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Analysis of Power Control Algorithm for DS-CDMA

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ABSTRACT : *In this paper, the performance of smart step closed loop power control (SSPC) algorithm and base station assignment method based on minimizing the transmitter power (BSA-MTP) technique for direct sequence-code division multiple access (DS-CDMA) receiver in a 2D urban environment has been compared. The simulation 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 : DS-CDMA, Power contoal Algorithm, Reverse Link

I. INTRODUCTION

In present modern wireless communication system in mobile communication the Direct Sequence-Code Division Multiple Access (DS-CDMA) plays vital role is a cellular system with other present techniques such as Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). The main importance's of DS-CDMA 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 understand effect of power control on the near-far problem, slow shadow fading and multipath fading [1–2]. The power control scheme in CDMA was proposed by Gejji [3] in which power control scheme was developed as a function of the distance for forward link and the direction from the base station (BS) to provide a more accurate power control scheme. In CDMA scheme has two basic power control mechanisms: closed-loop and open-loop power control. In Frequency Division Multiple Access or FDMA 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. Unlike FDMA and TDMA, CDMA systems users transmit simultaneously using the same frequency spectra. Thus, the main purpose of these systems is to maintain power level variations at a low enough level to avoid drastic reductions in system capacity and the effect on system performance of imperfections in 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.In this paper comparisons are presented between smart step closed-loop power control (SSPC) [4], switched beam technique and Equal sectoring method for reverse link performance of DS-CDMA system in 2D urban environment. In next section of this paper the complete description of system model, algorithms, discussion of results and conclusion.

II. SYSTEM DESIGN

Considering the 2D urban model for computing reverse link (path between a mobile set and base station) is shown in Fig 1. This shows that diffraction and reflection of power signal from mobile user and base station. This cause the loss in power of the signal due diffraction and reflections provide obstacle such as building, trees mountains etc. whereas these signal remains in the environment until its power of the signal fall below the threshold level.

Block diagram of reverse link is shown in Fig. 2. The USPS simulation software is used, in which it is considered to as physical environment of mobile user such that signal data radiated from mobile system reaches to base station as well as diffuse in all the directions. This software also stores all environment information angles of the path (reverse link or forward link) and transmitting and receiving power.

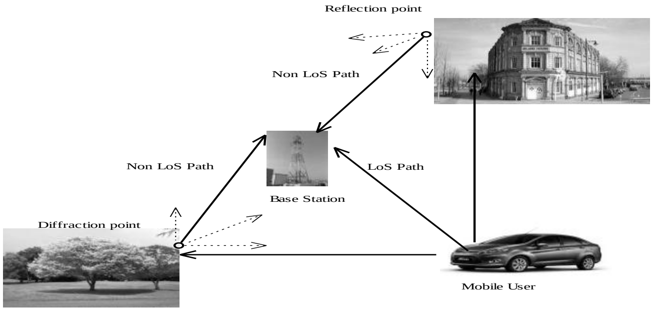

Figure1. 2D urban environment in reverse link.

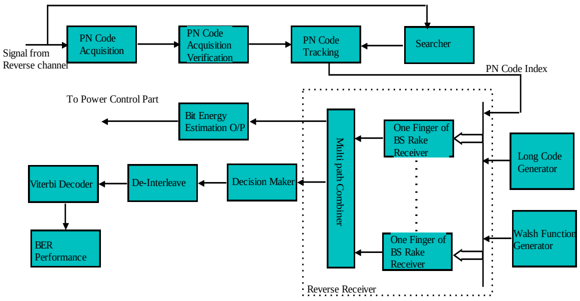

Figure2. Block diagram of Reverse Link receiver system.

2.1.Reverse Link Power Control System

Power control on the reverse link is an important issue in achieving high capacity for the DS-CDMA wireless system. Conventional power control uses an open-loop algorithm, or a closed-loop algorithm, or some combination of the two. Reverse link closed-loop power control for a packetized DS-CDMA network has been examined in [4-5] for a system accommodating voice and data users. A closed-loop algorithm based on equal signal strength for data users and on equal error probability for voice users is proposed. The closed-loop power control algorithm in [6-7] is designed to update the transmitted power of a mobile at a rate faster than that of multipath fading. The received power at the base station is compared to a threshold value and the result is hard quantized to a 1-b power command which informs the user whether to increase or decrease its transmitted power. Block diagram of Reverse Link receiver system is shown in Fig 2.

2.2.Power Control Algorithm

A major limiting factor for the satisfactory performance of CDMA systems is the near-far effect. 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 [8-9].Depending on the execution location, power control algorithms can be categorized as either centralized and distributed [1–9,14-15]. In centralized power control, a network center can simultaneously compute the optimal power levels for all users. However, it requires measurement of all the link gains and the communication overhead between a network center and base stations. Thus, it is difficult to realize in a large system [16]. Distributed power control, on the other hand, uses only local information to determine transmitter power levels. It is much more scalable than centralized power control. However, transmitter power levels may not be optimal, resulting in performance degradation [17].The distributed closed-loop power control problem has been investigated by many researchers from many perspectives during recent years [8,17,23]. For instance, the conventional fast closed-loop power control strategy used in practice in CDMA systems is a fixed step controller based on SINR measurements. The fixed step closed-loop power control (FSPC) algorithm is defined by [8].

$$P_{i.q}^{m'+1} = P_{i.q}^{m'} + \delta sign(\chi_{i.q}^{*} - \chi_{i.q}^{n'}) , \qquad (1)$$

Where $P_{i.q}^{m'}$, $\chi_{i.q}^{*}$, and $\chi_{i.q}^{n'}$ are the transmitter power, SINR target, measured SINR of user i, q at time m', respectively and δ is the fixed step size. Also, the $P_{i.q}^{m'+1}$ is transmitter power control (TPC) command in the feedback link of the base station to i, q at time m'+1 in decibel.

Also, the distributed traditional closed-loop power control (DTPC) is defined by [23]

$$P_{i.q}^{m'+1} = P_{i.q}^{m'} \left(\frac{\chi_{i.q}^{*}}{\chi_{i.q}^{n'}}\right) , \qquad (2)$$

In above algorithms, the simple intuition behind this iteration is that if the current SINR $\chi_{i.q}^{n'}$ of user *i*, *q* is less than the target SINR $\chi_{i.q}^{*}$, then the power of that user is increased; otherwise, it is decreased.It is to be noted that the convergence speed of DTPC algorithm is higher than that of FSPC algorithm. Also, the variance of the SINR mis-adjustment in FSPC algorithm is higher than that of DTPC algorithm. But it has been shown that the FSPC algorithm converges to $\left|\chi_{i.q}^{*} - \chi_{i.q}^{n'}\right| \le 2\delta k_d$, where k_d is the loop delay [7].The variable step closed-loop power control (VSPC) [18] algorithm has been proposed by Kurniawan. In this algorithm, variable step size is discrete with mode. It is shown that the performance of VSPC algorithm with mode $q_v = 4$ is found to be worse than that of a fixed step algorithm ($q_v = 1$) under practical situations with loop delay of two power control intervals, but the convergence speed of VSPC algorithm is higher than that of FSPC algorithm. Also in this algorithm, the variance of the SINR mis-adjustment is reduced when compared to the FSPC algorithm.

Practical implementations of power control in CDMA systems utilize closed-loop control, where the transmitter adjusts its power based on commands received from the receiver in a feedback channel. To minimize signaling overhead, typically one bit is used for the power control command. In practice, the command must be derived based on measurements made at the receiver, transmitted over the feedback channel to the transmitter, and finally processed and applied at the transmitter. All these operations constitute a loop delay, which can cause problems if it is not properly taken care of in the design of the power control algorithm. In many cases the loop delay is known due to a specific frame structure inherent in the system.

The smart step closed-loop power control algorithm (SSPC) was proposed by Moghadam et al [4].We express the SSPC algorithm as follows.

$$P_{i.q}^{m'+1} = P_{i.q}^{m'} + \delta\left|\chi_{i.q}^{*} - \chi_{i.q}^{n'}\right| sign(\chi_{i.q}^{*} - \chi_{i.q}^{n'})$$

Performance of the SSPC algorithm is shown in Fig 3

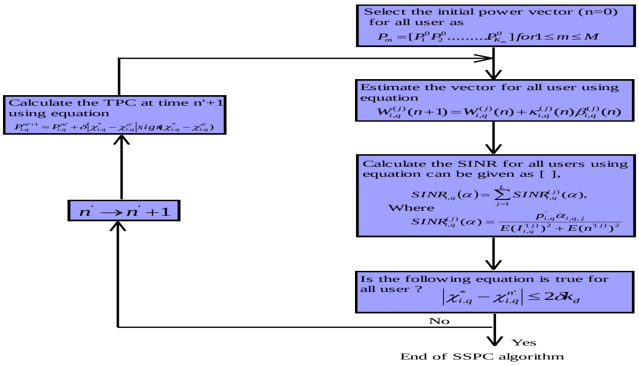

Figure3. Block diagram for SSPC[4] algorithm.

2.3.BSA-MTP Technique

To improve the performance of cellular systems, base station assignment technique can be used. In the joint power control and base station assignment, 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 [19,20].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 [20].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 beamforming, as well as base station assignment, naturally arises. In this paper, it is considered the BSA-MTP technique[4] 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

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

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

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

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

$$p'_{k,m} = G_{k,m}\; p_{k,m}$$

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, $K_r = [K_u/(M+1)]$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.

$$\Gamma_k(x,y) = \begin{cases} 1; k \in S_{BSq} \\ \dfrac{\min\limits_{\substack{m\in\Theta k \\ m\neq q}}\{1/G_{k,m}\}}{1/G_{k,q}}; k \in S_{\overline{BSq}} \\ \dfrac{\min_{m\in\Theta k}\{1/G_{k,m}\}}{1/G_{k,q}}; k \in S_0 \end{cases}$$

where $S_{\overline{BSq}}$ is the set of users that are in cell q but not connected to BS q

2.4.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 [21].We list the conditions of the SB technique for this paper as follows [22].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 one beam for each of its path to communicate with a base station at any time.

2.5.Equal Sectoring Method

One simple method used to sectorize a cell is equal sectoring; in which all sectors have the same coverage angle. In this paper, it is considered that three sectors for each base station with sector angle 120◦ for the ES method [24].

TABLE I. SYSTEM INFORMATION FOR DS-CDMA IN REVERSE LINK

Number of users (M)	**9**
Spacing between channels(d)	$\frac{\lambda}{2}$
Input data rate(T_b)	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 (L_p)	0.05 dB/m
Variance of the log-normal shadow fading	4 dB
Gradient step size in the CLMS algorithm(μ)	0.005
m-sequence generator with processing gain(G)	512
the average SINR(K_u) users	120
SNR	10 dB

III. DISCUSSION OF RESULTS

Figure 4 shows the comparison of the average SINR achieved over Ku = 120 users and signal to noise ratio, SNR=10dB, versus the power control iteration index (n`) for SSPC, and for 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 SSPC algorithm with EM and SB methods. For example, the convergence speed of the joint SSPC algorithm and the SB technique is faster than that in the other cases [4]. 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,

Figure 5 shows the comparison of TTP usage versus the power control iteration index (n`). In this simulation, it is considered that users now have maximum power constraints. It is observed that observe 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[4]. Thus it is observed that for BSA-MTP technique (solid line) is lower than that for conventional MTP technique (dashed line).Figure 6 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_ν^2 =4 dB. It should be mentioned that in this simulation, Kr =12 users can be transferred to other base stations with the BSA-MTP technique. 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 [4]. For example, at a SNR of 7.8 dB, the average BER using the BSA-MTP technique is 0.0001 for SB technique.

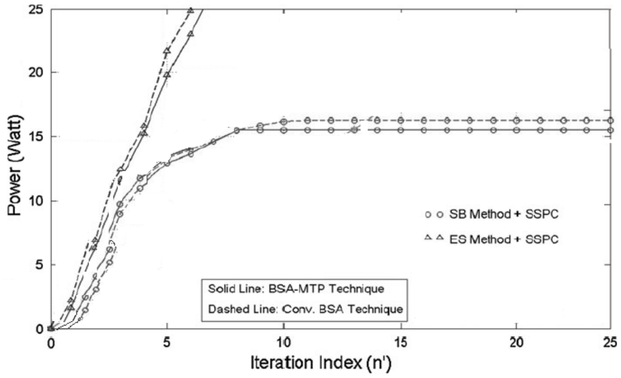

Fig. 4 Average SINR of all users versus power control iteration index (*n*_), with maximum power constraint of 1 watt, *Ku* =120, and SNR = 10 dB

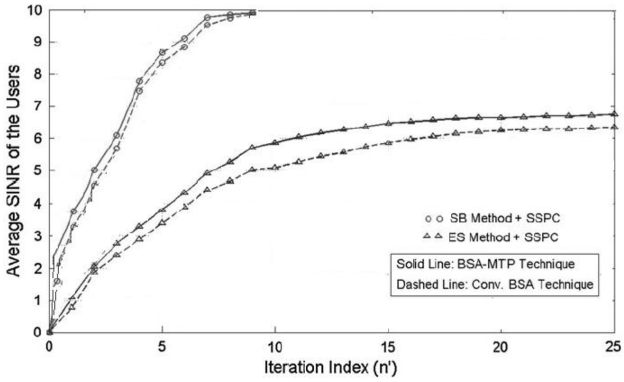

Fig. 5 Total transmit power of all users versus power control iteration index *(n`), Ku* =120, and SNR =10 dB. No power constraints

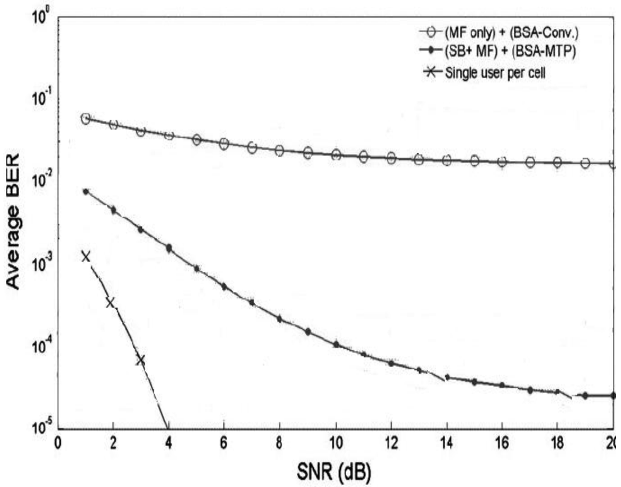

Fig. 6 Average BER versus the SNR for σ^2_υ= 4 dB and *Ku* = 120.

IV. CONCLUSION

In this paper, 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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