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Research paper

Impact Suboptimal Signal Degradation Handoff (SDH) Properties to Handoff Parameters

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Abstract

Study on mobile handoff is aim at avoiding inefficient mobile station transfer from a base station to other base station. Efficient handoff leads to smooth communication and seamless mobile station migration. This paper studies impact of cost and window length properties of the suboptimal signal degradation handoff (SDH) to handoff performance parameters such as received signal level, delay and number of handoff. Simulation results show that cost and average length increment cause signal degradation and delay increment. However, number of handoff decreases. The suggested optimal cost (c) for average window length (dr) 0 and 10 are 0.65 and 0.25. However, dr = 20 and 30 experience poor signal for any cost values.

Keywords: *Handoff, optimal cost, average window length*

1. Introduction

Handoff is a channel migration mechanism from one cell to other cell following the mobile station movement. A more frequent handoff occurs in a smaller cell [1]. Frequent handoff burdens switching within cellular network: so that the frequency should be optimized by finding the optimal handoff parameters.
Some handoff parameters that determine handoff performance are the suitable received signal level, the number of the occurred handoff, handoff failure and handoff delay [2]–[5]. Properties selection of a handoff algorithm is important to reduce radio transmission cost as well as to maintain quality of services (QoS) [6], [7].
Within a cellular network, the number of slots or channels, allocated frequencies, network codes are defined [1][8]. The coverage is also defined whether femto, pico, micro, macro or mega cell [9]. Signal within a cellular network is fluctuated, composed by direct signal, reflection, diffraction and scattering [6], [10], [11] which is affected by path loss and fading [6], [11]–[13].
In order to analyze the system, signal propagation within a cellular network is modelled either using continues time model or discrete time model [14]–[17]. Signal fluctuation is averaged in term of exponential average window so that the received signal smoother [16] [18][19].
Handoff between base stations are classified into: soft handoff (make before break) and hard handoff (break before make) [9]. Handoff decision is based on either centralized or decentralized decision: Network Controlled Handoff (NCHO), Mobile Assisted Handoff (MAHO) and Mobile Controlled Handoff (MCHO) [19], [20].
The handoff execution is based on signal level, traffic intensity, carrier to interference ratio, bit error rate, transmission power and mobile speed [21]. This paper discusses handoff initiation by using suboptimal Signal Degradation Handoff (SDH) [16] and its properties impact to handoff performance parameters

2. System Model

A homogeneous cellular network consists of three base stations (BTS): BTS_1, BTS_2, and BTS_3 are modeled. Each bases station is located in Cartesian coordinate of $BTS_i\left(x_{BTS_i}, y_{BTS_i}\right)$. It is assumed that each BTS has hexagonal equivalent coverage which covered by omnidirectional antennas. Distance $d_{i,k}$ is the distance between the k^{th} mobile station sample to BTS_i.

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

By assuming that number of mobile station within a cell is constant with random direction $\theta[0,2\pi]$, then the mobile station coordinate is (x_k, y_k) [22]:

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

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

Where $r = d_s$(sampel distance), $k \geq 2$ (the k^{th} sample).

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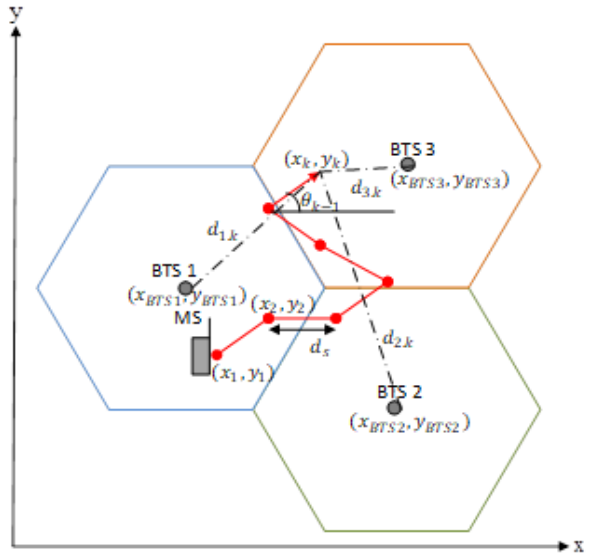


Fig.1: System model

The signal level accepted by a mobile station from BTS_i along path $d_{i,k}$ is approximated by [8], [23]:

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

where $i = 1,2,3$. $S_{i,k}$ be the signal level received by BTS_i on sample-k. $d_{i,k}$ is distance BTS_i to sample-k. K_1: path loss constant. K_2: path loss exponent. $W_{i,k}$: Gaussian distribution for shadowing effect $\left(N(0, \sigma_i^2)\right)$.

$W_{i,k}$ is represented by a zero-mean of autocorrelation function [24], [25]:

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

$W_{i,k}$ is recursively calculated from [25]:

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

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

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

3. Simulation Model

The received signal by mobile station is discretely sampled every $t_k = kt_s$ where t_s is the sampling time period. Distance between sampling periods is $d_s = vt_s$assuming that speed $v(m/s)$ is constant. To minimized signal fluctuation, signal level is processed by using exponential average [15], [16]. The average signal level is expressed by:

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

Suboptimal Signal Degradation Handoff

The suboptimal SDH determines handoff decision by using time limitation between k and $k+1$, as a function of Q [16], [25]:

$$U_k = \begin{cases} 1, \text{ jika } Q\left[\frac{S'(BTS_{canditate}(k),k)}{\bar{\sigma}}\right] + c \\ \quad < Q\left[\frac{S'(BTS_{active}(k),k)}{\bar{\sigma}}\right] \\ 0, \text{ others} \end{cases} \quad (8)$$

where,

$$Q(z) \triangleq \frac{1}{\sqrt{2\pi}} \int_z^\infty e^{-t^2/2}\, dt \quad (9)$$

c(cost) : parameter trade-off varied based on cellular environment.

A. Handoff Parameters

1) Call Quality Signal Level (CQSL)

CQSL is the sum of sampling points of received signal with the unacceptable signal points, approximated as [6]:

$$CQSL(l) \geq \frac{\sum_{k \epsilon N_g} A_k}{N} - \frac{S_{min}|N_g|(N-|N_g|)}{pN^2} \quad (10)$$

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

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

N_g : the number of samples of the acceptable signal strength. N_b : the number of sample of poor signal where: $S_{i,k} < S_{min}$with assuming $S_{max} = 1{,}5S_{min}$. C : the value where signal is unacceptable. N: good and bad signal numbers, $N_g = \{k | S_{i,k} \geq S_{min}\}$ and $N_b = (N - |N_g|)$. p: maximum acceptable proportion of signal samples below S_{min}.

The average CQSL(l) for s path of $l = (l_1, l_2, \ldots, l_s)$:

$$\overline{CQSL} = \sum_{l=1}^{s} \frac{CQSL(l)}{s} \quad (11)$$

2) Delay Handoff

Delay is the time when mobile station is not served by the closest base station. Delay Mobile station position is in between two equivalents base stations [16]:

$$Delay(l) = \sum_{k=1}^{N} D_k \quad (12)$$

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

The average delay can be written as:

$$\overline{Delay} = \frac{1}{s} \sum_{l=1}^{s} Delay(l) \quad (13)$$

3) Number of Handoff

When handoff occurs, decision variable $U_k = 1$, the opposite condition is no handoff exists $U_k = 0$. The number of handoff ($U_k(l)$) at path l is expressed by:

$$U_k(l) = \sum_{k=1}^{N-1} U_k \quad (14)$$

The average number of handoff is:

$$\overline{Handoff} = \sum_{l=1}^{s} \frac{U_k(l)}{s} \quad (15)$$

4. Simulation Results

By using Matlab simulation[26], [27] and the aforementioned model are evaluated. The BTS distance is set to be $100\sqrt{3}$ m. The BTS coordinates are BTS_1 (100, 161.6), BTS_2 (250, 75), BTS_3 (250, 248.2). It is assumed that mobile station moves straight every 1 m from MS(200, 0) with angle θ.

The number of path s=500, each path has N=400 signal samples, with distance of $d_s = 1$ m.

Next, it is assumed that the signal level along the path is $S_{i,k}(d_{i,k}) = K_1 - K_2 \log(d_{i,k}) + W_{i,k}$ where $K_1 = 85$ dB ; $K_2 = 35$ dB; speed $v = 2$ m/s, sample period is $t_s = 0.5$ s and

deviation standard σ = 5 dB, S_{min} = and S_{max} = 1,5S_{min}, proportional p = 0.

The call scenario is using retry model, the drop state occurs after signal level is 12 times under S_{min} (with drop timer 6s).

Figure 2 shows impact cost variation (c = 0.025, 0.04, 0.06, 0.1, 0.13, 0.25, 0.35, 0.45, 0.55, 0.65) and average window length (d_r = 0, 10, 20, 30) to handoff parameters.

In Fig. 2a, cost (c) increment causes the value of signal strength$\overline{CQSL}$ decreases. Initially, signal decreases exponentially up to c=0.5, then linearly to c=1. Signal strength decreases when dr increases.

In Fig.2b., cost (c) and d_r increments result delay increasing. Its increment is opposite to signal strength. The lower the dr: the lower the delay.

In Fig. 2c, Handoff number decreases significantly when cost increases. The higher the dr: the lower the number of handoff.

The optimal properties are approximated by considering $\overline{CQSL}$ close to S_{min}=15 dB, and $\overline{Delay}$ closes to 40 s and handoff number minimized. Figure 3 shows the trade-off between handoff properties to handoff performances: $\overline{CQSL}$, $\overline{Handoff}$ and $\overline{Delay}$.

The optimal value is obtained by setting cost (c) at d_r = 0, where the first suggestion is c = 0.65. For d_r = 10, it is suggested that c = 0.25. And for d_r = 20 and 30, should be avoided as signal is poor.

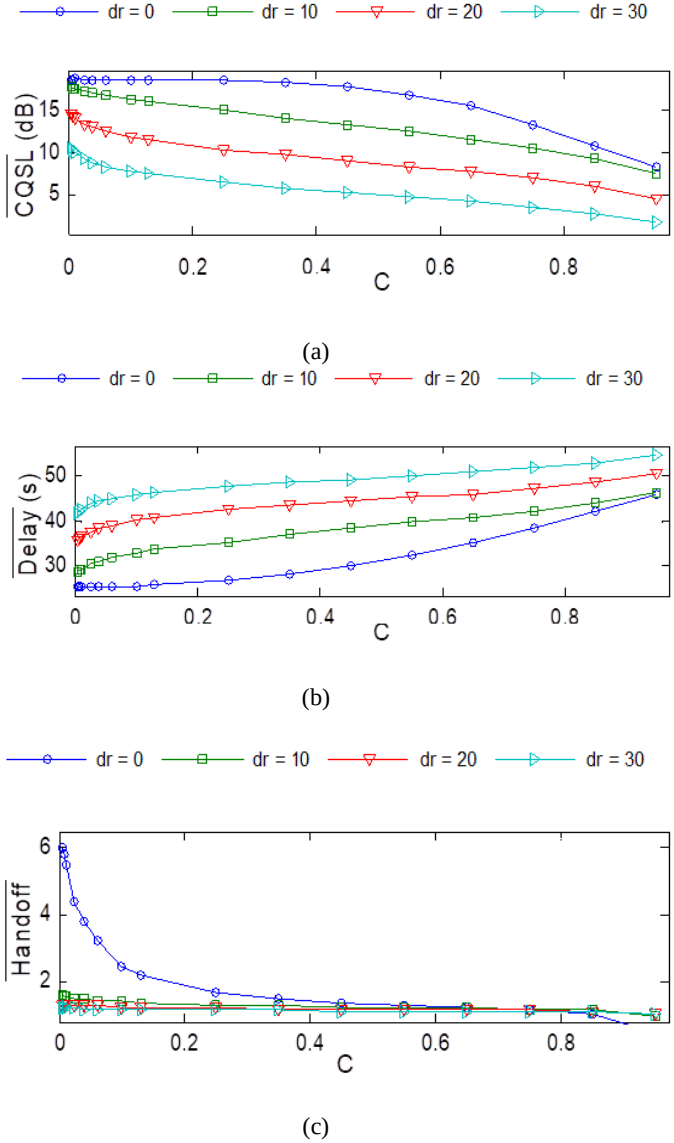


Fig.2: Cost Variation to handoff performance

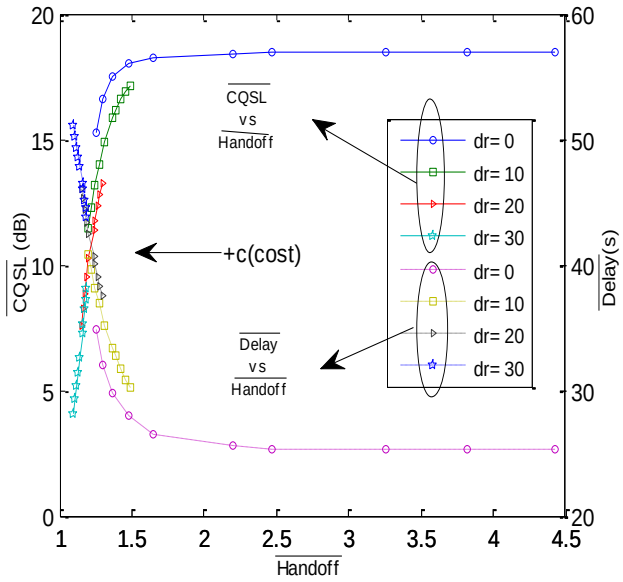


Fig. 3: Handoff trade-off parameter of the suboptimal SDH

5. Conclusion

This paper has examined the impacts of properties suboptimal SDH to handoff performance parameters. From the simulation results and analysis, the variations of parameter cost (c) average window length (d_r) have relation to signal quality, delay and handoff frequency.

Cost (c) increment causes $\overline{CQSL}$ decreases. Signal strength decreases when dr increases. Cost (c) and d_r increments result delay increasing. Handoff frequency decreases significantly when cost increases.

The optimal $\overline{CQSL}$ is closed to S_{min} and $\overline{Delay}$ closes to 40 s and handoff number is minimum for c>0.5. Values d_r = 20 and 30 should be avoided.

Acknowledgement

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