one of the techniques involve in reducing the effect of multipath fading in CDMA20001X.The results obtained in the presence of several antenna elements and in one antenna element are simulated in Matlab. The result show that using space diversity technique reduces the BER and improves the SNR in order to enhance the channel capacity of the network.**

***Keywords* - CDMA20001X, multipath fading, space diversity, BER.**

I. INTRODUCTION

Wireless communication is, by far, the fastest growing aspect of the communication industry. As such, it has captured the attention of the media and the imagination of the public. But, there are many technical challenges that must be overcome in order to make this vision a reality. A signal transmitted on wireless channel is subject to fading, shadowing, interference, delay spread, Doppler spread and propagation loss [1]. These effect reduces the performance of the wireless communication network such as CDMA20001x which is developed for 3G communication network [2]. The various means of solving these problems include spread spectrum techniques, space-time coding and antenna diversity [3]. But, antenna diversity also known as space diversity is more effective in solving the problem of multipath fading in wireless network [4]. Diversity is used to provide the receiver with several replicas of the same signal and also a means of combating effectively the problem of signal degradation in multipath environment [5]. There are many ways in which diversity can be achieved in wireless networks. These include time diversity, frequency diversity and space diversity [6]. In time diversity, the information bits are repeatedly transmitted at time intervals that exceeds the co-herence time of the channel, so that multiple repetitions will undergo independent fading conditions, when they are received and combined. Frequency diversity involves transmitting information on more than one carrier frequency. The same signal at sufficiently spaced carrier frequencies will provide independently fading versions of the signal, thus the probability of simultaneous fading of combined signal at receiver will be very low. Space diversity involves the use of two or more antennas separated at a considerable distance in such a way that the signal will undergo independent fading [7]. The implementation of space diversity has been shown by researchers to improve the channel capacity and reduce the multi-path interference at the expense of adding extra equipment (antenna, combiner) to the receiver but no extra spectrum is consumed [8]. Diversity gain is the most important characteristic in space diversity system, and can be obtained from correlation coefficient and embedded element efficiency [9]. When the embedded element efficiency is not taken into consideration, apparent diversity gain is obtained, else, effective diversity gain, which is an absolute measure of diversity gain [10].

II. DIVERSITY COMBINING METHODS

Diversity combining is used to overcome the problem of fading in radio channels and utilizes the fact that the signals arriving at different locations fade at different rates. The three most prevalent space diversity combining techniques are selection combining (SC), equal gain combining (EGC) and maximal ratio combining (MRC) [11]. Selection combining chooses the signal with the highest instantaneous signal to noise ratio of all branches, so that the output SNR is equal to that of the best incoming signal and makes it available to the receiver at all times [12]. Maximal ratio combining co-phases the signal branches, weights them according to their respective SNR's and takes their sum, thus, yielding the highest SNR [13]. In equal gain combining, the gain of the branches is set to a particular value that does not change unlike in MRC[14].

2.1 Equal Gain Combining

In equal gain combining technique as shown in Figure 1, the gains of the branches are all set to a pre-determined value and are not changed. Both branch signals are multiplied by the same branch gain (G) and the resulting signals are co-phased and summed. The inputs to the equal gain combiner are both Rayleigh distributed signals s_1 and s_2 received with envelopes r_1 and r_2, and with phase θ_1 and θ_2 respectively. In the presence of additive independent noise voltage sources n_1 and n_2, both n_1 and n_2 are zero mean white Gaussian random variables with a variance of N;

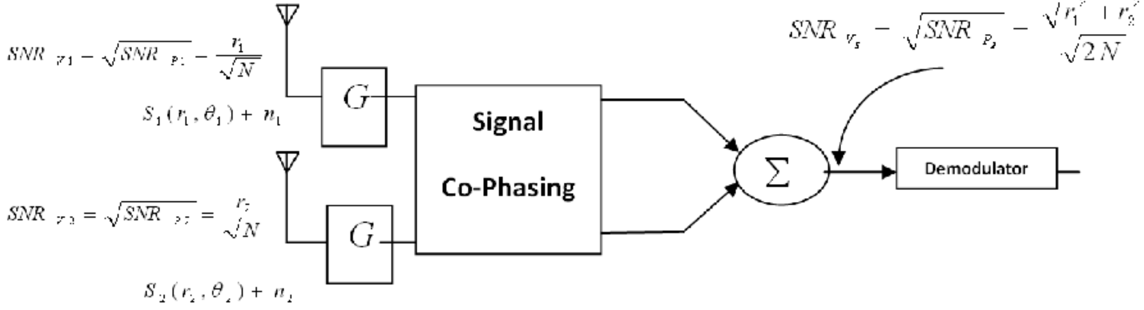

Fig.1. Block diagram of a two-branch Equal Gain Combining for equal noise powers in both branches

The amplitude of the signal of interest after EGC can be evaluated by multiplying the received signal envelopes r_1 and r_2 at t_0, by equal gain, G, on each branch, which when summed gives the signal envelope after equal gain combining at a time t_0 :

$$V_{S,E}(t_0) = r_1(t_0)(G) + r_2(t_0)(G) = G(r_1(t_0) + r_2(t_0)) \quad (1)$$

The instantaneous signal power, $P_{S,E}(t_0)$, is given by the envelope squared, thus

$$V_{P,E}(t_0) = V_{S,E}(t_0)^2 = G^2(r_1(t_0) + r_2(t_0))^2 \quad (2)$$

The noise component after EGC for all time t_1 $V_{N,E}(t_0)$, also gets multiplied by the gain G in both branches and evaluates after co-phasing and branch addition to

$$V_{N,E}(t_0) = n_1(G) + n_2(G) = G(n_1 + n_2) \quad (3)$$

The noise power, on the other hand, for a given event r_1(t0) and r_2(t0) is a stochastic variable whose power can be evaluated by computing the second moment of the probability density function of $V_{N,E}$. The noise power, $P_{N,E}$ is obtained by taking the expected value of the noise signal squared to yield (4).Thus,

$$P_{N,E}(t) = E\left[V_{N,E}(t)^2\right] = E\left[G^2(n_1^2 + 2n_1n_2 + n_2^2)\right] \quad (4)$$

$$P_{N,E}(t) = E\left[V_{N,E}(t)^2\right] = G^2E\left[n_1^2\right] + 2G^2E\left[n_1n_2\right] + G^2E\left[n_2^2\right] \quad (5)$$

The constant G^2 factors out of the expected value operator and the middle term involving the joint expectation of n_1 and n_2 evaluates to zero. The output noise power after equal gain combining evaluates to

$$P_{N,E}(t) = E\left[V_{N,E}(t)^2\right] = G^2E\left[n_1^2\right] + G^2E\left[n_2^2\right] = 2G^2N \quad (6)$$

The instantaneous power signal-to-noise ratio is the ratio of signal to noise power and at t_0 evaluates to

$$SNR_{P_E}(t_0) = \frac{Power_{Signal}(t_0)}{Power_{Noise}(t_0)} = \frac{P_{S,E}(t_0)}{P_{N,E}(t_0)} = \frac{V_{S,E}(t_0)^2}{E\left[V_{N,E}(t_0)^2\right]} \quad (7)$$

$$SNR_{P_E}(t_0) = \frac{G^2(r_1(t_0) + r_2(t_0))^2}{2G^2N} = \frac{1}{2N}\left(r_1(t_0) + r_2(t_0)\right)^2 \quad (8)$$

Similarly, the voltage signal-to-noise ratio (or SNRVE (t0)), after equal gain combining can be computed from (8) and gives

$$SNR_{P_E}(t_0) = \sqrt{SNR_{P_E}} = \frac{1}{\sqrt{2N}}\left(r_1(t_0) + r_2(t_0)\right) \quad (9)$$

Since the value of G does not affect the output signal-to-noise ratio, this value is usually set to unity in practical applications.

3. RESULTS AND ANALYSIS

A personal computer equipped with MATLAB version 7.5 and Simulink was used as a platform for the simulation. During the simulation, the various parameters that were considered during the simulation are shown in Table 1 and the results are shown in Table2 and Table 3

Table 1.Simulation parameters

Channel	Rayleigh Fading channel+ AWGN
Eb/No(dB)	1-20
Channel Bandwidth(MHz)	1.25
Chip rate	1.2288
Modulation	QPSK uplink/BPSK downlink
Synchronization mode	synchronization
Receiver type	Rake Receiver
No of antenna	1-25

Table2.Simulation result for SNR for varying number of antenna element

No. of Antenna Elements	Simulated SNR	Theory_SNR
1	1.52	0.00
2	2.98	1.00
3	4.49	2.00
4	6.02	3.00
5	7.53	4.00
6	8.99	5.00
7	10.49	6.00
8	12.01	7.00
9	13.52	8.00
10	15.06	9.00
11	16.41	10.00
12	18.02	11.00
13	19.60	12.00

14	21.04	13.00
15	22.43	14.00
16	24.06	15.00
17	25.45	16.00
18	27.01	17.00
19	28.53	18.00
20	30.05	19.00
21	31.54	20.00
22	32.95	21.00
23	34.49	22.00
24	36.13	23.00
25	37.46	24.00

Table 3.Simulation result for 2x1 Alamouti Scheme

Eb/ No (dB)	Sim_ BER	Theory_ BER Alamouti_nTx 2_nRx1	Theory_ BER MRC_nRx2
0	0.1150	0.1151	0.0581
1	0.0944	0.0939	0.0441
2	0.0748	0.0748	0.0328
3	0.0588	0.0582	0.0238
4	0.0443	0.0442	0.0169
5	0.0328	0.0329	0.0081
6	0.0238	0.0239	0.0081
7	0.0169	0.017	0.0055
8	0.0120	0.0119	0.0037
9	0.0080	0.0082	0.0024
10	0.0055	0.0055	0.0016
11	0.0037	0.0037	0.0010
12	0.0025	0.0024	0.0007
13	0.0016	0.0016	0.0004
14	0.0010	0.0010	0.0003
15	0.0007	0.0007	0.0002
16	0.0004	0.0004	0.0001
17	0.0003	0.0003	0.0000
18	0.0002	0.0002	0.0000
19	0.0001	0.0001	0.0000
20	0.0001	0.0001	0.0000

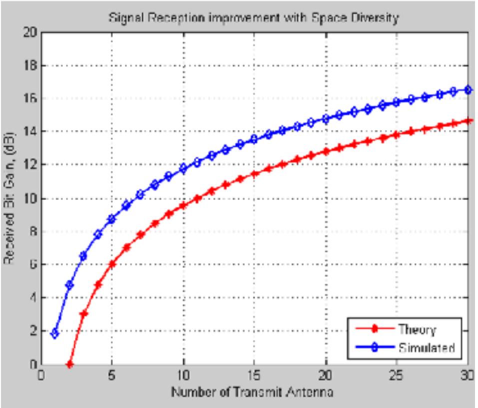

Fig.1. Plot of Received Bit Gain Vs Number of antenna

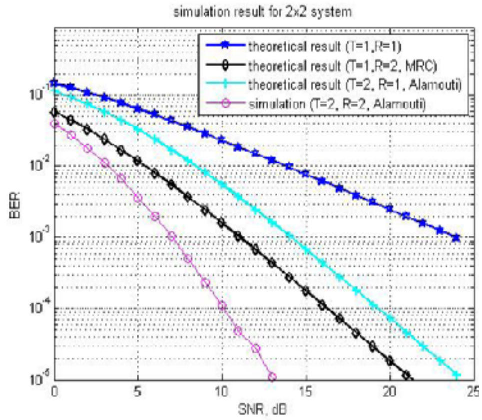

Fig.2. Performance of BER Vs SNR for 2x2 antenna system.

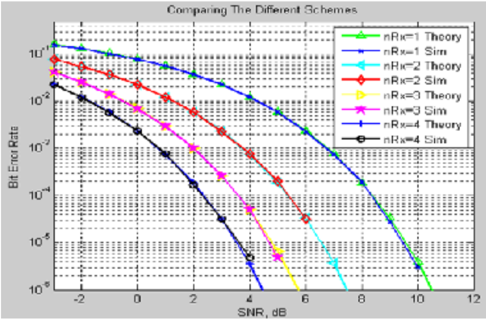

Fig.3. BER Vs SNR performance in presence of antenna diversity.

IV. SUMMARY OF RESULTS

The signal-to-noise ratio gain in dB is plotted against the number of antenna elements for theory and simulated results as indicated in Figure1. The performance of the system increases with increasing number of antenna elements as shown by SNR gain values. Figure 2 shows the BER versus the output SNR of coherent BPSK with MRRC and two-branch transmit diversity in Rayleigh fading. The simulation output shows that the Alamouti scheme with two transmit and a single receive antenna achieves the same diversity order as MRRC scheme with one transmit and two receive antenna. However, it can be seen that the scheme is 3dB behind than MRRC. The fact is that due to the energy from two transmit antenna in Alamouti is half of the energy radiated from a single antenna in MRRC. If the energy radiated is same for each transmit antenna in Alamouti and MRRC, then the resulting curve would be the same. Figure 3 shows BER versus SNR performance in presence of antenna diversity. The graph in Figure 3 shows that as diversity increases at the receiver end BER is reduced.

V. CONCLUSION

The simulated results for varying number of antenna element as shown in Figure 1 indicate that as diversity increases the BER is reduced and thus the performance of the wireless network is improved. Also, the results of the simulations in which BER performance of Alamouti scheme comprising 2x1, and 1x2 antenna systems for MRC shows that space diversity can provide high data transmission and therefore there is no need to increase the transmit power and bandwidth.

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