Comparative Analysis of Power Control Algorithms for Uplink in CDMA System-A Review

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Abstract *– In this paper, the comparative performance analysis of different closed loop power control algorithms with base station assignment technique (BSA-MTP) based on minimizing the transmitter power for Code Division multiple access (CDMA) receiver on Uplink in a 2D urban environment is used. It is observed that the convergence speed of the joint SSPC algorithm and SB methods is faster than that in the other algorithms used. The results indicate that the SSPC algorithm and the BSA-MTP technique can improve the network bit error rate in comparison with other conventional methods. Further, the convergence speed of the SSPC algorithm is faster than that of conventional algorithms.*

Keywords – *CDMA, BSA_MTP (Base Station Assignment Method -Minimizing the Transmitter Power, SB and CS methods.*

I. INTRODUCTION

In mobile communication system the Code Division Multiple Access (CDMA) plays vital role with other present techniques such as Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). The main features of CDMA system for mobile communication applications are the widespread one-cell frequency reuse, intrinsic multipath diversity, and soft capacity limit. To efficiently apply the advantage of CDMA, it is necessary to understand effect of power control on the near-far problem, slow shadow fading and multipath fading [1-2]. In Frequency Division Multiple Access strategies, the focus is on the frequency dimension. Here, the total bandwidth (B) is divided into N narrowband frequency slices. So several users are allowed to communicate simultaneously by assigning the narrowband frequency slices to the users, where the narrowband frequencies are assigned to a designated user at all time. Since the total bandwidth (B) is subdivided into N frequency slices or channels, only N users may be supported simultaneously. In TDMA all users use the whole bandwidth but in different time slots.

The CDMA is based on spread spectrum technology which makes the optimal use of available bandwidth. It allows each user to transmit over the entire frequency spectrum all the time. On the other hand GSM operates on the wedge spectrum called a carrier. This carrier is divided into a number of time slots and each user is assigned a different time slot so that until the ongoing call is finished, no other subscriber can have access to this. GSM uses both Time Division Multiple Access and Frequency Division Multiple Access for user and cell separation. More security is provided in CDMA technology as a unique code is provided to every user and all the conversation between two users are encoded ensuring a greater level of security for CDMA users.

II. SYSTEM STRUCTURE

Designing a perfect radio channel in mobile communications would be practically an impossible task since the channel is stochastic in nature as the mobile terminals keep moving almost all the time with different speeds and the channel fades are unpredictable. The signals in a radio channel undergo different propagation effects like reflection, refraction, scattering and shadowing. A smooth surface reflects the signals. But, when the signals encounter sharp edges of buildings, they are refracted, while a rough surface scatters them. When these signals are obstructed by big buildings, they pass through them causing the shadowing effect. All these effects cause the channel to be lognormal, Rayleigh and Rician distributed. Fig.1 shows how the signals travel in different paths from transmitter to receiver. So, the receiver receives multiple copies of the same signal with variation in time and phase.

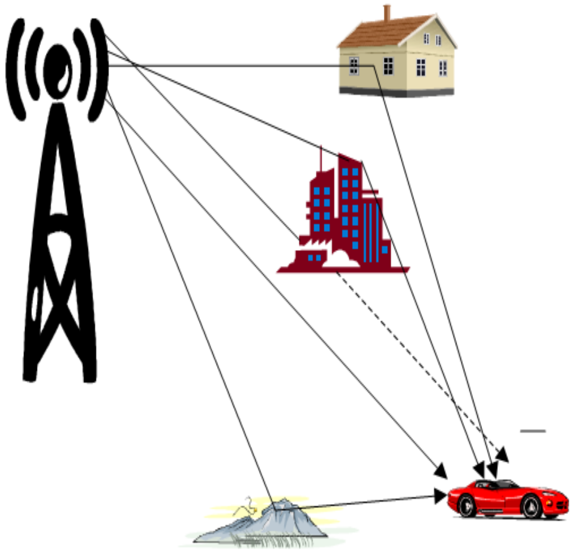

Fig.1: Multipath Propagation

These signals are either added constructively or destructively depending on the phase of the signals. The signals in the radio channel also undergo a path loss which depends on the distance between the transmitter and the receiver. The fading of signals is categorized as fast or multi-path fading and slow or shadow fading. The fast fading of signals is due to the rapid change of the signal amplitude and phase due to the multi-path arrival of the signal. Similarly, the slow fading of the signals is due to the shadowing effects caused by the buildings, mountains, hoardings etc.

III. POWER CONTROL

In order to meet the increasing demand of mobile subscribers for various services such as multimedia, internet, transferring of big data like digital pictures, it is crucial to have higher capacity and more severe Quality of Service (QoS) requirement, to meet this requirements new technologies and improved resource management including channel assignment, power control and handoff are needed.

There are some techniques involved in determining the power levels. They are: Inner Loop Power Control and Outer Loop Power Control. Inner Loop Power Control is further classified into: Open Loop Power Control and Closed Loop Power Control. Open Loop Power Control is generally used in combating the Near-Far and shadowing problems. As the name itself indicates, this power control does not have feedback mechanism as the mobile itself dynamically adjusts its transmitting power. The mobile tries to estimate the signal strength on the forward pilot channel (Base to Mobile) and decides its transmitting power. If the mobile senses a large power then, the mobiles assumes that the base station is near and reduces its power level and vice versa. Fig.2 depicts the mechanism clearly.

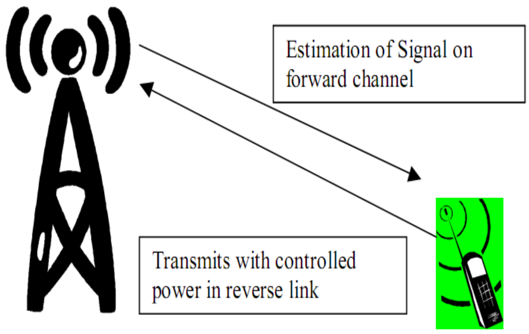

Fig.2: Open loop power control

Closed Loop Power Control is used in combating the fast fading effects, generally caused by multi-path fading. This mechanism is also termed as fast power control as it deals with the fast fading.

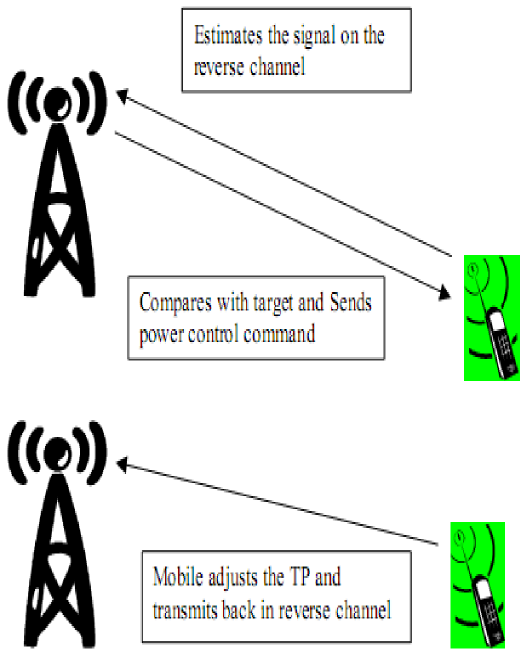

Fig.3: Closed loop power control

Since the forward and reverse links are considered to be highly uncorrelated, the feedback mechanism is employed in this power control. The base station estimates the signal from the mobile in the reverse channel (Mobile to Base) and compares that signal-estimate with a predetermined signal level and sends the appropriate power control command to the mobile station as illustrated in fig.3.

IV. POWER CONTROL ALGORITHM

Power control is an intelligent way of adjusting the transmitted powers in cellular systems so that the TTP is minimized, but at the same time, the user SINRs satisfies the system quality of service (QoS) requirements [4-5].

A. BSA-MTP Technique

To improve the performance of cellular systems, base station assignment technique can be used with smart step power control (SSPC) proposed by Moghadam [3]. algorithm. In the joint power control, a number of base stations are potential receivers of a mobile transmitter. Accordingly, the objective is to determine the assignment of users to base stations which minimizes the allocated mobile powers. In simple mode and in multiple-cell systems, the user is connected to the nearest base station.

This method is not optimal in cellular systems under the shadowing and multipath fading channels and can increase the system BER [6, 7]. The system capacity might be improved if the users are allowed to switch to alternative base stations, especially when there are congested areas in the network. Obviously, when uplink performance is of concern, the switching should happen based on the total interferences seen by the base stations [7]. It is considered that the power control problem for a number of transmitter-receiver pairs with fixed assignments, which can be used in uplink or downlink in mobile communication systems. In an uplink scenario where base stations are equipped with antenna arrays, the problem of joint power control and beam forming, as well as base station assignment, naturally arises. In this paper, it is considered the BSA-MTP technique [3] to support base station assignment as well in a 2D urban environment. The modified technique can be summarized as follows.

1. Initially by the conventional BSA technique, each mobile connects to its base station; the conventional BSA is defined as:

$$\Gamma_k(x,y) = \begin{cases} 1; k \epsilon S_{BSq} \\ \dfrac{\min_{m\epsilon\Theta k}\left\{ {}^{1}/_{G_{k,m}} \right\}}{{}^{1}/_{G_{k,q}}}; k \epsilon S_0 \end{cases}$$

(1)

Where $G_{k,m}$ and $G_{k,q}$ are the best link gain between user k and BS m and B respectively.

2. Estimate the weight vector for all users with the CGBF algorithm can be calculated by the equation:

$$W_{i,q}^{(j)}(n+1) = W_{i,q}^{(j)}(n) + K_{,iq}^{(j)}(n)\beta_{i,q}^{(j)}(n)$$

(2)

3. The transmitted power of all users can be calculated by the equation:

$$P'_{k.m} = G_{k.m}\, P_{k.m}$$

(3)

is received power in the BS m of user k,m in the presence of closed-loop power control, where $P_{k,m}$ is the transmitted power of user k,m.

4. Thus, Kr=[Ku/(M+1)] users whose transmitted power is higher than that of the other users are transferred to other base stations according to the following equation, where the function [x] returns the integer portion of a number x.

$$\Gamma_k(x,y) = \Gamma_k(x,y) = \begin{cases} 1; k \epsilon S_{BSq} \\ \dfrac{\min_{\substack{m\epsilon\Theta k \\ m\neq q}}\left\{ {}^{1}/_{G_{k,m}} \right\}}{{}^{1}/_{G_{k,q}}}; k \epsilon S_{BSq} \\ \dfrac{\min_{m\epsilon\Theta k}\left\{ {}^{1}/_{G_{k,m}} \right\}}{{}^{1}/_{G_{k,q}}}; k \epsilon S_0 \end{cases}$$

(4)

Where S_{BSq} is the set of users that are in cell q but not connected to BS_q

B. Switched-Beam Technique

One simple alternative to the fully adaptive antenna is the switched-beam architecture in which the best beam is chosen from a number of fixed steered beams. Switched-beam systems are technologically the simplest and can be implemented by using a number of fixed, independent, or directional antennas [8].We list the conditions of the SB technique for this paper as follows [9].

1. The beams coverage angle is 30° and overlap between consecutive beams is 20°. Thus each base station has 36 beams.

2. The each user can use η_{max} beams for each of its path to communicate with a base station at any time. A number of beams are chosen such that SINR for each user lies between minimum and maximum level under reducing the transmitted power of each base station.

C. Cell Sectoring Method

Sectoring is the process of replacing an omnidirectional antenna at the base station by several directional antennas. In cell sectoring method all cells are divided into three or six equal sectors. Each sector has the same coverage angle. In this paper, it is considered that three sectors for each base station with sector angle 120◦ for the CS method [10].

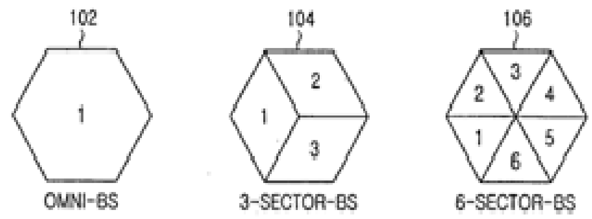

Fig.4: Sectoring of a cell

System information for CDMA in reverse link:

Number of users (M)	9
Spacing between channels(d)	$\frac{\lambda}{2}$
Input data rate (Tb)	9.6Kbps
The number of antenna weights(N)	3
The number of antenna sensors in CGBF algo(S)	5
The number of antenna sensors in CLMS algo(S)	3
Propagation paths for all users (L)	4
Resolution(R)	1
Path loss parameter (Lp)	0.05dB/m
Variance of the log-normal shadow fading	4dB
Gradient step size in the CLMS algorithm(μ)	0.005
m-sequence generator with processing gain(G)	512
The average SINR(Ku) users	120
SNR	10dB

V. DISCUSSION OF RESULTS

Fig. 5 shows the comparison of the average SINR achieved over K_u = 120 users and signal to noise ratio, SNR=10dB, versus the power control iteration index (n`) for SSPC with the BSA-MTP technique (solid line) and conventional BSA technique (dashed line). In this simulation, the two-stage receiver uses SB and ES methods. Here, it is considered that the each user has a maximum power constraint of 1watt. It is observed that the convergence speed of the joint SSPC algorithm and SB methods is faster than that in the other cases [3].

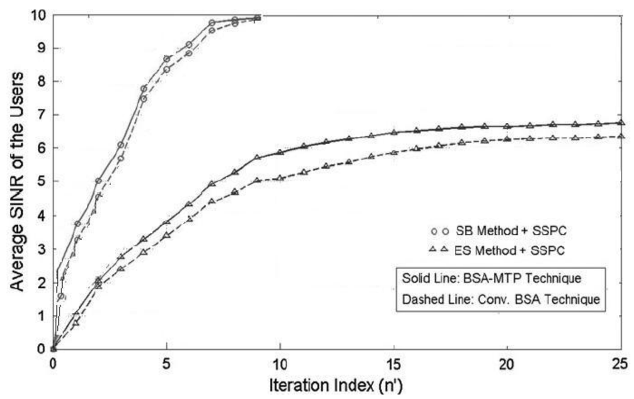

Fig.5: Average SINR of all users versus power control iteration index (n_), for power constraint of 1 watt,
Ku =120, and SNR = 10 dB

It can be also observed from this figure that the convergence speed with BSA-MTP technique is faster than that with conventional BSA technique. On the other hand, we observe that the average SINR level achieved is below the target SINR value for the ES method.

Fig. 6 shows the comparison of TTP usage versus the power control iteration index (n`).

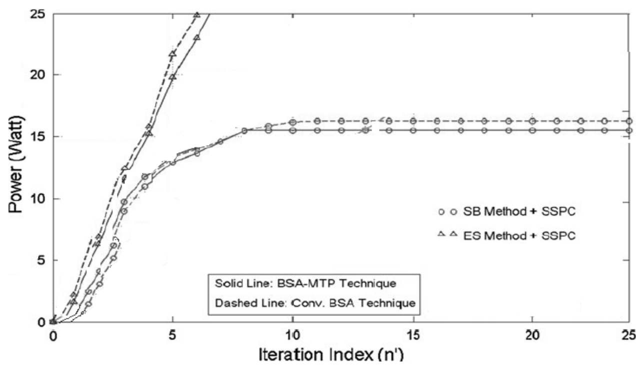

Fig.6: TTP of all users versus power control iteration index (n`), Ku =120, and SNR =10 dB.

In this simulation, it is considered that users now have maximum power constraints. It is observed that the ES method can never achieve the target SINR value for all users. It also observed that the TTP for the joint SSPC algorithm and SB technique is lower than that for the other cases [3]. Thus it is observed that for BSA-MTP technique (solid line) is lower than that for conventional MTP technique (dashed line).

Fig. 7 shows that the average BER for all users in network with the SNR for different receivers (one, two-stage receivers), K_u =120 active users, and a log-normally distributed PCE with σ_v^2=4 dB. It should be mentioned that in this simulation, K_r =12 users can be transferred to other base stations with the BSA-MTP technique.

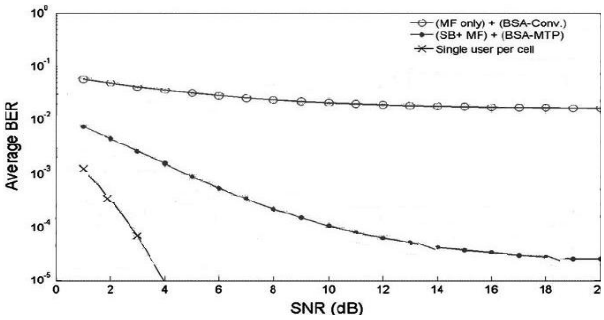

Fig.7: Average BER versus the SNR for σ^2_v= 4 dB and Ku = 120.

In addition, the BSA-MTP technique the average BER is lower than the conventional BSA technique. For example, at a SNR of 10dB, the average BER is 0.006 for the two-stage receiver with the conventional BSA technique, while for the BSA-MTP technique, the average BER is 0.0005. It is observed that using the BSA-MTP technique in SB and MF receiver, the average BER is lower than that in the other cases [3]. For example, at a SNR of 7.8 dB, the average BER using the BSA-MTP technique is 0.0001 for SB technique.

VI. CONCLUSION

The receiver performance of multiple-cell DS-CDMA system with the space diversity processing, closed-loop power control, and power control error in a 2D urban environment has been successfully performed. The output result of the MFs are combined and then fed into the decision circuit for the desired user. The SSPC algorithm and the BSA-MTP technique have performed to produce good results. It is observed from the results that the TTP for BSA-MTP technique is lower than that in conventional case. Thus, it decreases the BER by allowing the SINR targets for the users to be higher, or by increasing the number of users supportable at a fixed SINR target level. It also observed that the convergence speed of the joint SSPC algorithm and SB technique is higher than that of the other cases reported. It has also been observed that the BSA-MTP technique will decrease the average BER of the system to support a significantly larger number of users.

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