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Analysis of Optimal Parameters for Hopping Pilot Beacon in a CDMA Mobile Cellular Network

Wan Choi* and Jin Young Kim**

Abstract

In this paper, optimal parameters of a hopping pilot beacon are analyzed in a CDMA mobile cellular network. The hopping pilot beacon is used for inter-frequency handoff. It can reduce the number of pilot beacons needed for the inter-frequency handoff by transmitting neighbor frequency pilots periodically through a pilot beacon. The optimal parameters for transmission time and period of the hopping pilot bacon are derived by mathematical approach. It is highly recommended that the optimal values for the hopping pilot beacon under various operation environments.

key Words : Hopping pilot beacon, inter-frequency handoff, CDMA Network

I. INTRODUCTION

In CDMA (code division multiple access) mobile cellular networks, handoff plays an important role in determining overall system performance [1,2]. The handoff process provides a means of seamlessly transferring calls from one base station (BS) to another BS so that mobile calls in progress are not interrupted. When a call in progress is forcibly terminated, this is the epitome of service quality degradation because the call has to be reestablished. The handoff process is essential in maintaining quality of a call in progress and in keeping as low as possible both forced terminated calls and load to the network from signaling and switching [3-6].

The handoff process can be largely classified into two categories: *hard and soft handoff* [5]. In the hard handoff, the old radio link is broken before the new radio link is established, and a mobile station (MS) always communicates with one BS at any given time. If the old radio link is disconnected before the network completes the setup, the call is forcibly terminated. In the soft handoff, a MS may communicate with multiple radio links through different BS's at the same time. It is well known that the soft handoff link transfer may not be faster than the hard handoff whereas the soft handoff is not time critical compared to the hard handoff.

When the MS moves from the BS to another BS and these two BSs have different frequency, inter-

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* First author: Radio Network R&D Team Research and Development Division KTF, Korea

** Co-author: School of Electronics Engineering Kwangwoon University Seoul 139 701, Korea

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frequency handoff is required in order to maintain a call in progress. In the inter-frequency handoff, the radio link is interrupted during a short time while support is swiched from one frequency to another [7]. The inter-frequency hanoff has two basic types: *handdown* and *handover*. The handdown is a hard handoff between two different frequencies within the same cell. A MS entering a sector configured as border is instructed to issue frequent and periodic pilot strength measurement messages. This allows the BS to closely monitor the MS situation without waiting for reports triggered by pilot. When the pilot report indicates that the serving pilot has dropped below a threshold, the MS is directed to handdown from serving frequency to target frequency. The handdown from one frequency to another is done without knowledge of another frequency's pilot energy level. It works well for a border area where traffic flow is linear and predictable. For the handdown, the border area needs to deploy multiple frequencies (i.e. Dummy FA) [8,9].

The handover is a hard handoff between two different cells with different frequencies. In the handover, the MS simply handoffs from one frequency to another directly with the help of *pilot beacon*. The pilot beacon provides pilots of neighbor cells for the serving cell. In this situation, the MS handoffs frequency from the serving one to the target one when the pilot energy level from the pilot beacon exceeds that of the serving frequency by the predetermined margin. The handover with pilot beacon prevails than the handdown in the inter-frequency handoff since the former is more reliable than the latter. However, the handover needs additional costs for pilot beacons. The additional costs depend on the number of neighbor pilots on the neighbor cells because the multiple pilot beacons are required to provide information of multiple pilots of the neighbor cells.

Hopping pilot beacon is a modified pilot beacon, and it replaces simultaneous transmission of multiple pilot signals by periodic transmission of multiple pilot signals. The hopping pilot beacon periodically changes transmission of the neighbor pilots. Thus, it can reduce the number of pilot beacons needed for inter-frequency handoff, and guarantee available inter-frequency hanodff performance if appropriate transmission parameters are selected.

In this paper, we analyzed the optimal parameters of hopping pilot beacon for inter-frequency handoff in the CDMA mobile cellular networks. The optimal transmission time of a hopping pilot beacon is closely related with pilot search and handoff algorithms. We derive the optimal values of parameters for the hopping pilot beacon.

The rest of our paper is organized as follows: In section II, the pilot search and handoff algorithms are described. In section III and IV, optimal parameters for mobile statations are derived in traffic state and in idle state, respectively. In section V, the optimal transmission parameters are recommended, and numerical examples are presented. In section IV, conclusions are drawn.

II. SYSTEM MODEL

A. Transmission Pattern of Hopping Pilot Beacon

The hopping pilot beacon periodically changes frequencies to simulate multiple pilot beacons tramsmitting pilot information as shown in Figure 1. It periodically transmits n different neighbor pilots of neighbor frequencies on a serving frequency. The transmission time of the hopping pilot beacon can be typically modeled by three parameters, T_{on}, T_{off}, and the number of different

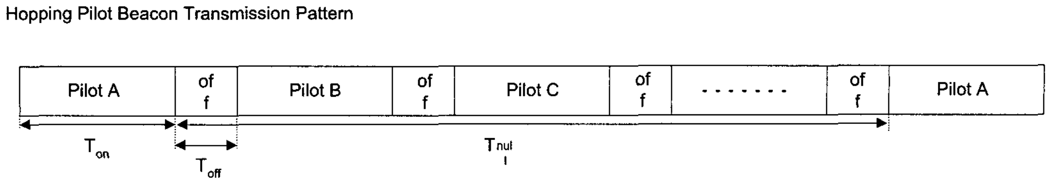

Figure 1. Transmission pattern of a hopping pilot beacon

neighbor pilots n. The T_{on} and T_{off} denote the duration during which each neighbor pilot is transmitted and a switching time between the neighbor pilots, respectively. Then, a MS can receive each neighbor pilot during the transmission time period (T_{on}), and can not receive it during the null period (T_{null}) in a periodic manner. The T_{null} can be obtained in terms of T_{on}, T_{off} and n, and given by

$$T_{null} = (n-1) \cdot T_{on} + n \cdot T_{off} \tag{1}$$

B. Pilot Search Time

The required time for the MS to search a pilot depends on the pilot search algorithm and hardware complexity (the number of correlators). According to the number of correlators for searcher, the MS of the IS-95 CDMA system is classified into two modes: 1) 1x search mode – the searcher employs two correlators for in-synch and out-of-synch hypotheses. In the 1x mode, double-dwell search algorithm is used for pilot search. 2) 8x search mode –the searcher uses eight times the number of correlators for the 1x mode. Typically, single-dwell search algorithm is used for the pilot search in the 8x mode.

In a double-dwell search algorithm, an early dump test is performed to save search time [10]. The MS generates PN (pseudonoise) sequence for a given offset, and calculates partial correlation with the received pilot signal for early dump integration time, T_e. To obtain robustness to phase error, non-coherent accumulation is performed in calculation of the partial correlation [10]. If the partial correlation value exceeds the given early dump threshold energy ,E_{th}, the correlation value for search integration time, T_{int}, is calculated. Otherwise, the MS generates the next PN sequence and repeats the same procedure. The MS completes searching for the pilot after investigating all possible PN offsets in window size, S_w. The pilot search time of the double dwell search algorithm may vary for the number of PN offsets of which partial correlation values exceed the early threshold energy, N_{th}. Then, the pilot search time for the 1x search mode is given by

$$\begin{aligned} T_{search\_time} &= T_e \cdot N_p \cdot S_w + (T_{int} \cdot N_p - T_e \cdot N_p) \cdot N_{th} \\ &\leq T_{int} \cdot N_p \cdot S_w \end{aligned} \tag{2}$$

where N_p denotes the number of non-coherent accumulation passes.

The single-dwell search algorithm can be used for the case that searcher speed is fast. In the single-dwell algorithm, the early dump test is not performed. Hence the pilot search time of the single-dwell algorithm for the 8x search mode is given by

$$T_{search\_time} = T_{int} \cdot N_p \cdot S_w / 8 \tag{3}$$

The pilot search time may be different for the different pilots due to window size of active and neighbor pilots. The MS can complete pilot search only if the pilot signal is being transmitted at least during pilot search time of the MS. So, the required minimum transmission time for each pilot of the hopping pilot beacon, T_{signal_need}, is equal to the pilot search time of the MS.

C. Pilot Search Period of Mobile Station

The MS searches pilots in a predetermined order. It firstly searches all the pilots included in active/candidate sets. After all the pilots in the active/candidate sets are searched, the pilot in the neighbor set is searched. Then, the MS searches all the pilots in the active/candidate sets again, and repeats the search in the predetermined order. The pilot in the remaining set is searched once for every fifty times of active pilot searches [9]. Thus, the search period of the active pilots is small enough to neglect that of the remaining pilots. The search period of active pilot is given by

$$T_{search\_period} = N_{act} \cdot T_{aci\_srch\_time} + T_{ngbr\_srch\_time} \quad (4)$$

where N_{act} denotes the total number of pilots included in the active/candidate set. If the MS is in idle state, $N_{act} = 1$. If the MS is in traffic state, the N_{act} is determined according to the handoff situations.

D. Idle Handoff

The MS in the idle state searches the pilots included in the neighbor set. If the pilot energy level of the neighbor set is larger than that of active pilot, idle handoff is performed. The idle handoff is not requested again until a timer expires in order to prevent duplicated idle handoff.

E. Traffic Handoff

In traffic state, the MS categorizes the pilots into four sets (active, candidate, neighbor, remaining set) according to their energy levels, and manages them for handoff [4]. The candidate set is divided into pre-candidate set and real candidate set [3]. If the pilot in the neighbor or remaining set exceeds a predetermined threshold, it is included in the pre-candidate set. Among pilots in the pre-candidate set, a pilot of which energy exceeds the pre-determined threshold by the pre-determined times is included in the real-candidate set. If the pilot is newly included in the real-candidate set, the MS sends pilot strength measurement message to the BS in order to request handoff. The BS sends handoff direction message to the MS in order to direct the handoff.

F. Timing Diagram

The pilot signal from the hopping pilot beacon is periodic with period $T_{on} + T_{null}$ as shown in Figure 1. Let the time when the MS starts searching a pilot (we assume this pilot as pilot A) be $x(t)$. The $x(t)$ can be modeled as an uniformly distributed random variable, and its *p.d.f.* (probability density function) is given by

$$f_X(x) = \frac{1}{T_{on} + T_{null}}, \qquad 0 \le x \le T_{on} + T_{null} \quad (5)$$

The timing diagram of transmission time of a hopping pilot beacon and the start time when the MS starts to search pilot A is shown in Fig. 2. If the MS starts to search pilot A at $x(t)$, the MS periodically searches the pilot A at $x(t) + k \cdot T_{search\_period}$, $k = 1, 2, \cdots, \infty$

Ⅲ. OPTIMAL PARAMETERS FOR MS IN TRAFFIC STATE

In this section, the optimal parameters of the hopping pilot beacon are derived for a MS in the traffic state. The parameters of the hopping pilot beacon should be selected to obtain reasonable handoff performance. The MS includes the pilot of the neighbor or the remaining set in the pre-candidate set if its energy level exceeds T_ADD. The counter of newly included pilot in the pre-candidate set is set to be 2, and is increased by 1 whenever it exeeds T_ADD. While, the counter will be decreased by 1 whenever its energy level drops below T_ADD. The pilot is returned to the neighbor set if the value of counter reaches zero. If the value of counter reaches 7, the MS sends the pilot strength measurement message to the BS, and includes the pilot in the real-candidate set. Thus, the MS can continuously search the pilot (i.e. pilot A) more than five times to gaurantee the transition from the pre-candidate set to the real-candidate set. Now, we will analyze optimal paramters for the following two cases.

A. Case A: $T_{search\_period} \le T_{on} - T_{signal\_need}$

The following constraints should be satisfied for thea MS to continuously search the pilot A more than *k* times.

$$0 \le x(t) \le T_{on} - T_{signal\_need} - (k-1)\cdot T_{search\_period} \tag{6}$$

Since the $x(t)$ is an uniformly distributed random variable, the probability that the MS continuously searches pilot A more than *k* times is given by

$$P[0 \le x(t) \le T_{on} - T_{signal\_need} - (k-1)\cdot T_{search\_period}]$$
$$= \frac{T_{on} - T_{signal\_need} - (k-1)\cdot T_{search\_period}}{T_{on} + T_{null}} \tag{7}$$

where $T_{on} > T_{signal\_need} + (k-1)\cdot T_{search\_period}$. Since the T_{null} equals to $(n-1)\cdot T_{on} + n\cdot T_{off}$, the equation (7) can be rewritten as

$$P[0 \le x(t) \le T_{on} - T_{signal\_need} - (k-1)\cdot T_{search\_period}]$$
$$\frac{T_{on} - T_{signal\_need} - (k-1)\cdot T_{search\_period}}{n\cdot(T_{on} + T_{off})} \tag{8}$$

The probability of (8) is maximized if the T_{off} is minimized. Thus, the T_{off} should be the minimum value that the hopping pilot beacon allows. Hence the T_{on} should satisfy the follwing constraints:

$$T_{on} \ge T_{signal\_need} + 4\cdot T_{search\_period} \tag{9}$$

$$\max\{P[0 \le x(t) \le T_{on} - T_{signal\_need} - 4\cdot T_{search\_period}]\}$$

$$= \max\{\frac{T_{on} - T_{signal\_need} - 4\cdot T_{search\_period}}{T_{on} + T_{null}}\} \tag{10}$$

The pilot signal which the MS receives in the pre-candidate set has the second order Chi-distribution with mean T_ADD [11]. The probabilities that the pilot signal is over T_ADD and is below T_ADD are, respectively, given by

$$p = \int_{T\_ADD}^{\infty} f_X(x) = 0.368 \tag{11}$$

$$q = \int_{0}^{T\_ADD} f_X(x) = 0.632 \tag{12}$$

However, in the handoff situations, the probabiltiy that the received pilot signal is over T_ADD is larger than equation (11) becuase the MS is moving to target cell. Thus, we assume that the p and the q are equally 0.5. Then, the average number of searching pilot A in transition from the pre-candidate set to the real-candidate set is derived as

$$N_{search} = 5\cdot a_5\cdot p^5 + 7\cdot a_7\cdot p^6 q + 9\cdot a_9\cdot p^7 q^2 + 11\cdot a_{11}\cdot p^8 q^3 + 13\cdot a_{13}\cdot p^9 q^4 + \cdots \approx 10.4 \tag{13}$$

where a_i is the number of events that the MS transits to the real-candidate set after it continuously searches the pilot A for *i* times, and is given by

$$a_5 = {}_5C_5 \tag{14.a}$$

$$a_7 = {}_7C_1 - {}_2C_1\cdot a_5 \tag{14.b}$$

$$a_9 = {}_9C_2 - ({}_4C_2\cdot a_5 + {}_2C_1\cdot a_7) - 1 \tag{14.c}$$

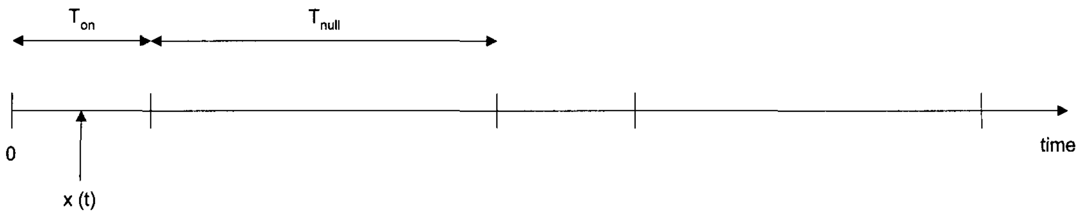

Figure 2. Timing diagram for search and transmission time of a hopping pilot beacon

$$a_{11}={}_{11}C_3-({}_6C_3\cdot a_5+{}_4C_2\cdot a_7+{}_2C_1\cdot a_9)-{}_9C_1-2 \tag{14.d}$$

$$a_{13}={}_{13}C_4-({}_8C_4\cdot a_5+{}_6C_3\cdot a_7+{}_4C_2\cdot a_9+{}_2C_1\cdot \\ \vdots \qquad\qquad \vdots \\ a_{11})-{}_{11}C_2-2\cdot{}_9C_1-1 \tag{14.e}$$

To ensure that the MS can continuously search more than 11 times to obtain the reasonable handoff performance, from (13), we can conclude that the T_{on} should be maintained as follows:

$$T_{on}\ge T_{signal\_need}+10\cdot T_{search\_period} \tag{15}$$

The probability that the MS can continuously search pilot A more than 11 times is given by

$$P[0\le x(t)\le T_{on}-T_{signal\_need}-10\cdot T_{search\_period}] \\ =\frac{T_{on}-T_{signal\_need}-10\cdot T_{se}}{T_{on}+T_{null}} \tag{16}$$

If the energy level of the pilot in the real-candidate set is larger than T_DROP, a drop timer is enabled.The MS searches the pilot, and sends pilot strength measurement message before the drop timer expires accoridng to the result of T_COMP test or T_ADD test. The MS sends the pilot strength measurement message to request handoff if the strength of the pre-filtered pilot in the real-candidate set is larger than that of the pilot in active set by T_COMP × 0.5 dB for five consecutive times in T_COMP test. Hence, it is recommended that the MS be able to continuously search the pilot A of the real-candidate set five times. If the following criterion (17) is satisfied, it is guaranteed that the MS can search the pilot in the real-candidate set at least five times whenever the pilot is included in the real-candidate set before the T_DROP timer expires.

$$T\_TDROP>(4+5)\cdot T_{search\_period}+T_{search\_period}- \\ T_{signal\_need}+T_{null}+T_{signal\_need}+T_{active\_search\_time} \\ =10\cdot T_{search\_period}+T_{null}+T_{active\_search\_time} \tag{17}$$

From (15), (17), and the fact that T_{null} equals to $(n-1)\cdot T_{on}+n\cdot T_{off}$, the recommended value of T_{on} is upper and lower bounded by

$$T_{signal\_need}+10\cdot T_{search\_period}<T_{on}< \\ \frac{T\_TDROP-10\cdot T_{search\_period}-T_{active\_search\_time}-n\cdot T_{off}}{n-1} \tag{18}$$

where $T_{signal\_need}+10\cdot T_{search\_period} < (T\_TDROP-10\cdot T_{search\_period}-T_{active\_search\_time}-n\cdot T_{off})/(n-1)$.

B. Case B: $T_{null}+T_{signal\_need}\le T_{search\_period}\le T_{null}+T_{on}$, *where* $m(integer)\ge 0$

From the Figure 3, the follwing criterion should be satisfied for the MS to continuously search the pilot A for 11 times at its every search period.

$$\frac{10\cdot(T_{on}+T_{null})+T_{signal\_need}-T_{on}}{10}\le T_{search\_period} \\ \le T_{on}+T_{null} \tag{19}$$

Since the $x(t)$ is an uniformly distributed random variable, the probability that the MS continuously searches the pilot A for 11 times at its own search

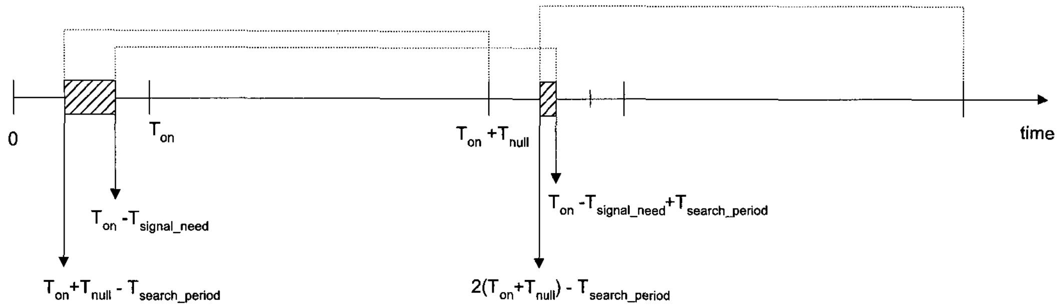

Figure 3. Timing diagram for search and transmission time when $T_{null}+T_{signal\_need} \le T_{search\_period} \le T_{null}+T_{on}$, where $m\,(integer) \ge 0$

period is given by

$$P[T_{on}+T_{null}-T_{search\_period} \le x(t) \le T_{on}-T_{signal\_need} + 10\cdot T_{search\_period} - 10\cdot(T_{on}+T_{null})] = \frac{10\cdot T_{search\_period} - 10\cdot n\cdot(T_{on}+T_{off}) - T_{signal\_need} + T_{on}}{n\cdot(T_{on}+T_{off})} \quad (20)$$

From (19) and the fact that T_{null} equals to $(n-1)\cdot T_{on} + n\cdot T_{off}$, the recommended value of T_{on} is upper and lower bounded by

$$\frac{T_{search\_period} - n\cdot T_{off}}{n} \le T_{on} \le \frac{10\cdot T_{search\_period} - 10\cdot n\cdot T_{off} - T_{signal\_need}}{10\cdot n - 1} \quad (21)$$

We can find that the case A ($T_{search\_period} \le T_{on} - T_{signal\_need}$) is more suitable than the case B ($T_{null} + T_{signal\_need} \le T_{search\_period} \le T_{null} + T_{on}$, where $m\,(integer) \ge 0$) for the handoff of the MS in traffic state because the probability that the MS continuously searches the pilot A for 11 times for the case A is larger than that of the case B.

IV. OPTIMAL PARAMETERS FOR MS IN IDLE STATE

In this section, we analyze the optimal parameters of the hopping pilot beacon when the MS is in the idle state. We analyzed only for the case that $T_{search\_period} \le T_{on} - T_{signal\_need}$ because this case is more suitable when the MS is in the traffic state.

If the MS decides idle handoff, it newly assigns the demodulator finger as a new result of active pilot search. To guarantee reasonable idle handoff performance, the probability that the pilot is being transmitted while the MS searches the pilot after it decides idle handoff should be maximized. Let the time when the MS decides the idle handoff be $y(t)$. The *p.d.f.* of $y(t)$ will be given by

$$f_Y(y) = \frac{1}{T_{on} - T_{signal\_need}}, \quad T_{nghbr\_search\_time} < y(t) < T_{on} - T_{signal\_need} + T_{nghbr\_search\_time} \quad (22)$$

The MS sets handoff throttle timer (280 ms) on as soon as it decides the idle handoff. The MS does not compare the energy of the neighbor pilot and the active pilot while the timer is on. This prevents duplicated idle handoff decision. Typically, the idle handoff is completed before the throttle timer expires. The time when the MS starts to search the new active pilot is $y(t) + k\cdot T_{search\_period}$, and the *p.d.f.* of k is given by

$$f_K(k) = \frac{1}{\left\lfloor \frac{280ms}{T_{search\_period}} \right\rfloor}, \quad k = 1, 2, \cdots, \left\lfloor \frac{280ms}{T_{search\_period}} \right\rfloor \tag{23}$$

From (22) and (23), the probability that the hopping pilot beacon is transmitting the active pilot while the MS searches the active pilot after the MS decides the idle handoff is given by

$$P[m \cdot (T_{on} + T_{null}) < y(t) + k \cdot T_{search\_period} < m \cdot (T_{on} + T_{null}) + T_{on} - T_{signal\_need}] \approx \frac{T_{on} - T_{signal\_need}}{T_{on} + T_{null}} \tag{24}$$

We can easily find that the probability that the hopping pilot beacon is transmitting the active pilot while the MS searches the active pilot is proportional to the T_{on}, and is inversely proportional to the number of neighbor pilots of neighbor cells.

V. NUMERICAL RESULTS

From the results of section III and IV, the optimal value of the T_{off} for the hopping pilot beacon should be the allowable minimum value since the T_{off} is inversely proportional to the handoff success probability. The optimal bound of the T_{on} is given by

$$T_{signal\_need} + 10 \cdot T_{search\_period} < T_{on} < \frac{T\_TDROP - 10 \cdot T_{search\_period} - T_{active\_search\_time} - n \cdot T_{off}}{n-1}, \tag{25}$$

where $T_{signal\_need} + 10 \cdot T_{search\_period} < \dfrac{T\_TDROP - 10 \cdot T_{search\_period} - T_{active\_search\_time} - n \cdot T_{off}}{n-1}$.

Though the handoff performance can be improved as the T_{on} increases, the appropriate margin should be condsidered in selecting the T_{on} in order to reflect channel conditions. The T_{null} is determined in terms of T_{on}, T_{off}, and the the number of different neighbor pilots n as follows:

$$T_{null} = (n-1) \cdot T_{on} + n \cdot T_{off}. \tag{26}$$

For the numerical examples, the followings are assumed: 1) T_TDROP = 1 sec, 2) Neighbor window size = 80 chip, 3) Active window size = 28 chip, 4) T_{int} (search integration time) = 512 chip, 5) N_p (number of non-coherent accumulation passes) = 1, and 6) T_{off} = 1 ms.

In the selection of optimal values of parameters, it was also considered that the search time of the MS may vary according to the search algorithm (single-dwell/double-dwell) and search speed modes (1x/8x modes). We assumed that the average search time of the single-dwell algorithm is three times of that of the double-dwell algorithm for the same search speed mode. The MS's being used in Korea adopt either the 1x mode with double-dwell search or the 8x mode with single-dwell search. The optimal parameters of the hopping pilot beacon should be selected so that both types of MS's can be supported.

In Fig. 4, the bounds on T_{on} vs. the number of pilots in the active and candidate set are shown. In this figure, the number of pilots transmitted by the hopping pilot beacon is set to be two. The bounds on T_{on} may vary for the different number of pilots in active set and candidate set, and the number of pilots included in the active and candidate set depends on the channel environments and handoff situations.

The bounds on T_{on} when the number of pilots transmitted by the hopping pilot beacon is three are given in Figure 5. In this case, the T_{on} should be selected as the value between the lower and the upper bound.

The bounds on T_{on} when the number of pilots transmitted by the hopping pilot beacon is four are given in Figure 6. In this case, the optimal value of T_{on} can not be found because the lower bound

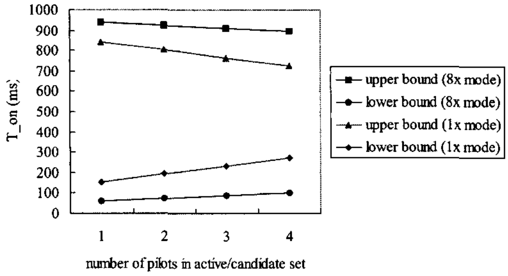

Figure 4. Bounds of T_{on} vs. the number of pilots included in active/candidate set when the number of pilots transmitted by the hopping pilot beacon is two.

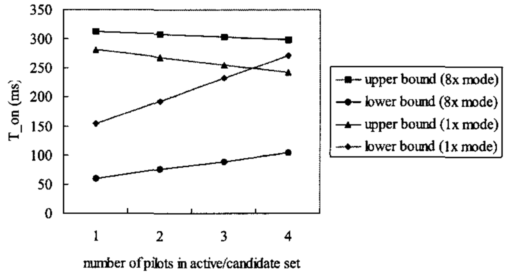

Figure 6. Bounds of T_{on} vs. the number of pilots included in active/candidate set when the number of pilots transmitted by the hopping pilot beacon is four.

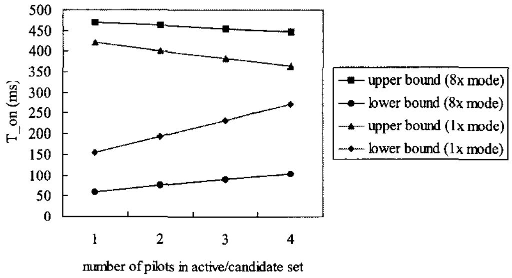

Figure 5. Bounds of T_{on} vs. the number of pilots included in active/candidate set when the number of pilots transmitted by the hopping pilot beacon is three.

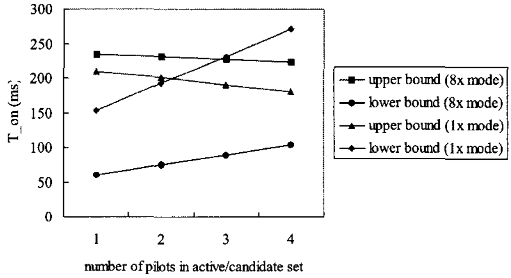

Figure 7. Bounds of T_{on} vs. the number of pilots included in active/candidate set when the number of pilots transmitted by the hopping pilot beacon is five.

of the 1x mode MS is higher than the upper bound of the 1x mode MS. We can conclude that the four pilots transmitted by the hopping pilot beacon are not adequate because the number of pilots in the active and the candidate set can be four in the real handoff situations.

The bounds of T_{on} when the number of pilots transmitted by the hopping pilot beacon is five are given in Figure 7. As shown Figure 6, the 1x mode MS can not be supported when the number of pilots in the active/candidate set is over 2.

VI. CONCLUSIONS

In this paper, we analyzed the transmission parameters of a hopping pilot beacon, and recommended the optimal values of the parameters. The hopping pilot beacon was employed for the inter-frequency handoff. The optimal parameters for transmission time and period of the hopping pilot bacon were derived from mathematical and numerical approaches. We also recommended the optimal values for the hopping pilot beacon under various operation environments.

It is generally expected that the handoff performance will be improved as the T_{on} is larger. However, appropriate margin in selectiong T_{on} should be considered reflecting channel propagation environments and handoff situation. From the above results, the recommended maximum number of pilots transmitted by the hopping pilot beacon is three, and the recommended value of T_{on} is about 300 ms when the pilot beacon periodically transmits three pilots. It is highly expected that the recommended values be used in a practical design of the CDMA mobile cellular networks.

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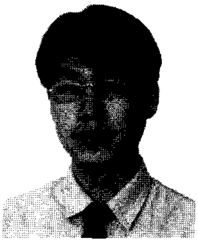
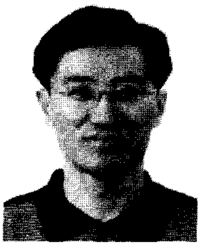
저자소개



Wan Choi

Dr. Wan Choi joined the School of Engineering, Information and Communications University (ICU), Daejeon, Korea, in the spring of 2007 as an assistant professor. He received his B. Sc. and M. Sc. degrees from the School of Electrical Engineering and Computer Science (EECS), Seoul National University (SNU), Seoul, Korea, in 1996 and 1998, respectively, and the Ph.D. degrees in the Department of Electrical and Computer Engineering at the University of Texas at Austin in 2006. During his Ph.D. study, he was affiliated with the Wireless Networking and Communications Group (WNCG). He was Senior Member of the Technical Staff of the R&D Division of KT Freetel Co. Ltd., Korea from 1998 to 2003 where he researched 3G CDMA systems. He also researched at Freescale Semiconductor and Intel Corporation during 2005 and 2006 summers, respectively, where he collaborated with them on practical wireless communication issues. His research interests include areas of wireless communications, including spread spectrum communications, OFDM communications, MIMO communications, and advanced communications systems.

He is the recipient of IEEE Vehicular Technology Society Jack Neubauer Memorial Award which recognized the best system paper published in the IEEE Transactions on Vehicular Technology for 2001. He also received IEEE Vehicular Technology Society Dan Noble Fellowship Award in 2006 with the recognition of an individual most likely to impact the areas of concentration of the IEEE VT Society including “wireless”, also known as mobile radio, motor vehicles and transportation electronics. While at the University of Texas at Austin, he was the recipient of William S. Livingston Graduate Fellowship, the highest award for a graduate student at UT Austin, and Information and Telecommunication Fellowship from Ministry of Information and Communication (MIC), Korea.



Jin Young Kim

received the B. Sc., M. Sc., and Ph. D. degrees from the School of Electrical Engineering, Seoul National University (SNU), Seoul, Korea, in 1991, 1993, and 1998, respectively. He was Member of Research Staff at the Institute of New Media and Communications (INMC) and at the Inter-university Semiconductor Research Center (ISRC) of the SNU from 1994 to 1998. He was Postdoctoral Research Fellow at the Department of Electrical Engineering, Princeton University, NJ, U.S.A, from 1998 to 2000. He was Senior Member of Technical Staff at the Network Research and Development Center, SK Telecom, Korea, from 2000 to 2001. He is currently Associate Professor at the School of Electronics Engineering, Kwangwoon University, Seoul, Korea.

He has been selected as a recipient of Postdoctoral Program sponsored by KOSEF (Korean Science and Engineering Foundation) in 1998. He received the Best Paper Award from several academic conferences and societies including the *IEEE MoMuC '97 and the APCC '00*, and Award from *Minister of Information and Communication* of Korea in 1997. He also received the Jack Neubauer Memorial Award for the Best Paper of the Year 2001 published by the IEEE Vehicular Technology Society on the subject of Vehicular Technology Systems.

His research interests include spread spectrum communications for applications to terrestrial and satellite systems, broadband access, modulation/demodulation, packet radio network, optical communications, synchronization, channel coding, and detection/estimation theory. He has published over 150 papers in archival journals and conferences in the filed of wireless communications. He also holds over 20 patents from U.S.A, Japan, and Korea.

He was listed in the *Marquis Who's Who in the World and Who's Who in Science and Engineering* through the 2001-2007 and 2001-2007 Editions, respectively. Dr. Kim is now Member of *IEEE, IEE, IEICE, IEEK, KEES, KITS,* and *KICS.*