MODIFIED POWER UPDATING ALGORITHM IN DS-CDMA NETWORKS

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ABSTRACT

Cellular systems are generally encountered with near-far problem. Several power control updating algorithms have been proposed to deal with this problem. One of the commonly used algorithms is proposed by Zander that drives all the mobiles to achieve the system threshold signal to interference ratio (SIR), which is necessary for a mobile to get the access of base station. This algorithm deals with the link gain matrix associated with the system. Removal policy is applied which removes a mobile from the network if it fails achieve threshold value after being given several trials. The system is rebalanced by changing the link gain matrix. This increases the capacity as new incoming users can be served by the system. In this paper, a new power updating algorithm for cellular system is proposed and simulated to show that mobiles converges faster in terms of number of iterations required to get system threshold.

I. INTRODUCTION

In cellular, power control is one of the most important system requirements [1]. It is used to increase the capacity of the systems. Without power control, power received at the base station from all mobiles within the network will be different depending on the multi path fading and the average distance of the mobile from the base station. The mobiles that are closer to the base station will capture the demodulation process, causing interference to those that are away from the base station. Power control is also used to prolong the battery life of mobile handset as it reduces the average power transmitted by the mobile which in turn prolongs the battery life.

II. SYSTEM MODEL AND STRUCTURE

System is assumed to be interference limited and effect of positive receiver noise is neglected [2]. The speed of convergence of power algorithm is much smaller than the typical duration of a call. Hence, large-scale propagation effects and shadow fading are main cause of variations in link gain matrix. Locations of the mobiles are uniformly distributed over the cell area and mobiles transmit power at a constant rate. It is assumed that mobile is always associated with the BS of the cell in which it is situated. For uplink, the quality of communications is established if the calculated SIR at the receiver exceeds a required threshold.

III. CHANNEL MODELING

Uplink and downlink frequency channels are considered to be reciprocal from propagations loss and shadowing point of view [2]. The Effect of fast or Raleigh fading is neglected, assuming efficient coding and modulation schemes. Path loss is proportional to d^{-4}, d being the distance between BS and the mobile. Log normal shadowing with 0 db standard deviation is considered. Thus, the gain is given as $G_{ij} = \frac{A_{ij}}{d^4}$, where A_{ij} are lognormal fading components and G_{ii} is the path gain between i[th] mobile with base station of the j[th] cell.

IV. POWER CONTROL ATTRIBUTES

The main idea of power control is to adjust the transmitter power of user mobile for a given channel, so that the interference levels at the receiver of user locations are minimized [3,4,5]. Maintaining adequate transmission quality on the actual communication link is an obvious constraint .The measure of quality usually employed in the cellular system design is the SIR for CDMA system. The SIR ratio is the ratio of signal power to the power of all active interfering transmitters. The interference is modeled as the sum of transmission powers for all active interferers.

All the power control algorithms developed so far are SIR based algorithms and are either centralized or distributed in nature. As all the mobile transmitter use entire available bandwidth of the channel in CDMA system, hence only Q-1 transmitters will be interferers to a particular test mobile with Q as total number of mobiles within a cell. Every active transmitters act as a source of interference to the desired active mobile.

Since the transmission quality is dependent on the SIR ratio at the receiver of a mobile, it is written as

$$\Gamma_i = \frac{P_{rxi}}{\sum_{\substack{j=1 \\ j\neq i}}^{Q} I_j}$$

where P_{rxi} is the power received from the desired transmitter mobile i[th] and I_j is the received power from the j[th] interferer. The link gain on the path between the mobile in cell i and the BS in cell j by G_{ij}

$$\Gamma_i = \frac{G_{ii} P_i}{\sum_{\substack{j=1 \\ j\neq i}}^{Q} G_{ij}.P_j}$$

With P_i as the transmitted power used by the transmitter of BS in cell i and G_{ii} is the path gain of the desired signal path in cell i. After simplification, the link gain path is calculated as

$$\Gamma_i = \frac{P_i}{\sum_{j=1}^{Q} P_j.Z_{ij} - P_i}$$

where the normalized link gain Z_{ij} is defined as

$$Z_{ij} = \frac{G_{ij}}{G_{ii}}, i \neq j \qquad\qquad = 1; i = j$$

A normalized uplink matrix associated with a system is defined as $Z = \{Z_{ij}\}$. Generally, the power control techniques are based on the eigen value calculation of this matrix. In a cellular system, SIR level γ is said to be achievable, if there exists a power vector P ≥ 0 such that $\Gamma_i \geq \gamma$ for all transmitters i. The maximum achievable SIR that can be attained in a system can be given as [ ]

$$\gamma^* = \frac{1}{(\lambda^* - 1)}$$

where λ^* is the largest eigen value of the matrix Z. Power vector P* will be the eigen vector corresponding to λ^*.

If SIR threshold is considered as γ , then SIR in all active links should be greater than the threshold. So, for the system to work successfully, inequality followed is given as

$$\Gamma_i = \frac{P_i}{\sum_{j=1}^{Q} P_j.Z_{ij} - P_i} \geq \gamma \quad \text{or} \quad P_i + \gamma P_i \geq \gamma\left(\sum_{j=1}^{Q} P_j.Z_{ij}\right)$$

In matrix form, above equation becomes $\frac{1+\gamma}{\gamma}.P \geq Z.P$

From the properties of the matrix, the above inequality will be true if

$$\frac{1+\gamma}{\gamma} = \lambda \quad \text{or} \quad \gamma = \frac{1}{\lambda - 1}$$

where λ is the largest eigen value of the normalized link gain matrix Z. Hence SIR balanced system reaches the largest achievable level γ*.

V. PROPOSED POWER CONTROL UPDATING ALGORITHM

Many power-balancing techniques are used for CDMA system. Zander [3,7] has proposed a distributed balancing algorithm which uses only local SIR information. Distributed balancing algorithm can achieve SIR balancing with probability one & thus when combined with cell removal algorithm, obtains a minimum outage probability [ ]. Power scheme proposed by Zander is expressed as

$$P^{(n+1)} = c^{(n)}\left[1 + \frac{1}{\Gamma_i^{(n)}}\right]P^{(n)} \quad \text{where } c^{(n)} \text{ is given by}$$

$$C^{(n)} = \frac{1}{\sum_i P_i^{(n)}}$$

This algorithm also guarantees convergence to an optimal power vector. Above equation can be represented in matrix form as

$$P^{(n+1)} = c^{(n)}.Z.P^{(n)}$$

Convergence depends on the ratio of second largest & largest eigen values of *Z*. Smaller the ratio, faster the convergence. Now a new distributed power algorithm is proposed as

$$P^{(n+1)} = c^{(n)}\left[\frac{1}{\Gamma_i^{(n)}}\right]P^{(n)}$$

After simple calculation, above algorithm can be reduced as

$$P^{(n+1)} = c^{(n)}.(Z-1)^{(n)}.P^{(n)} \quad \text{where } c^{(n)} \text{ is given by}$$

$$c^{(n)} = \frac{1}{\mathrm{Max}\{P_i\}_i}$$

Here, convergence depends on the eigen value of matrix (Z-1). As all the eigen values of matrix (Z-1) are obtained by subtracting one from the corresponding values of matrix Z, it is clear that the eigen values of matrix (Z-1) will be smaller than matrix Z. So, eigen values of (Z-1) will be more close to zero. Hence, the ratio of second largest & largest eigen value of (z-1) is much smaller than one compared Z proposed by the Zander.

From power vector method and convergence mechanism [7,8], it can be verified that convergence will be achieved faster in this proposed balancing algorithm.

However, power transmitted by the mobile can not be unlimited and un-quantized, hence some constraints is applied along with quantization, which allows user to updates transmitted power through available ranges in quantized steps[9]. The proposed power algorithm is then become as constraints power scheme.

VI. OUTAGE PROBABILITY

Probability of error of desired user 1 is calculated in terms of outage probability as[10]

$$P_b = Q\left(\frac{1}{\left[\sqrt{\sum_{k=2}^{K}\frac{E_b^{(k)}}{3.E_b^{(1)}.N}+\frac{\eta}{2.E_b^{(1)}}}\right]}\right)$$

where, N is the processing gain, η is bandwidth, $E_b^{(k)}$ is energy per bit for user k and $E_b^{(1)}$ is the energy per bit for desired user 1.Function *Q(x)* is defined by $Q(x) \cong \frac{1-0.7}{x^2}.e^{-\frac{x^2}{2}}.\frac{1}{x.\sqrt{2\Pi}}$

Each user contributes $\frac{E_b^{(k)}}{3N}$ to the noise level. If just a single user has a significantly higher power level than the desired user, that interferer will dominate the performance. As K=1 is the desired user, $E_b^{(k)} = E_b^{(1)}$ can be taken for finding out probability of error as to get $P_b = Q\left(\frac{1}{\frac{\sqrt{k-1}}{3N}} + \frac{\eta}{2.E_b^{(1)}}\right)$

VII. RESULTS

For the purpose of simulation spreading bandwidth is 1.23 MHz, data rate with mobile (R) is 8 Kbps, processing gain is 150, E_b/N_0 requirement is 7db, SIR Threshold is 0.035 (≈ -15 db), maximum no. of iterations allowed for removal is 8, no. of Q-levels considered are 64,128,256,512 and power ranges (db) taken are 30,40,50,60.

Figure (1) is simulated with 18 mobiles/cell under 50dB power range & 128 quantization levels for constrained distributed Zander power control algorithm. This gives 12 numbers of iterations, which is required to get the threshold. However, proposed constrained distributed power control algorithm requires only 10 numbers of iterations for getting system threshold as illustrated from figure (2). Hence, it is proved through simulation also that proposed power control scheme converges faster than the Zander algorithm. It is seen that proposed power control removes a mobile from 8 `th iteration, whereas Zander scheme takes longer trials to get the removal. So, proposed power algorithm not only shows a faster convergence but also gives a quick removal of a mobile to re-balance the system than Zander power control scheme.

Similar results can be drawn from figure (3) and figure (4). These plots have been simulated with 19 mobiles/cell under 50 dB power range & 128 quantization levels for constrained distributed power control scheme. Again, the proposed algorithm gives a faster convergence as well as less number of trials with respect to Zander power control. This new scheme allows 11 iterations to converge with 8 trials for removal of a mobile, whereas Zander algorithm requires 13 convergence trials with 10 removal iterations for getting the system threshold.

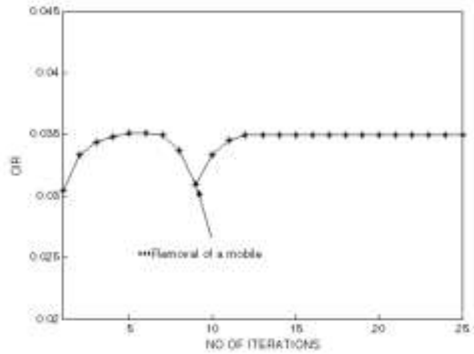

Fig (1): Removal of a mobile with 50 dB power range, 128 quantization levels 18 mobiles/cell for Zander algorithm.

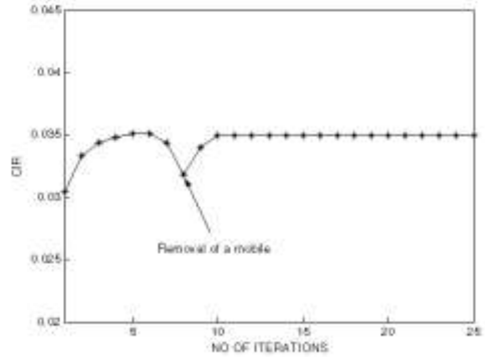

Fig (2): Removal of a mobile with 50 dB power range, 128 quantization levels and 18 mobiles/cell for proposed algorithm.

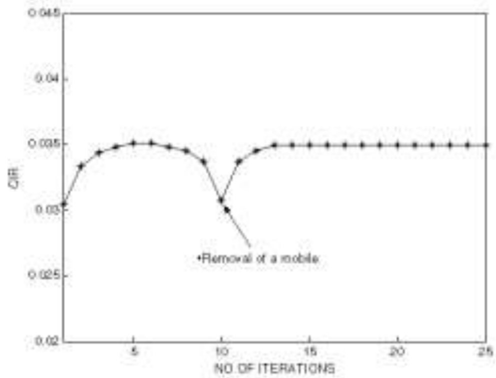

Fig (3): Removal of a mobile with 50 dB power range, 128 quantization levels and 19 mobiles/cell for Zander algorithm.

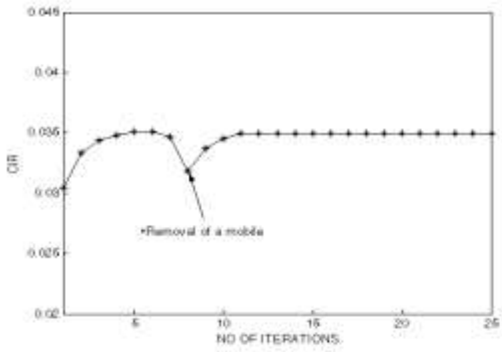

Fig (4): Removal of a mobile with 50 dB power range, 128 quantization levels and 19 mobiles/cell for proposed algorithm.

VII. CONCLUSIONS

The comparison between proposed power control scheme and already existing Zander algorithm to show that the new scheme is faster in terms of convergence the system. Number of iterations and the outage probability are taken for the performance parameters.

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