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Evaluation of the Optimal Handoff Parameters using the Method of Threshold with Hysteresis

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Abstract

Evaluating the performance of handoff method is important to choose the optimal method of handoff. This selection will prevent the use of expensive sources of radio transmissions with standard attainment of quality service (QoS) that can still be expected. In this paper, is evaluated the threshold method with hysteresis based handoff tradeoff parameters, namely: the quality of the signal level, delay, and the number of handoff to obtain the optimum value. Based on the analysis, proposed that approaches the optimal value of tradeoff of handoff parameter when a window length equal to zero (dr = 0) is the operating point of the threshold (T) at value of 15 to 18 dB with hysteresis value (H) of 1 to 4 dB. Then, when the window length is 20 (dr = 20), proposed to set up the operating point of threshold (T) = 18 dB with hysteresis value at H = 1 or 2 dB.

1. Introduction

Handoff is the mechanism for transferring channel from one cell to another cell in the movement of the Mobile Station (MS) in the cell coverage of the cellular system. The frequency of handoff occurs more frequently in the smaller cell area [1]. A relatively large number of handoff in a cellular network result in the load switching, so the handoff events need to be examined to find the optimal parameters. Some parameters which become a study to get the optimal handoff method are: decent signal level received by the MS, the expected number of handoff, handoff occurrence number is not necessary, failed handoff events and co-channel handoff [2-5]. Selection of handoff method is needed to reduce the cost of transmission of sources radio and to maintain the standard QoS [6].

Handoff execution can be carried out based on the signal level, the intensity of the network traffic, the ratio of carrier interference, bit error rate, transmission power and speed of MS [7]. Several methods of handoff initiation which is based on the signal level information are relative signal level, relative signal level to the threshold, relative signal level with hysteresis and relative signal level to threshold with hysteresis [3]. This paper discusses the evaluation of the optimal value of handoff parameters by using threshold method with hysteresis based on the tradeoff of handoff parameters, namely: the quality of the signal level, delay and number of handoff.

The rest of the paper is organized as follows. Section 2 describes about the system model used for computer simulation; Handoff method follows the cellular layout and radio propagation assumptions. It is followed by description of threshold method with hysteresis in section 3. The tradeoff of handoff parameter is explained in section 4. The simulation results is discussed in section 5. Finally, the conclusion is drawn in section 6.

2. System Model

Mobile network scheme is modeled with a homogeneous 3 BTS namely: BTS_1, BTS_2 and BTS_3. Each of BTS is placed on a cartesian coordinate system of $BTS_i(x_{BTS_i}, y_{BTS_i})$ and has cel coverage which equivalent to the model of the hexagonal-shaped cells and covered by the omnidirectional antenna. Distance $d_{i,k}$ is the distance from the MS to each k-th sample of BTS_i.

$$d_{i,k} = \sqrt{\left(x_k - x_{BTS_i}\right)^2 + \left(y_k - y_{BTS_i}\right)^2} \quad (1)$$

The movement speed of the MS in cell coverage is determined constant and has a random direction θ $[0,2\pi]$ and every time sampled with the coordinates (x_k, y_k) [8].

$$x_k = r\cos\theta_{k-1} + x_{k-1} \quad (2)$$

$$y_k = r\sin\theta_{k-1} + y_{k-1} \quad (3)$$

Where, $r = d_s$ (sample interval distances), $k \geq 2$ (stating that the k-th sample). Trajectory models of MS in the cell indicated by the Cartesian coordinates as in Figure 1.

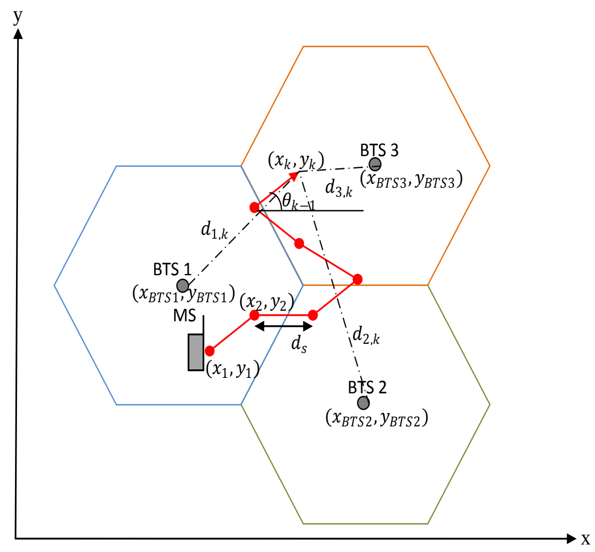

Figure 1. MS trajectory models in Cartesian system

The Level of the signal received by the MS from the BTS_i along the trajectory $d_{i,k}$ is [6]:

$$S_{i,k}(d_{i,k}) = K_1 - K_2 log(d_{i,k}) + W_{i,k} \quad (4)$$

Where, $i = 1,2,3$; $S_{i,k}$: the received signal strength from base stations BTS_i at the k-th sample; $d_{i,k}$: MS distance to the BTS_i at the k-th sample; K_1: pathloss constant; K_2: pathloss exponent. $W_{i,k}$: Gaussian distribution $\left(N(0, \sigma_i^2)\right)$ which represents the shadowing effect. The $W_{i,k}$ is represented by a zero mean AR-1 of stationary Gaussian processes are characterized by the autocorrelation function [9].

$$E[W_{i,k} W_{i,k+m}] = {\sigma_i}^2 {a_i}^{|m|} \quad (5)$$

$W_{i,k}$ is written recursively as follows:

$$W_{i,0} = \sigma_i^2 N_{i,0}$$

$$W_{i,k+1} = a_i W_{i,k} + \sigma_i \sqrt{1 - a_i^2} N_{i,k} \quad (6)$$

Where, $N_{i,k}(0,1)$: random variable. d_i: distance correlation. σ_i^2: variance of shadow fading. a_i: coefficient correlation of $N_{i,k}$; $a_i = \exp(-vt_s/d_i)$.

Level of the signal received by MS discretely sampled for each $t_k = kt_s$, where t_s is the sampling time period. The distance between each sample point is $d_s = vt_s$ assuming MS velocity v ($v(meter/sekon)$) is constant. To refine or minimize the effect of fluctuating signals the signal level received by the MS treated with exponential average method [10]. So that, the equation after the signal level is averaged is

$$\bar{S}_{i,k}(d_{i,k}) = e^{-\left(\frac{d_s}{d_r}\right)} \bar{S}_{i,k-1}(d_{i,k-1}) + \left(1 - e^{-\left(\frac{d_s}{d_r}\right)}\right) S_{i,k}(d_{i,k}) \quad (7)$$

Where, d_r is average window length.

$\bar{S}_{i,k}(d_{i,k})$ is the average signal received by the MS from the BTS_i as a function of the distance d to the signal sample to k. $\bar{S}_{i,k-1}(d_{i,k-1})$: the average signal received by the MS from the BTS_i as a function of the distance d on samples to k-1.

3. Method of Threshold with Hysteresis

The handoff events begins when a signal strength of the active BTS which currently serving the MS falls below the threshold value. On the other hand, the signal strength of BTS candidate is higher than the signal strength of the active BTS are serving the MS in amount of value of hysteresis H. This relationship is expressed as follows [11].

$$(\bar{S}_s < T_{ho}) \cap (\bar{S}_c > \bar{S}_s + H) \quad (8)$$

Where, $\bar{S}_s$: signal strength from active BTS currently serving the MS. $\bar{S}_c$: signal strength from neighboring BTS as a candidate to serve the MS. T_{ho}: the threshold value which may be varying depend on the network operator and the transmission power of BTS.

4. Tradeoff of Handoff Parameter

The tradeoff of handoff parameter that will be discussed are call quality signal level, co-channel handoff and handoff number.

4.1 Call Quality Signal Level (CQSL)

CQSL is sum of sample points from the signal strength that can be accepted and associated with the signal strength of sample points that unacceptable, formulated with: [6]

$$CQSL(l) \geq \frac{\sum_{k \epsilon N_g} A_k}{N} - \frac{S_{min}\,|N_g|(N-|N_g|)}{pN^2} \quad (9)$$

Where, $\forall\, k \,\epsilon\, N_g$,

$$A_k = \begin{cases} S_{i,k} & if\ S_{i,k} \leq S_{max} \\ S_{max} & \text{others} \end{cases}$$

N_g : the number of sample points of signal strength that can be accepted. N_b: the number of sample points of poor signal strength, namely: $S_{i,k} < S_{min}$ so unacceptable. S_{min} and S_{max}: signal minimum and maximum signal, where $S_{max} = 1{,}5 S_{min}$. C: value of penalty which the sample points are not acceptable. N: number of sample points of signal strength, so $N_g = \{k | S_{i,k} \geq S_{min}\}$ and $N_b = (N - |N_g|)$. p: proportion of the maximum allowable of sample points of signal strength whose value falls is below S_min.

The average value of CQSL (l) consisting of s path where each path $l = (l_1, l_2, \ldots, l_s)$ consists of N samples of a signal, stated the following equation:

$$\overline{CQSL} = \sum_{l=1}^{s} \frac{CQSL(l)}{s} \quad (10)$$

4.2 Co-channel Handoff

Co-channel handoff (Delay (l)) is the length of time in which the MS is not served by the nearby BTS moving along the path l. The movement of the MS along the path l is composed of N points sampled signal is stated as follows.

$$Delay(l) = \sum_{k=1}^{N} D_k \quad (11)$$

where, $D_k = \begin{cases} t_s, & if\ delay\ occurs \\ 0, & \text{otherwise} \end{cases}$

Thus, the co-channel average ($\overline{Delay}$) of the number s of path l defined by the following equation

$$\overline{Delay} = \frac{1}{s} \sum_{l=1}^{s} Delay(l) \quad (12)$$

4.3 Handoff Number

When the handoff occurs, the decision variables $U_k = 1$. Conversely when $U_k = 0$ states that handoff does not occur. The number of handoff events $U_k(l)$ on the path l consisting of N points sampled signal is expressed by the following equation:

$$U_k(l) = \sum_{k=1}^{N-1} U_k \quad (13)$$

The handoff average value of the s number of l trajectory is written by the following equation.

$$\overline{Handoff} = \sum_{l=1}^{s} \frac{U_k(l)}{s} \quad (14)$$

5 Simulation Results and Discussion

Simulations carried out with the aid of software Matlab R2009b. Three of BTS which are separated by the same distance each at 100 √ 3 meters. Each of BTS is located in the cartesian system BTS_1(100, 161.6), BTS_2(250, 75) and BTS_3(250, 248.2) [6]. MS is assumed to move straight on every movement of 1 meter with a direction (angle θ) of the random variable starting from the coordinates (200, 0). A number of 500 path (s) of MS generated in the area three BTS. Every path of MS consists of 400 signal samples (N) with distance of each sample (d_s) is 1 meter.

Signal strength generated for each sample point along the path of moving MS is expressed by equation $S_{i,k}(d_{i,k}) = K_1 - K_2 log\left(d_{i,k}\right) + W_{i,k}$, where $K_1 = 85\ dB$ and $K_2 = 35\ dB$. Shadowing correlation distance (d_i) is specified 20 meters; MS moving speed (v) is 2 m / s, time samples of each signal (t_s) is 0.5 seconds; standard deviation of shadow fading (σ) is 5 dB; minimum signal that still acceptable by the user (S_{min}) is 15 dB; maximum signal level of signal quality in call (S_{max}) is $1{,}5.S_{min}$; proportion of sample point of signal strength with quality below the minimum signal (p) determined 0.1 [6].

The scenario of drop calls that used is retry models [11]. The state of the drop occurred after the signal level is met 12 times under S_min (GSM drop timer is 6 sec) [6].

In Figure 2 is shown the variation of the threshold value (T) with a size of 11 to 20 dB and a value of hysteresis (H) in the range of 1 to 10 dB. The increase in the threshold value impact on increasing the value of $\overline{CQSL}$, the lowering value of $\overline{Delay}$ and the increasing value of $\overline{Handoff}$. The increase in the value of hysteresis results in impairment of $\overline{CQSL}$, the increase in the value $\overline{Delay}$ and reduce the value $\overline{Handoff}$.

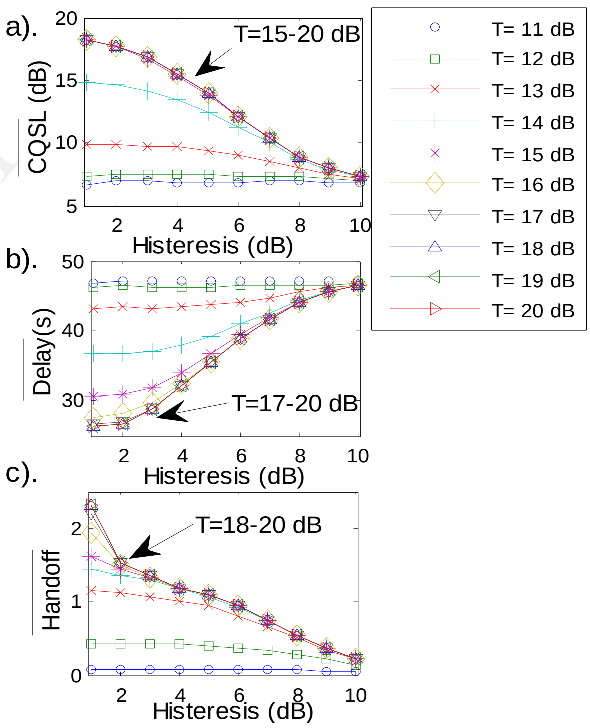

Figure 2. Variation of the threshold (T) against tradeoff of handoff parameterwith dr = 0.

In Figure 3, there is shown the influence of the window average length of the threshold method (14 and 17 dB) with hysteresis (H) in the range 1 to 10 dB. When the window length dr = 20 has been minimized the value of $\overline{Handoff}$, but lower the value of $\overline{CQSL}$ and add to value of $\overline{Delay}$. So the value of window length (dr) can be varied for setting of handoff tradeoff parameter to the desired value.

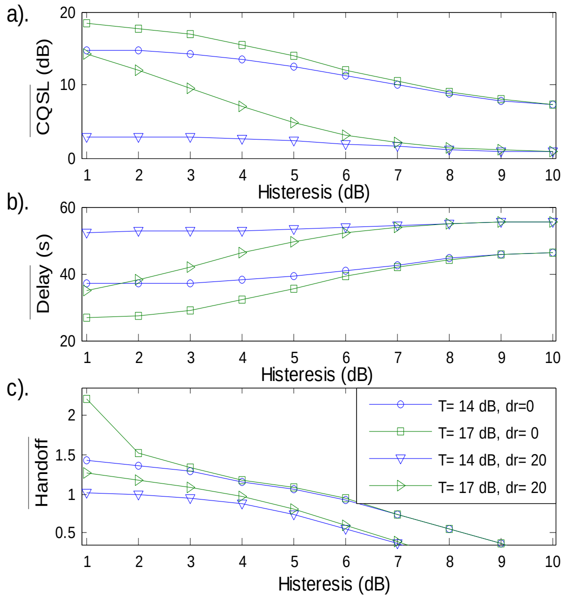

Figure 3. Variation of the average window length (dr = 0 and 20) against tradeoff of handoff parameter

In Figure 4, shown the tradeoff curve of the threshold method with hysteresis of the relationship between $\overline{CQSL}$ against $\overline{Handoff}$ (represented by the solid line) and $\overline{Delay}$ against $\overline{Handoff}$ (represented by the dotted line). Threshold value (T) is set at a value of 13 to 18 dB with a value of hysteresis (H) be set at a value of 1 to 4 dB.

Selection of the optimal value from the tradeoff of handoff parameter is to avoid signal quality falls below S_min = 15 dB, maintaining the value of handoff delay about 40 second and the number of handoff is set to the minimum value. The benefit of obtaining the optimal value of this is to keep the signal quality remains above the minimum value, to avoid co-channel interference and avoid the waste of switching due to handoff in network.

In Figure 4a, approaches the optimal value of tradeoff of handoff parameter is at T = 15 dB with H = 4 dB. However, in Figure 4b the optimal values from tradeoff of parameter handoff is at T = 1 and 2 dB with H = 18 dB.

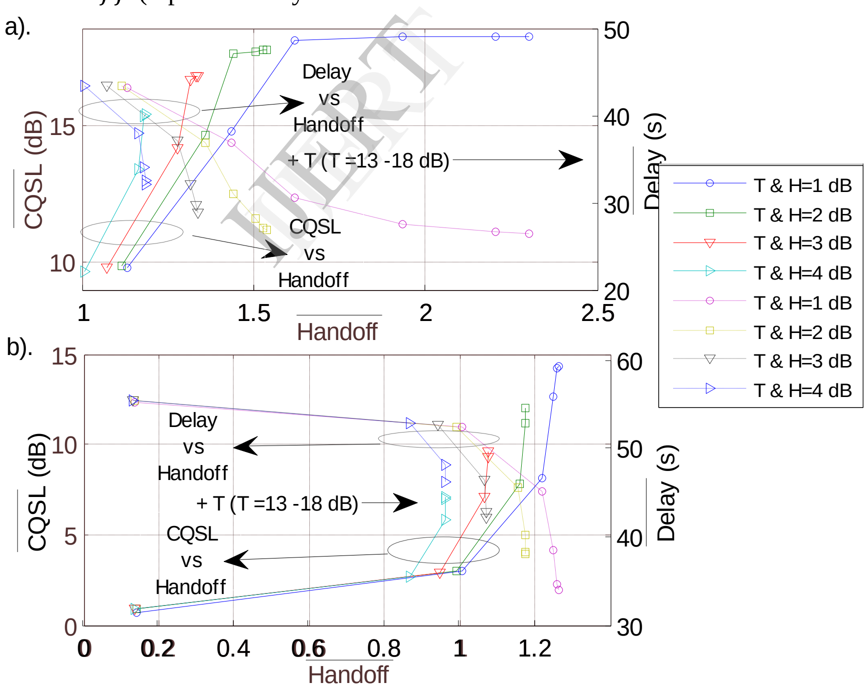

Figure 4. The tradeoff between the parameters $\overline{CQSL}$ against $\overline{Handoff}$ (solid line) and parameters $\overline{Delay}$ against $\overline{Handoff}$ (dashed line). a). dr = 0 b). dr = 20

VI. Conclusion

Optimizing the tradeoff of handoff parameter on the Threshold with Hysteresis method can be done by varying the threshold and hysteresis values as well as the average length of the window. The larger the threshold value can speed up the handoff and greater the value of hysteresis can add to the delay. However, increase the average length of the window can reduce the handoff and consequences on the addition of delay.

Proposed that approaches the optimal value of tradeoff of handoff parameter when the length of the window equal to zero (dr = 0) is the operating point of threshold (T) of 15 to 18 dB and with hysteresis values of 1 to 4 dB. Then, proposed that approaches the optimal value of tradeoff of handoff parameter when the length of the window equal to 20 (dr = 20) is the operating point of threshold (T) at 18 dB and with hysteresis values (H) at 1 our 2 dB.

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