Path Loss Exponent and User Velocity Dependent Variable Hysteresis Margin Based Call Handover Algorithm

P. P. Bhattacharya[(1)], P. K. Banerjee[(2)]

[(1)] ***Netaji Subhash Engineering College, Techno City, Police Para, Garia, Kolkata – 700 152, West Bengal, India***
Phone – 91-33-2436 1285, Fax – 91-33-2436 1286
E – mail : partha_p_b@yahoo.com

[(2)] ***Dept. of Electronics & Telecommunication Engineering, Jadavpur University, Kolkata – 700 032, West Bengal, India***
Phone – 91-33-2414 6010, Fax – 91-33-2414 6010

ABSTRACT

With the use of picocells to meet the increased demand of traffic density, the mobile communication networks need to comply with greater number of call handover requests than the normal cells. As the probability of handover requests is directly proportional to the mobile velocity, the handover response should be made dependent on mobile velocity to avoid unwanted call termination and early handover for high and low velocity vehicles respectively. Due to the dependency of handover performance to path loss exponent, a variable hysteresis scheme has already been proposed. As the handover performance is highly dependent on user velocity, if the hysteresis margin is made adaptive and varied dynamically in a complimentary manner with mobile velocity, the call termination as well as unnecessary handover may be minimized for high and low velocity mobiles respectively. In this work, a variable hysteresis margin based handover scheme is thus proposed and studied which takes care of both path loss exponent and mobile velocity. For different values of path loss exponent the positions of handover requests have been found out for different mobile velocities. Results show that handover delay decreases proportionately as user velocity increases, thus eliminating call termination or call quality degradation probability for high velocity mobiles and early handover for low velocity mobiles.

INTRODUCTION

In mobile cellular communication system, the signal strength based handover algorithms are mostly used because of their simplicity and effectiveness. Handover decisions can be taken based on the signal strength values by considering a particular hysteresis margin between the signal strengths from serving base transceiver station (BTS) and target BTS. These fixed hysteresis margin based handover algorithms suffer from call quality degradation and increase in call termination probability for mobiles with very high velocity while unnecessary handover for low velocity mobiles. The algorithms based on averaging the signal strength needs a balance between probability of handover and probability of outage. This problem is not there in the algorithms based on least square estimate of path loss [1, 2]. In this paper, a handover algorithm is proposed based on least square estimate of path loss parameters. In the proposed scheme the signal strengths from two BTSs have been estimated using least square method and the effect of user velocity on the performance of call handover has been studied. As the probability of handover requests is directly proportional to the mobile velocity [3, 4, 5], the handover response should be made dependent on mobile velocity to avoid unwanted call termination and early handover for high and low velocity vehicles respectively. Hence the effect of mobile velocity on handover performance has been studied. From the study it is found that there is a great dependence of probability of handover, average number of handover per call attempt with user velocity. Results show that call termination probability increases for high velocity mobiles and there are possibilities of unnecessary handover for low velocity mobiles which is in conformity with the expected results. To combat this problem a velocity dependent variable hysteresis margin based call handover scheme is proposed and studied.

To estimate signal strength at MS, a model of cellular mobile communication system with two base transceiver stations separated by a distance D is considered where the MS is moving with a constant velocity V. The signal strengths from two BTSs have been estimated using least square method [1, 2] for an average cell radius of 250 meters. The difference in signal strengths is shown in Fig.1 as a function of distance from serving BTS. From the figure it may be seen that signal strength decreases steadily at the midzone of a cell but falls sharply at its edge. In this environment there may be some serious effect on low and high velocity mobiles. Low velocity mobiles may stop or turn back after the handover execution resulting unnecessary handover and the high velocity mobiles may penetrate deep into the next cell before the handover execution resulting call termination. The effect of mobile velocity on handover performance have been studied and presented in the next section.

EFFECT OF MOBILE VELOCITY ON HANDOVER PERFORMANCE

In this paper, a model is considered where the user is assumed to travel with uniform velocity V throughout the cell with cell radius R. To study the effect of user mobility on handover performance a user mobility parameter α is considered and defined as [3, 4]

$$\alpha \underline{\Delta} \frac{2R}{V\,T_m} \tag{1}$$

where T_m is the mean call duration. The time interval t_{mc} between a user starts a call in a cell and reaches the cell boundary is given by

$$t_{mc} \underline{\Delta} \frac{L}{V} \tag{2}$$

where L is the distance which the user transits. Thus a handover occurs if $t_{mc} < t_d$, where t_d is the time of call duration.

The probability that a call in the current cell produces a handover towards a neighbouring cell can be given as [5]

$$P_h = \frac{1 - e^{-\alpha}[1-\alpha]}{2\alpha} - \frac{\alpha}{2}\int_{\alpha}^{\infty} \frac{e^{-x}}{x}\,dx \tag{3}$$

To analyze the system and study its performance, the cell radius is taken to be 250 meters and the mean call duration time is 1 minute which is the average call duration time for mobile users in our country. The average number of handovers per call attempt η_h may be expressed as [5]

$$\eta_h = \frac{(1-P_{ba})P_h}{1-(1-P_{bh})P_h} \tag{4}$$

where P_{ba} is the blocking probability for new call attempts and P_{bh} is the handover failure probability. The average number of handover is computed as function of user mobility assuming the new call blocking probability (P_{ba}) and handover blocking probability (P_{bh}) to be equal.
Probability of handover, average number of handover are computed using (3), (4) and plotted in Fig.2 and Fig.3 respectively for mobile velocity varying from 10 Km / hr to 100 Km / hr, which is the conventional velocity of moving vehicle in Indian urban area during peak and light traffic load. Since the average number of handover changes significantly with mobile velocity, fixed hysteresis margin based algorithm may pose problem of call termination or early handover. These problems may be eliminated if the hysteresis margin is made variable and velocity dependent. Considering these a model of velocity dependent call handover algorithm is proposed and described in the next section.

PROPOSED HANDOVER SCHEME

The signal strength decreases as exp ($-\gamma$d) where d is the distance and γ is the path loss exponent. In uniform propagation environment, γ can be taken as constant. But in real environment γ may have different values at different places. The two signals will differ more if the path loss exponent is large. Due to the sensitivity of handover performance to path loss exponent, a variable hysteresis scheme is already in use [6] where the hysteresis margin is expressed as a function of path loss exponent and is given by

$$h \propto \exp[-\gamma/6] \tag{5}$$

It may be noted from Fig.2 and Fig.3 that the handover performance is highly dependent upon the MS velocity and the probability of handover (P_h), average number of handover (η_h) increases as velocity of the mobile station increases. Thus if the hysteresis margin is changed dynamically in a complimentary fashion with MS velocity, the call termination as well as unnecessary handover may be minimized for high velocity and low velocity mobiles respectively. Thus a scheme of variable hysteresis margin based system is proposed which takes care of both path loss exponent as well as mobile velocity where the hysteresis is varied as

$$h = H\exp[-\gamma/6]/\eta_h \tag{6}$$

where η_h is the average number of handover and depends on mobile velocity as given by (1), (3) and (4) and H is the constant hysteresis margin which is independent of path loss parameter and user velocity. It has been found that a constant hysteresis margin H = 5 dB will be optimum for avoiding unnecessary handover due to early request and call degradation probability due to delay in request. Thus depending on path loss exponent and user velocity, the variable hysteresis margin h will be calculated and the handover request will be done at the corresponding position.

RESULTS

The position of handover requests as a function of velocity of MS for different values of path loss exponent have been computed and plotted in Fig.4. Results show that the distance of handover position from serving BTS decreases as user velocity increases, thus eliminating call termination or call quality degradation probability for high velocity mobiles and early handover for low velocity mobiles. For the same mobile velocity the distance of handover position is much lower for high values of path loss exponent, which is desirable. Thus the present handover request scheme is applicable for very low to very high velocity mobiles.

CONCLUSION

The present handover algorithm avoids both call termination and unnecessary handover for high and low velocity mobiles respectively. Since the algorithm avoids unnecessary handover, it will also reduce the Base Station Controller (BSC) and Mobile Switching Center (MSC) processor loading. The mobile station will estimate its velocity using the available standard techniques such as level crossing rate, zero crossing rate etc. followed by average number of handover. Then using the algorithm it will decide the position of handover request which will avoid call termination and early handover.

REFERENCES

[1] N. Benvenuto and F. Santucci, "A least square path loss estimation approach to handover algorithms", *IEEE Transaction on Vehicular Technology*, vol. 48, pp 437-447, March 1999.

[2] P. P. Bhattacharya, P. K. Banerjee, "A Least Square Path Loss Estimation For Mobile Communication Under Rayleigh Fading Environment", *Proc. of Computer and Devices for Communication* (CODEC 2004), Kolkata, India.

[3] E. Del. Re, R. Fantacci and G. Giambene, "Handover and Dynamic Channel Allocation Techniques in Mobile Cellular Networks", *IEEE Transactions on Vehicular Technology*, Vol 44, No 2, May 1995, pp 229 – 237.

[4] P. P. Bhattacharya, P. K. Banerjee, "Characterization of Velocity Dependent Mobile Call Handover", *Proc. International Conference on Communication, Devices and Intelligent Systems* (CODIS 2004), India, pp. 13-15.

[5] M. D. Austin and G. L. Stuber, "Velocity Adaptive Handover Algorithms for microcellular Systems", *Proc. IEEE ICUPC '93*, Ottawa, Canada, Oct, 1993, PP 793-805.

[6] Brahmjit Singh, K. K. Aggarwal, Shakti Kumar, "Sensitivity of Handover Performance to Path Loss Exponent: A Variable Hysteresis Margin Based Handover Initiation Scheme", *IETE journal of research*, Vol 50, No.1, 2004, pp-3-8.

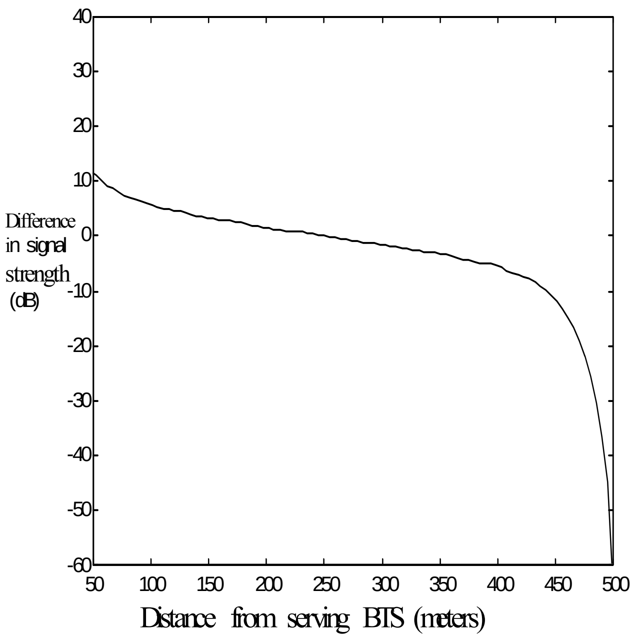

Fig.1. Difference in signal strength

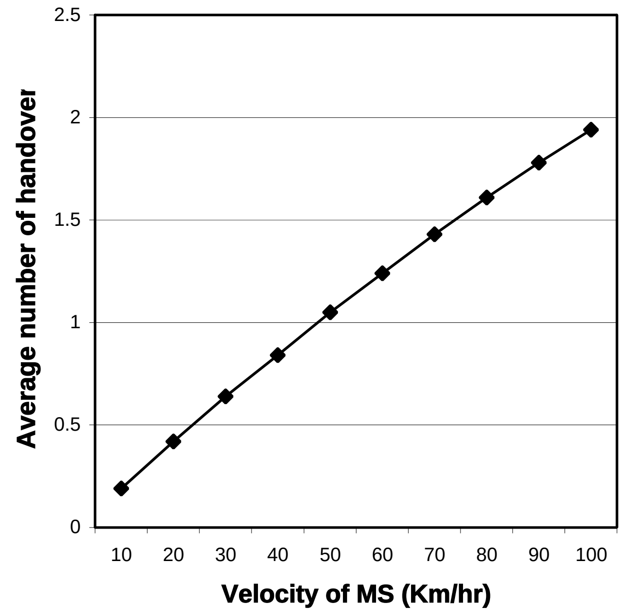

Fig.3. Average number of call handover versus MS velocity

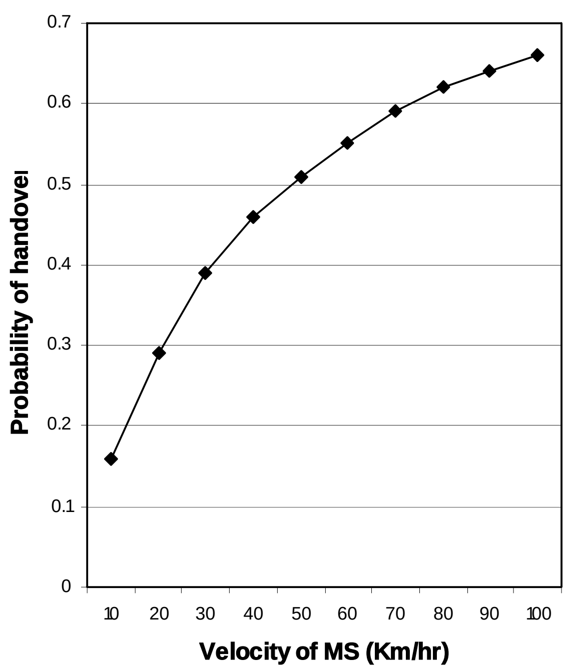

Fig.2. Probability of call handover versus MS velocity

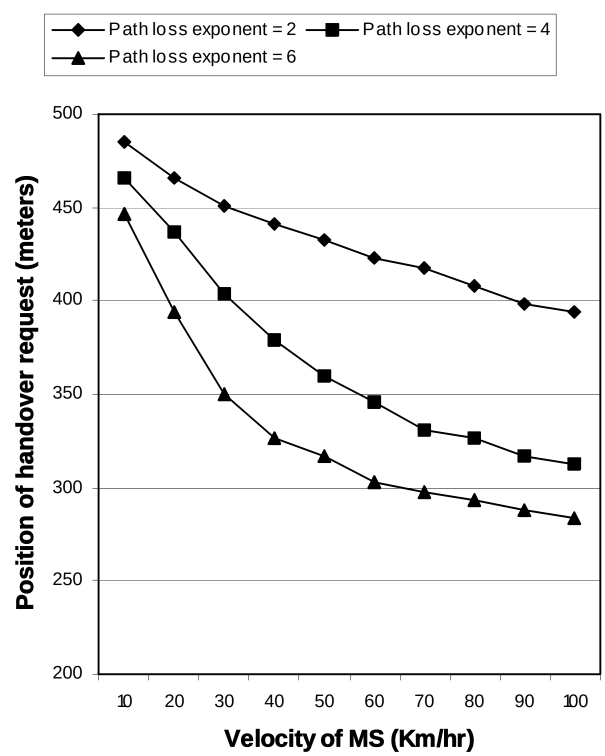

Fig.4. Position of handover requests versus MS velocity