Simulation of Handoff Techniques in Mobile Cellular Networks

Dr. S. A. Mawjoud

Electrical Engineering Department, University of Mosul

Samialmawjoud_2005@yahoo.com

Abstract

Mobility is the distinct feature of wireless mobile cellular system. Usually, continuous services is achieved by supporting handoff which is the transfer of an ongoing call from the current cell to the next adjacent cell as the mobile moves through the coverage area. usually handoff calls are given higher priority than new calls since it has a significant impact on the network performance. Simulation study of the relative signal strength with hysteresis and threshold (RSS-HT) algorithm for varying hysteresis and threshold are studies to evaluate the mean number of cell handoffs, mean number of wrong cell handoffs and expected average signal strength.

Keywords- Cellular network, signal strength, handoff schemes.

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1. Introduction:

Handoff is the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with current connection while a call is in progress [1]. It is often initiated either by crossing a cell boundary or by deterioration in the quality of signal in the current channel. Handoff is classified into two broad categories-hard and soft handoffs. Hard handoff is characterized by "break before make" i.e. current resources are released before new resources are used. Soft handoff is characterized by "make before break" i.e. both existing and new resources are released before new resources are used during the handoff process. Soft handoff is used in Code Division Multiple Access (CDMA), while hard handoff is implemented in Global system for Mobile (GSM) [2].

2. The Mobile Radio Channel Environment:

The mobile radio channel is a fading channel [3], since handoff decision is to detect the mobile user crossing the cell boundary. This can be accomplished by measuring received signal strength (RSS) at mobile stations (Mobile Assisted and Mobile Controlled Handoff Network Systems) from the base stations [4]. Since the signal strength varies considerably due to multipath fading (e.g. deepest fade typically 30 dB). Also this rapid multipath fading is accompanied by slow variation in the average signal pattern due to scatters and different terrain variations as the mobile moves. The slower fading effect (shadow fading) follow log-normal distribution. Hence handoff methods in the presence of multipath and shadow fading usually results in multiple handoffs (ping-pong) instead of a required single handoff [5].

These unnecessary handoff are problematic, firstly it increases the network load since each handoff requires network resources and secondly causing shortage in channel resources leading to call dropping. Therefore efficient handoff detection algorithm is necessary to avoid such problems in the system.

In this paper hard handoff is dealt with.

3. Handoff Algorithms:

Traditional handoff algorithms are as follows [3].

- Handoff based on Relative Signal Strength (RSS) in which the strongest base station (BS) is selected at all time [6].
- Handoff based on Relative Signal Strength with threshold (RSS-T) in which a user handover is executed only if the current signal is sufficiently weak (less than a threshold) and the other is the stronger of the two.
- Handoff based on Relative Signal Strength with hysteresis (RSS-H) in which a user handover is done if the new BS is sufficiently stronger by hysteresis margin (n) than the current one. This method prevents repeated handoffs (Ping-Pong effect) [7][8].
- Handoff based on relative Signal Strength with hysteresis and threshold of serving base station (RSS-HT_{ser}) in which the user handover to a new BS

occurs only if the current signal level drops below a threshold and the target BS is stronger than the current one by a given hysteresis margin.

- Handoff based on prediction techniques: in which the handoff decision in made on the expected future value of the received signal [7]. In cellular system wrong handoff may occur, this can be reduced my delaying the occurrence of handoff until the new BS signal strength gets sufficiently stronger. To achieve this, an additional criterion of absolute signal strength considered as threshold) of a new BS has been involved in the signal strength based RSS-H algorithm. The resultant algorithm is termed as RSS-HT_{new}. This algorithm improve the performance as follows:
- With the proper setting of the new BS threshold it reduces the number of unnecessary handoffs to a new base station when the signal strength of the new BS is not sufficient to serve the call.
- With appropriate higher threshold setting, the number of handoff occurring to the neighboring cell not intended for handoff (wrong handoff) can be minimized.

3.1 Problems in GSM Handoff Process [8]:

Hard handoff in GSM system is based on measurement data. This causes the main problem, since radio propagation in an real environment is unpredictable and highly irregular. In particular shadow fading caused by obstacles can produces some undesirable effects. This is mostly manifested by the fact that too many handoffs are taking place.

3.2 Ping Pong Handoff:

It is very undesirable effect that frequently occurs which is so-called ping pong handoff. It is a handoff to a neighboring cell that returns to the original cell after a short time (less than 10 Sec.) due to power budget criterion. A handoff is mainly executed on the base of this criterion in cells with good radio coverage and only minimal (disruption due to interference). To avoid such “ping-pong” effect he mobile station (MS) is allowed to continue maintaining a radio link with the current BS, until the signal strength from BS2 exceed that of BS1 by some prespecified threshold value H and some time named handoff Margin (HO-Margin) as shown in figure 1. Besides transmitting power, the handoff also depends on the mobility of the MS. In normal operation a threshold (H) of 5-10 dB is used to prevent minor variation in signal level of different base stations from causing a handoff.

Strong shadow fading caused by large obstacle can cause up to 30 dB. If such an obstacle is found in the line of sight (LOS) of the serving base station but not of the neighboring station, it is possible that a handoff may be triggered. As soon as the MS moves out of the shadowing area the level again become normal and handoff takes place to the original cell. With medium and high mobility of an MS, this results in handoff to a neighboring station back to the original base station within a short period of time (< 10 sec) (ping-pong handoff).

Handoff is only possible theoretically between points a and c, but is recommended at point b because that is where the level of BS2 has first fallen below the allowable hysteresis value h, in other word sufficiently above that of BS.

Due to propagation-related signal level fluctuations at the receiver, the curved characteristics shown only apply to the statistical average as in figure 1. Therefore the location of a handoff is randomly distributed in the area around b.

4. Analysis of Handoff Algorithm:

A two cell model have been considered in [3], [6] and [10].

Considering a three base station model shown in figure 2.

The model (network) [11] has three BSs, A, B and C separated by D meters with a mobile moving at constant speed along the straight line path shown in figure 2. The signal strength received at the mobile unit from the three BSs, is measured in dBs. The signal received by the mobile unit from each of the three BSs [a (d), b (d) and c(d)] shown in equation 1 to 3 below is the sum of two terms, one due to path loss and the other due to shadow fading. Rayleigh fading also exists, but gets average out and neglected because it has a much shorter correlation distance composed with shadow fading [10].

Rayleigh fading has shorter correlation distance compared with shadow fading. The low pass filter used for averaging will sufficiently attenuate Rayleigh fading while retaining part of shadow fading. The signal received (express in dB) from these three base stations at the mobile station can be written as:

$$a(d)=\mu-\eta\log(d)+u(d) \quad \ldots (1)$$

$$b(d)=\mu-\eta\log(D-d)+v(d) \quad \ldots (2)$$

$$c(d)=\mu-\eta\log\sqrt{\left(\frac{D}{2}-d\right)^2+\left(\frac{3}{\sqrt{3}}-\frac{D}{2}\right)^2}+W(d) \quad \ldots (3)$$

Where:

D is the distance between two BSs.

d is the position of the MS from BS_B.

μ and η are parameters for path loss.

μ depends on transmitted power at the base station.

η is equivalent to path loss slope equals 3 for the attenuation in this environment (i.e. η = ten times the path loss exponent).

u(d) , v(d) and w(d) represent shadow fading, which follows log-normal distribution. This log-normal distribution is represented by the zero mean stationary Gaussian random processes in dB and assumed exponential, supported by measurement [12].

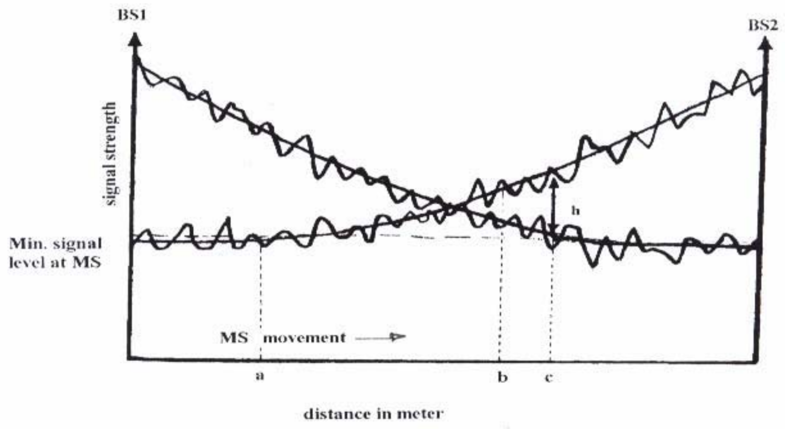

Figure (1): GSM power budget handoff

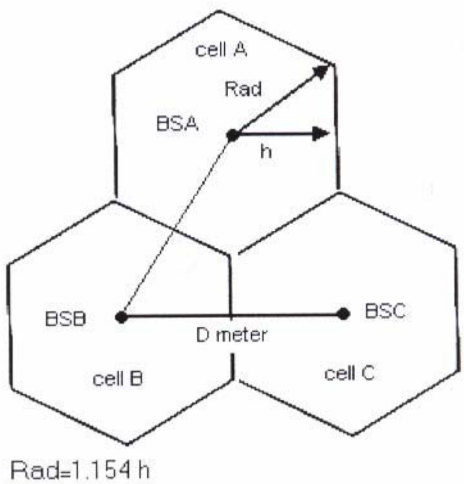

Figure (2): A three base stations model

5. Simulation:

The values of the parameters used in the simulation are assumed as follows μ = 0 dB, η = 30, D = 2000 m, correlation distance = 20, averaging constant = 30 and standard deviation of the shadow fading = 6 dB.

A test of handoff need is performed periodically at every sampling distance equal to 1 m.

Since all quantities in equations 1, 2 and 3 are expressed as function of distance so that the result is independent of the speed of the MS.

The performance evaluated of this algorithm are, mean number of handoffs, mean number of wrong handoff and expected average signal strength (EASS) of the serving BS to indicate delay.

6. Results:

The performance of the relative signal strength with hysteresis and threshold (RSS-HT) algorithm for varying hysteresis and threshold parameters are evaluated.

Figure 3 shows the main number of handoffs versus hysteresis margin for different values of threshold. It can be seen that the higher the threshold level the lower is the mean number of handoffs. Higher threshold values also reduces the mean number of handoffs as shown in figure 4 but the delay in handoff increases. Inspection of figure 4, for – 90 db threshold and hysteresis of 2 dB, the mean number of wrong cell handoffs to cell A is 0.5 this can be reduced to 0.075 by increasing the threshold to – 85 dB this also decreases the mean number of handoff from 3.6 to 0.5 but results in increased handoff delay.

Figure 5 shows the EASS in dB versus hysteresis for different threshold levels. For hysteresis of 2 dB and increasing threshold level for – 90 to – 85 dB the EASS decreases from – 89.4 dB to – 91.3 dB this is achieved at the cost of increased handoff delay (i.e. decrease in the EASS).

Figure 6 shows crossover point (from current cell to new cell) versus hysteresis values for different threshold level. For hysteresis of 2 dB at – 90 dB threshold the crossover point is at 1060 m and at – 85 dB threshold it is 1150 m.

Therefore crossover distance increases for certain values of hysteresis with increasing threshold level causing handoff delay.

7. Conclusion:

Handoff occurs as a mobile moves from the existing cell to the adjacent cell when the signal strength received by the mobile station is higher than the signal strength from the original cell by a certain value (hysteresis value).

Increasing the hysteresis value results in:

- Decrease the average number of handoffs,
- Increase delay in handoffs,
- Increase crossover points, and decrease in EASS.

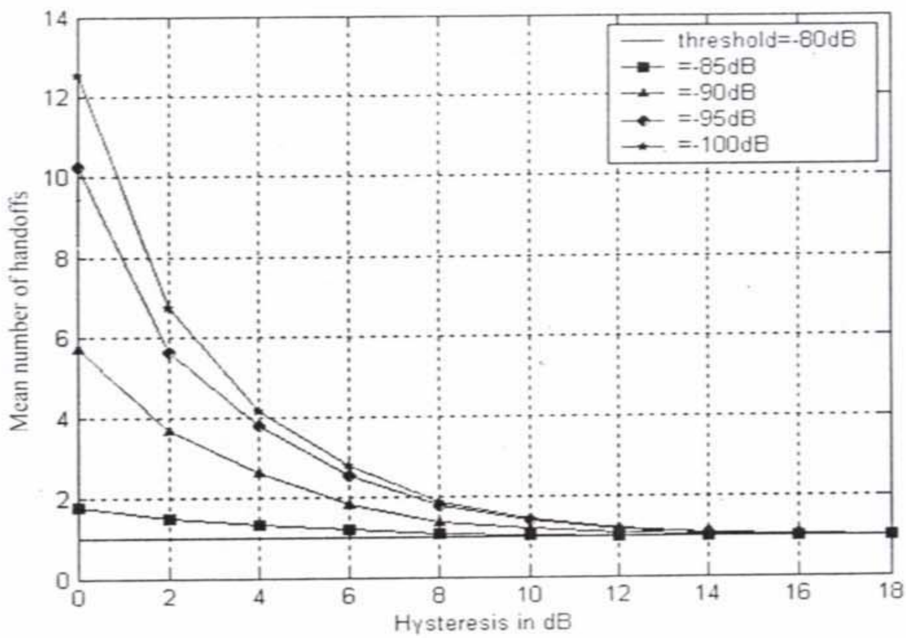

Figure (3): Mean number of handoffs versus hysteresis levels in 3BS model for RSS-HT new algorithm.

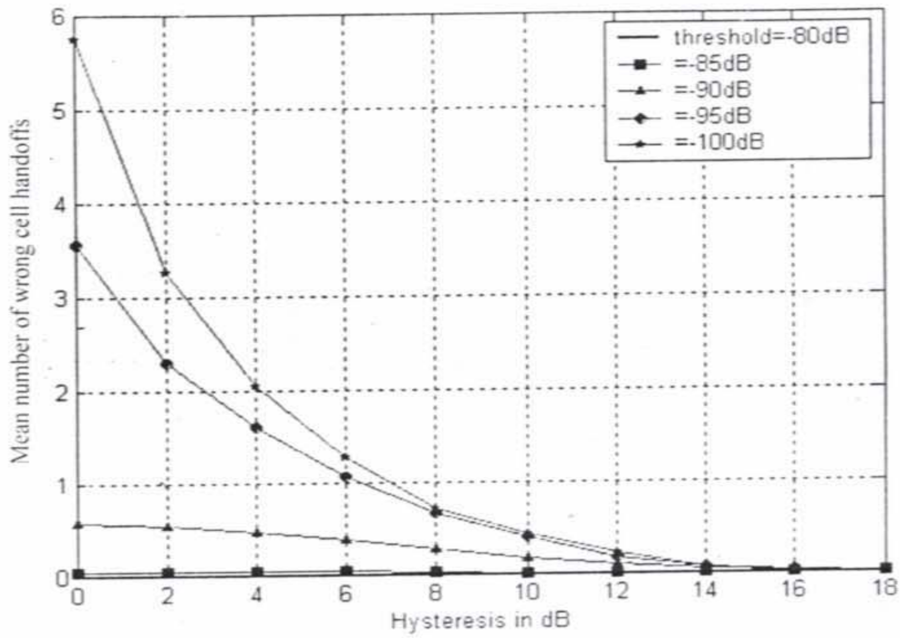

Figure (4): Mean number of wrong cell handoffs versus hysteresis levels in 3BS model for RSS-HT new algorithm.

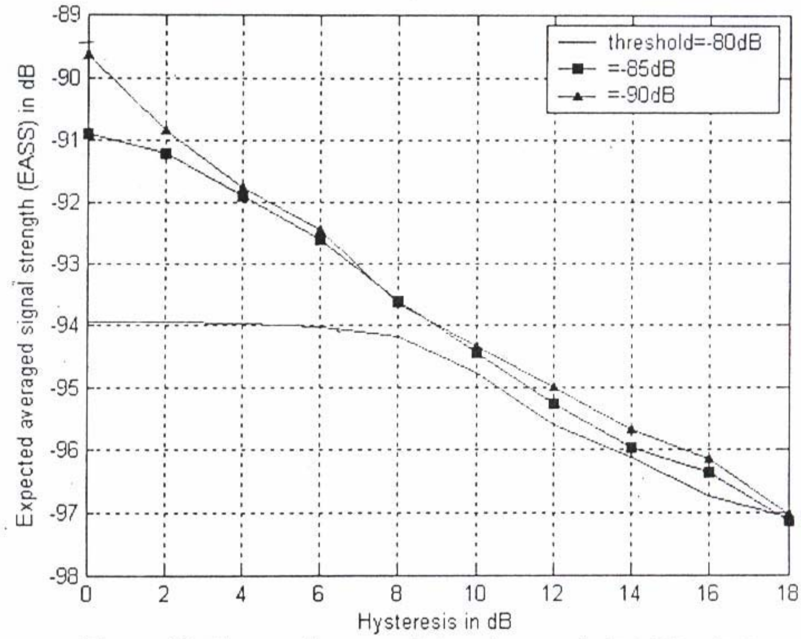

Figure (5): Expected averaged signal strength (EASS) of BS1 at which handoff initiation occurs to BS2 versus hysteresis levels in 3BS model for RSS-HT new algorithm.

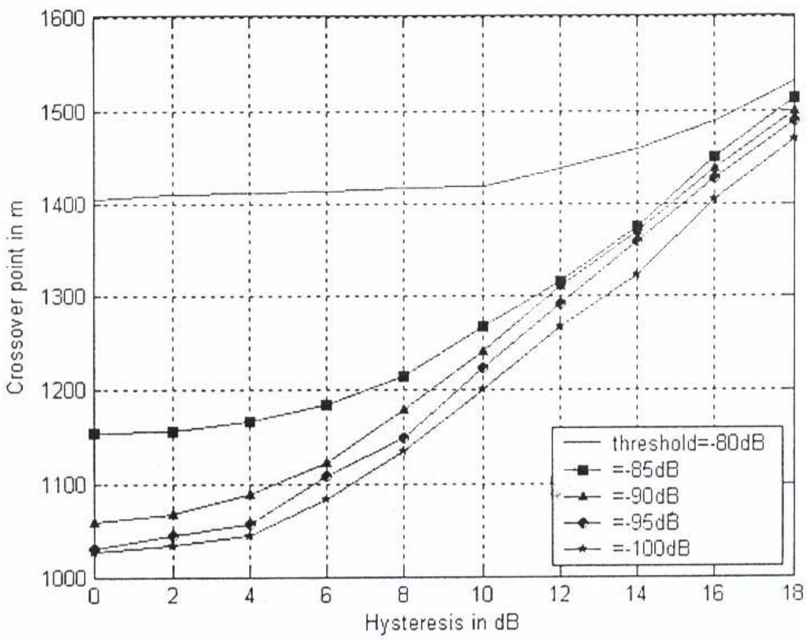

Figure (6): Crossover point versus hysteresis levels in 3BS model for RSS-HT new algorithm.

Therefore crossover point and EASS causing delay in handoff.

Decreasing threshold in the RSS-HT new cause increase the probability of handoff and therefore the number of handoffs and the number of wrong handoff increase, also crossover point decrease with lower values of threshold and EASS increases.

8. References:

1. Q. A. Zeng and D. P. Agrawal, "Handbook of Wireless Networks and Mobile Computing", Chapter 1, pp. 1-25, John Wiley & Sons, Inc., 2002.
2. D. P. Agrawal and Q-A. Zeng, "Introduction to Wireless and Mobile System", Thomson Brooks/Cole, chapter 9, p. 189-194, 2003.
3. P. Marichamy, S. Chakabarti and S. L. Maskara, "Overview of Handoff Schemes in Cellular Mobile Networks and Their Comparative Performance Evaluation", IEEE Proc. Vehicular Technology Conference (VTC'99)-Fall, Amsterdam, The Netherlands, pp. 1486-91-Sep. 1999.
4. R. S. Sharma, "Communication Networks Architecture", CDA 5501, Term Paper Fall 2002.
5. N. D. Tripathi, J. H. Reed and H. F. Van Landingham, "Handoff in Cellular Systems", IEEE Personal Communication Dec. 1998.
6. S. S. C. Rezaei and B. H. Khalaj, "Grey Prediction Based Handoff Algorithm", International Journal on Information Technology, Vol. 1, pp. 165-167, 2004.
7. S. T, Sheu and C. C. Wu, "Using Grey Prediction Theory to reduce Handoff Overhead in Cellular Communication Systems", The 11th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 200) Vol. 2, pp. 782-786, 2000.
8. B. H. Walke, "Mobile Radio Networks: Networking-Protocols and Traffic performance", John Wiley and Sons, Ltd, pp. 205-211, 2002.
9. D. P. Agrawal and Q-A. Zeng, "Wireless and Mobile Systems", Thomson Brooks/Cole pp. 102-106, 2003.
10. N. Zhang and J. M. Holtzman, "Analysis of Handoff Algorithm Using Both Absolute and Relative Measurement", IEEE Trans. ON Vehicular Technology Vol. 45, No. 1, pp. 174-179, 1996.
11. P. Marichamy, S. Chakabarti and S. L. Maskara, Performance Evaluation of Handoff detection Schemes. 0-7803-7651-X/03© 2003 IEEE.
12. M. Gudmundson, "Correlation Model for Shadow Fading in Mobile Radio Systems", Elect. Lett. Vol. 27. No. 23, pp. 2145-2146, Nov. 1991.

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