



EFFECT OF SOFT HANDOVER PARAMETERS ON CDMA CELLULAR NETWORKS

¹N.P.SINGH , ²BRAHMJIT SINGH

¹Asstt Prof., Department of Electronics and Communication Engineering, National Institute of Technology, Kurukshetra - 136119

² Prof., Department of of Electronics and Communication Engineering , National Institute of Technology, Kurukshetra – 136119

ABSTRACT

CDMA cellular networks support soft handover, which guarantees the continuity of wireless services and enhanced communication quality. Cellular networks performance depends upon Soft handover parameters. In this paper, we have shown the effect of soft handover parameters on the performance of CDMA cellular networks. We consider HYST_ADD and HYST_DROP as the Soft handover parameters. A very useful statistical measure for characterizing the performance of CDMA cellular system is the mean active set size and soft handover region. It is shown through numerical results that above parameters have decisive effect on mean active set size and soft handover region and hence on the overall performance of the soft handover algorithm.

Keywords: *Code-Division Multiple Access(CDMA), Soft handover , Shadow fading , Soft handover region, Mean active set size*

1. INTRODUCTION

Code-Division Multiple Access (CDMA) based cellular standards support soft handover, which makes smooth transition and enhanced communication quality. Soft handover offers multiple radio links to operate in parallel. Mobile users are separated by unique pseudo-random sequences and multiple data flows are transmitted simultaneously via radio interface. The User Equipment (UE) near the cell boundary is connected with more than one Base Station (BS). Consequently, in soft handover UE is able to get benefit from macrodiversity. Soft handover can, therefore, enhance both the quality of service and the capacity of CDMA based cellular networks [1-2].

Soft handover problem has been treated in literature for performance evaluation of the algorithms using both analytical and simulation methods [3-7, 20]. An analytical model has been proposed in [8] to evaluate cell assignment probabilities to compute outage probability, macrodiversity gain, and signaling load.

Soft handover is associated with active set and its size. The inclusion and drop of a particular BS in/from the active set is determined by the initiation trigger utilized for soft handover algorithm.

Initiation trigger include, received pilot signal strength, Carrier to Interference ratio, Bit-Error-Rate, Energy per bit to noise power density. In the present work, we consider received pilot signal strength as the initiation trigger. It is easily measurable quantity and directly related to the quality of the communication link between UE and BS and the most commonly used criterion for handover initiation trigger. In the present work, we have utilized received pilot signal strength as the initiation trigger.

Due to the random nature of the received signal at UE, there are frequent inclusion and drop of BS(s) in the active set. Active set consists of those base stations which are connected with UE and soft handover region [15] is that region in which UE is connected with more than one base station. It is essential for properly designed soft handover algorithm [16, 17, 18, 19, 21, 22, and 23] to reduce the switching load of the system while maintaining the quality of service (QoS). In this paper, we have considered mean active set size and soft handover region as the metric for performance evaluation of the soft handover algorithm. It is directly related to performance of handover process and is required to be minimized.

The rest of the paper is organized as follows. Section 2 describes the system model used for

computer simulation; Soft handover algorithm follows cellular layout and radio propagation assumptions. It is followed by description of soft handover algorithm in section 3. Numerical results are obtained, plotted and discussed in section 4. Finally, conclusion and future work are drawn in section 5 and 6 respectively.

2. THE SYSTEM MODEL

We consider a simple cellular network consisting of two representative cells supported by two BS(s). Both of the BS(s) are assumed to be located in the center of the respective cell and operating at the equal transmitting power as depicted in Fig. 1. Hexagonal geometry of the cell has been considered. The UE moves from one cell to another along a straight line trajectory with constant speed. BSs are assumed to be D meters apart.

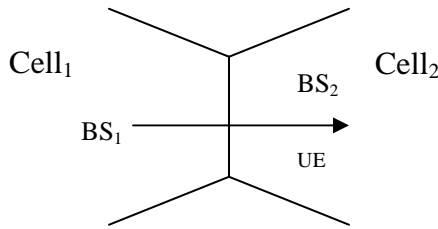


Fig. 1 Cellular configuration

Received Signal Strength (RSS) at UE is affected by three components as follows:

- (i) Path loss attenuation with respect to distance
- (ii) Shadow fading
- (iii) Fast fading

Path loss is the deterministic component of RSS, which can be evaluated by outdoor propagation path loss models [9-10]. Shadowing is caused due to the obstruction of the line of sight path between transmitter and receiver by buildings, hills, trees and foliage. Multipath fading is due to multipath reflection of a transmitted wave by objects such as houses, buildings, other man made structures, or natural objects such as forests surrounding the UE. It is neglected for handover initiation trigger due to its short correlation distance relative to that of shadow fading.

The UE measures RSS from each BS. The measured value of RSS (in dB) is the sum of two terms, one due to path loss and the other due to lognormal shadow fading. The propagation attenuation is generally modeled as the product of the η^{th} power of distance and a log normal

component representing shadow fading losses [9]. These represent slowly varying variations even for users in motion and apply to both reverse and forward links. For UE at a distance 'd' from BS₁, attenuation is proportional to

$$\alpha(d, \zeta) = d^{-\eta} 10^{\frac{\zeta}{10}} \quad (1)$$

where ζ is the dB attenuation due to shadowing, with zero mean and standard deviation σ . Alternatively, the losses in dB are

$$\alpha(d, \zeta)[dB] = 10\eta \log d + \zeta \quad (2)$$

where η is path loss exponent. The autocorrelation function between two adjacent shadow fading samples is described by a negative exponential function as given in [11]. The measurements are averaged using a rectangular averaging window to alleviate the effect of shadow fading according to the following formula [12]. Let d_i denote the distance between the UE and BS_{*i*}, $i=1, 2$. Therefore, if the transmitted power of BS is P_t , the signal strength from BS_{*i*}, denoted $S_i(d)$, $i=1, 2$, can be written as [14].

$$S_i(d) = P_t - \alpha(d_i, \zeta) \quad (3)$$

$$\hat{S}_i(k) = \frac{1}{N_w} \sum_{n=0}^{N-1} S_i(k-n)W_n \quad i = 1, 2 \quad (4)$$

where; \hat{S}_i is the averaged signal strength and S_i is the signal strength before averaging process. W_n is the weight assigned to the sample taken at the end of $(k-n)^{th}$ interval. N is the number of samples in the averaging window

$$N_w = \sum_{n=0}^{N-1} W_n$$

In the case of rectangular window $W_n = 1$ for all n . The size of averaging window should be selected judiciously as larger size of the window may not detect the need of handover initiation trigger at right time. On the other hand, smaller window may cause ping-pong effect, which is not desirable. In this work, first of all we have determined the optimum value of the size of averaging window for given system parameters and then the effect of propagation parameters is analyzed for that typical setting of averaging window size.

Shadow fading in the present work is modeled as follows [13]

$$\zeta(k) = \rho\zeta(k-1) + \sigma\sqrt{(1-\rho^2)}W(0,1) \quad (5)$$

where ρ is correlation coefficient and $W(0,1)$ represents truncated normal random variable.



3. SOFT HANDOVER ALGORITHM

CDMA systems support the soft handover process. Active set is defined as the set of base stations to which the UE is simultaneously connected. In soft handover region, UE is connected with more than one base station. A soft handover algorithm is performed to maintain the user's active set. For the description of the algorithm, the following parameters are needed.

- HYST_ADD: Hysteresis for adding.
- HYST_DROP: Hysteresis for dropping.

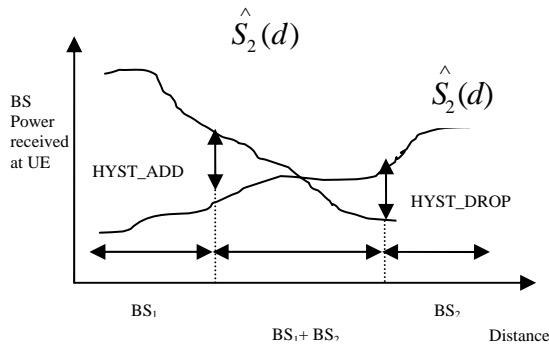


Fig.2 Soft handover algorithm

Active set is updated in following manner:

- If active set consists of BS₁ and $\hat{S}_1(d) > \hat{S}_2(d)$ and $(\hat{S}_1(d) - \hat{S}_2(d))$ is greater than HYST_ADD, Active set consists of BS₁
- If $|\hat{S}_1(d) - \hat{S}_2(d)| < \text{HYST_ADD}$, Active set consist of BS₁ and BS₂.
- If active set consists of BS₁ and BS₂ and $|\hat{S}_1(d) - \hat{S}_2(d)|$ becomes greater than or equal to HYST_DROP, Active set consist of that base station whose average signal strength is higher. Base station with smaller signal strength will be dropped from the active set.

Where $\hat{S}_1(d)$, $\hat{S}_2(d)$ is the averaged signal strengths from BS₁ and BS₂ respectively.

4. RESULTS AND DISCUSSION

In this section, mean active set size and soft handover region has been computed as the function of different system parameters and characteristic parameters of radio propagation environment. Numerical results for this performance metric are

obtained via computer simulation for the system parameters indicated in Table 1. System simulation is performed in Matlab 7.0. To obtain mean active set size and soft handover region for each system parameter setting, 5000 runs of the simulation program are performed.

Table 1. System parameters for system simulation

D = 2000 m	Distance between two adjacent BSs
$\eta = 4.0$	Path loss exponent
$d_s = 1\text{m}$	Sampling distance
$P_t = 0.0\text{dBm}$	Base station transmitter power
$\rho = 0.9512$	Correlation coefficient
$\sigma = 8.0$	Standard deviation
N=20	Averaging window size

Fig. 3a & 3b show the effect of HYST_ADD on the mean active set size. Mean active set size increases with the increase of the add hysteresis HYST_ADD. Mean active set size is maximum at the boundary and decreases as UE moves toward BS. High mean active set size increases signaling load on network and very low value of mean active set size may not give full advantage of macro diversity but it will increase the probability of outage.

Fig. 4a & 4b shows the variation of mean active set size with distance for different value of drop hysteresis HYST_DROP. Mean active set size increases as drop hysteresis HYST_DROP is increased. A large increase in mean active set size is observed. The reason for this result is attributed to the fact that greater value of drop hysteresis will increase active set size for larger area and hence soft handover region will increase. Large soft handover region will increase interference and this is not desirable. Therefore drop hysteresis should neither be very large nor very small.

Finally, Fig. 5 and Fig. 6 depicts the variation of soft handover region with add hysteresis and drop hysteresis. This plot shows that, as add hysteresis and drop hysteresis are increased, soft handover region increases rapidly. Large soft handover region increases interference and hence capacity decreases. Very small soft handover region may increase probability of outage. This is an interesting



result and should be taken into consideration while designing soft handover algorithm

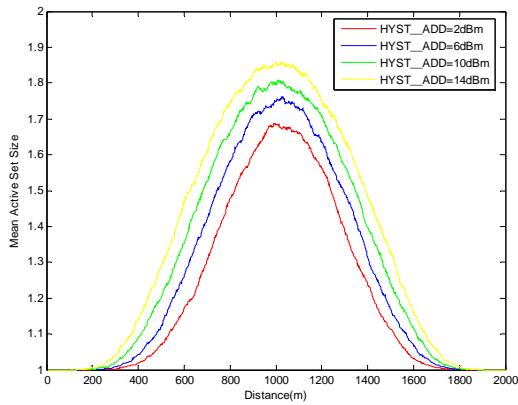


Fig. 3a Effect of HYST_ADD on mean active set size for given HYST_DROP=14dBm.

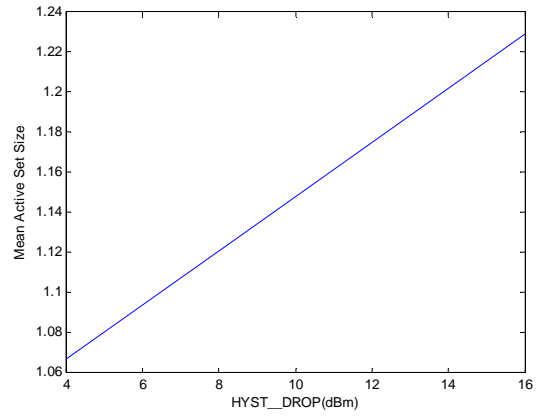


Fig. 4b Effect of HYST_DROP on mean active set size for given HYST_ADD=1dBm.

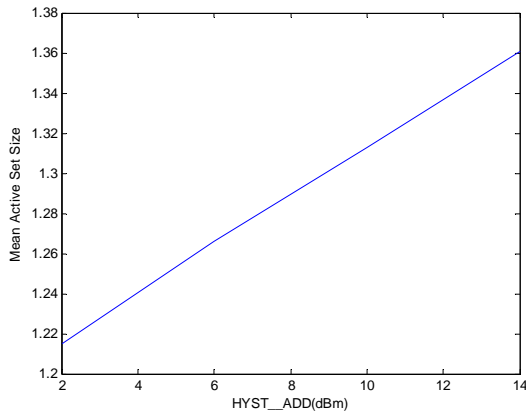


Fig. 3b Effect of HYST_ADD on mean active set size for given HYST_DROP=14dBm.

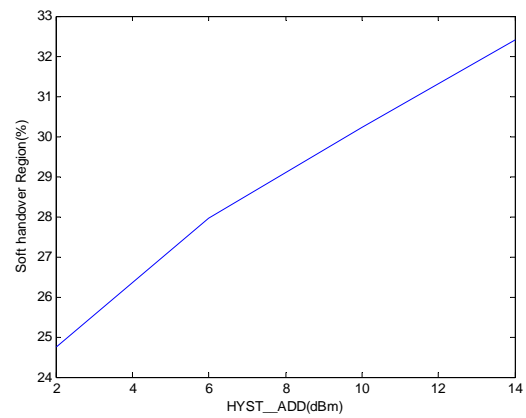


Fig. 5 Effect of HYST_ADD on soft handover region for given HYST_DROP=14dBm

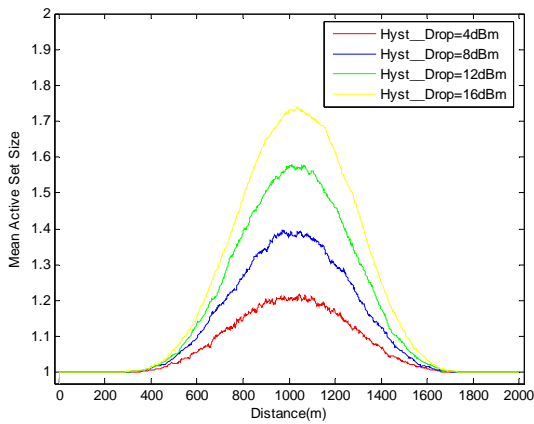


Fig. 4a Effect of HYST_DROP on mean active set size for given HYST_ADD=1dBm.

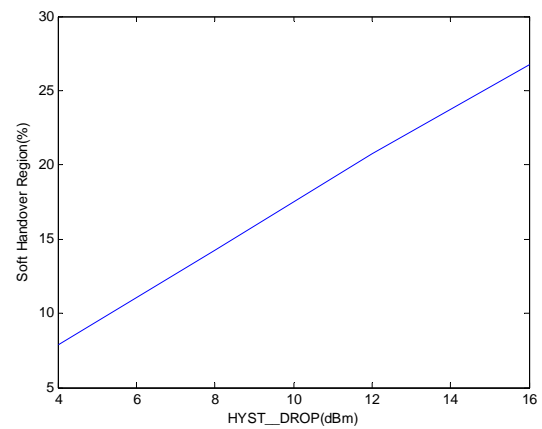


Fig. 6 Effect of HYST_DROP on soft handover region for given HYST_ADD=1dBm.



5. CONCLUSION

In this paper, we have tried to understand the impact of soft handover parameters HYST_ADD and HYST_DROP on soft handover performance, which was measured in terms of mean active set size and soft handover region. Simulation results show that soft handover parameter setting has a decisive effect on the handover performance. By careful tuning and setting appropriate values for the handover parameters, a higher system performance can be achieved

6. FUTURE WORK

There is a need to integrate WLAN, WMAN, and Cellular networks in a best possible way. WLAN generally provide higher speeds and more bandwidth, while cellular technologies generally provide more ubiquitous coverage. Thus the user might want to use a WLAN connection whenever one is available, and to 'fail over' to a cellular connection when the wireless LAN is unavailable. Vertical handover refer to handover from one technology to another technology to sustain communication. Mobile IP provides mobility among different technologies at network layer but the problem is that during handover it breaks the connection which causes some packet loss. Soft handover algorithm can be used in future with trust assisted handover approach in hybrid wireless networks.

REFERENCES:

- [1] K. S. Gilhousen, I.M. Jacobs, R. Padovani, L. Weaver, "Increased Capacity using CDMA for Mobile Communications", IEEE Journal on Selected Areas in Communications, Vol. 8, May 1990, pp. 503-514.
- [2] A.J. Viterbi, A.M. Viterbi, K.S. Gilhousen, E. Zehavi, "Soft Handoff Extends Cell Coverage and Increases Reverse Link Capacity," IEEE Journal on Selected Areas in Communications, Vol. 12, October 1998, pp. 1281-1287.
- [3] N. Jhang, J.M. Holtzman, "Analysis of CDMA Soft-Handoff Algorithm", IEEE Transactions on Vehicular Technology, Vol. 47, May 1998, pp. 710-714.
- [4] B. Homnan, V. Kunsriruksakul, W. Benjapolakul, "A Comparative Evaluation of Soft Handoff between S-95A and IS-95B/cdma2000", Proc. IEEE Vehicular Technology, 2000, pp. 34-37.
- [5] V. Vassiliou, J. Antoniu, A. Pitsillides, G. Hadjipollas, "Simulating Soft Handover and Power Control for Enhanced UMTS", IEEE 16th International Symposium on Personal, Indoor and Mobile Radio Communications, 2005, pp. 1646-1651.
- [6] D. Zhang, G. Wei, J. Zhu, "Performance of Hard and Soft Handover for CDMA Systems", IEEE Vehicular Technology Conference 2002, pp. 1143-1147.
- [7] J. Reig, "Capacity Analysis in Downlink WCDMA Systems Using Soft Handover Techniques With SIR-Based Power Control and Site Selection Diversity Transmission", IEEE Transactions on Vehicular Technology, Vol. 55, July 2006, pp. 1362-1372.
- [8] A.E. Leu B.L. Mark, "Discrete-time Analysis of Soft Handoff in CDMA Cellular Networks", Proc. IEEE Vehicular Technology Conference, 2002, pp. 3222-3226.
- [9] V. K. Garg, J.E. Wilkes, "Principles and Applications of GSM", Prentice Hall PTR, Upper Saddle River, NJ 07458.
- [10] K. Feher, "Wireless Digital Communications, Modulation and Spread Spectrum Applications", Prentice-Hall of India, New Delhi-2001.
- [11] V. M. Gudmundson, "Correlation Model for Shadow Fading in Mobile Radio Communication System," Electronics Letters., vol.27, November 1991, pp.2145-2146.
- [12] G.E. Corazza D. Giancristofaso, F. Santucci, "Characterization of Handover Initiation in Cellular Mobile Radio Networks", IEEE Technology Conference, 1994, pp. 1869-1872.
- [13] N.P.Singh, Brahmjit Singh "Effects of Soft Handover Margin under various Radio propagation parameters in CDMA Cellular Networks", IEEE conference on WCSN-2007, pp 47-50
- [14] Brahmjit Singh "An improved handover Algorithm based on signal strength plus distance for interoperability in mobile cellular networks" Wireless Personal Communication (2007), 43:879-887.
- [15] Xinbing Wang, Shiguang Xie, and Xiuwen Hu "Recursive Analysis for Soft Handoff Schemes in CDMA Cellular Systems" IEEE



- Transaction on Wireless Communications, Vol.8, NO. 3, March 2009
- [16] Qualcomm Corporation, "Diversity-Handover method and performance", ETSI SMG2 Wideband CDMA Concept Group Alpha Meeting, Stockholm, Sweden, Sept. 1997
- [17] EIA/TIA/IS-95A, 'Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System', Telecommunication Industry Association, Washington CD, May 1995
- [18] J. Laiho-Steffens, M. Jasberg, K. Sipila, A. Wacker and A. Kangas, "Comparison of three diversity handover algorithms by using measured propagation data", proceedings of VTC'99 Spring, Houston, TX, pp. 1370-1374, May 1999
- [19] Universal Mobile Telecommunications System (UMTS); Radio Resource Management Strategies, (3GPP TR 25.922 version 5.0.0 Release 5)
- [20] R. P. Narrainen and F. Takawira, "Performance analysis of soft handoff in CDMA cellular networks," Vehicular Technology, IEEE Transactions on, Vol. 50, Issue. 6, pp. 1507-1517, Nov. 2001
- [21] X. Yang, S. Ghaheri-Niri and R. Tafazolli, "Performance of power triggered and E_c/N_0 -triggered soft handover algorithms for UTRA," 3G Mobile Communication Technologies, Conference Publication, No. 477, pp. 7-10, 2000
- [22] X. Yang, S. Ghaheri-Niri and R. Tafazolli, "Evaluation of soft handover algorithms for UMTS," Personal, Indoor and Mobile Radio Communications, 2000 11th IEEE International Symposium on, Vol. 2, pp. 772-776, 2000
- [23] S. S. Wang, S. Sridsha and M. Green, "Adaptive soft handoff method using mobile location information," Vehicular Technology Conference, 2002, VTC Spring 2002. IEEE 55th, vol. 4, pp. 1936- 1940, 2002

AUTHOR PROFILES:

N.P. Singh received B.E. & M.E. degree in Electronics and Communication Engineering from Birla Institute of Technology, Mesra Ranchi, India in

1991 & 1994 respectively and presently pursuing PhD degree in Electronics and Communication Engineering at National Institute of Technology Kurukshetra, India. The current focus of his research interests is on radio resource management, interworking architectures design, mobility management for next generation wireless networks.



Brahmjit Singh received B.E. degree in Electronics Engineering from Malviya National Institute of Technology, Jaipur in

1988, M.E. degree in Electronics and Communication Engineering from Indian Institute of Technology, Roorkee in 1995 and Ph.D. degree from Guru Gobind Singh Indraprastha University, Delhi in 2005 (India). Currently, he is Professor, Electronics and Communication Engineering Department, National Institute of Technology, Kurukshetra, India. He teaches post-graduate and graduate level courses on wireless Communication and CDMA systems. His research interests include mobile communications and wireless networks with emphasis on radio resource and mobility management. He has published 65 research papers in International/National journals and Conferences. Dr. Brahmjit Singh received the Best Research Paper Award from The Institution of Engineers (India) in 2006.