광대역 OFCDM시스템에서 셀룰러와 핫-스팟 셀들이 공존할 때 분리 I/Q채널 CSSC를 이용한 셀 탐색 알고리즘

김대용* · 권혁숭**

A Suitable Cell Search Algorithm Using Separated I/Q Channel Cell Specific Scrambling Codes for Systems with Coexisting Cellular and Hot-Spot Cells in Broadband OFCDM Systems

Dae-Yong Kim* · Hyeog-Soong Kwon**

요 약

동위상(I) 파일럿 채널에 할당된 셀룰러 셀 CCSSC와 직교위상(Q) 파일럿 채널에 할당된 핫 스팟 셀 HSCSSC가 공존하는 광대역 OFCDM시스템에 환경하에서분리된 I/Q채널 CCSC를 이용한 탐색 알고리즘을 제안하였다. 제안된 알고리즘은 이동 기지국에서 무선 인터넷을 사용하고자 할 때 셀룰러 셀 CCSSC의 영향으로 감소하는 최상의 핫 스팟 셀 HSCSSC을 빠르게 추적하는데 적합하다. 시뮬레이션 결과 제안된 셀 추적 알고리즘이 기존의 셀 추적 알고리즘과 비교하여 훨씬 빠른 결과를 수행할 수 있음을 보였다.

ABSTRACT

For systems with coexisting cellular and hot-spot cells in broadband orthogonal frequency and code division multiplexing (OFCDM) systems, a suitable cell search algorithm is proposed for the common pilot channel (CPICH) in the forward link using separated I/Q channel cell specific codes(CSSC), in which the cellular cell specific scrambling code (CCSSC) is assigned to the in-phase (I) pilot channel of all cellular cells, and the exclusive hot-spot cell specific scrambling code (HSCSSC) group is assigned to the quadrature (Q) pilot channel of all hot-spot cells. Therefore, the proposed algorithm enables a mobile station (MS) to search quickly for the most desirable hot-spot cell due to reducing the effect of CCSSC, when a MS wants to use a mobile internet. The computer simulation results show that the proposed cell search algorithm can achieve faster cell search time performance, compared to conventional cell search methods

Keyword

OFCDM, cell search, hot-spot, I/Q

Ⅰ. Introduction

Mobile communications and wireless networks are developing at an astonishing speed, with evidence of significant growth in the areas of mobile users and terminals, mobile and wireless access networks, and

* 영남대학교 정보통신공학과

** 밀양대학교 정보통신공학부

접수일자 : 2005. 7. 11

mobile services and applications. The wideband-code division multiple access (W-CDMA) is representative of the 3rd generation (3G) mobile system which supports maximum information bit rates, such as 144, 384 kbps, and 2 Mbps, respectively in vehicular, pedestrian, and indoor environments. However, recent mobile internet users, as well as traffic of mobile internet access, are both increasing rapidly. Therefore, wireless Local Area Network (LAN) services are popular in hot-spots and indoor offices. As above, mobile users are demanding that a totally new wireless access system, supporting much higher data rate communication services, such as above 100 Mbps for broadband packet along with IP-based radio access networks, be available to them. In addition, the broadband packet wireless access system flexibly supports isolated-cell environments, such as hot-spot areas and indoor offices as well as the multi-cell environments represented by cellular systems using a common air interface. OFCDM [2] is originally based on multi-carrier code division multiple access (MC-CDMA), which is one of the greatest candidates to satisfy the conditions mentioned above, in the forward link. Meanwhile, OFCDM also has a asynchronous cell-site operation, unlike the synchronous operation in cdma2000 which requires global system timing. Therefore, a mobile station (MS) must synchronize a fast Fourier transform (FFT) window timing, frame timing, cell specific scrambling code (here after CSSC) group, and identify the scrambling code of the most desirable cell site with the highest receiving signal power. This process is called cell search since a MS searches for the best desirable cell site with which the MS should establish a radio link. For an OFCDM system, the three-step cell search algorithm employing the synchronization channel (SCH) method [3], the CPICH method (hereafter CPICH-based method) [4], and the additional exclusive hot-spot CSSCs method (hereafter the additional HSCSSCs method) [5] were already proposed.

The best cell of [3] and [4] is the one that has the mini-mum path loss between the cell site and the MS from the viewpoint of minimizing transmission power of the MS and maximizing the system capacity. However, in the 4th generation (4G), hot-spot cells with lower transmission power as well as cellular cells with higher trans-mission power must coexist and should be seamlessly supported. The additional exclusive HSCSSCs method [5] was proposed to solve this problem. However, as the hot-spot cell increase, the HSCSSCs also increase. So all CSSCs (CCSSCs + HSCSSCs) increase. Therefore, the effect of the CSSCs isn't small anymore. Under the circumstances, we propose a three-step cell search algorithm that utilizes the CPICH of the separated I/Q channel of the CSSCs. This algorithm considerably reduces the cell search time compared to the conventional methods. This paper is organized as follows: The additional HSCSSCs method [5] is described in Sect. II. Then, the proposed algorithm is presented in Sect. III. The computer simulation model and results are presented in Sect. IV. Finally, Sect. V. presents our conclusions.

Ⅱ. The Additional HSCSSCs Assignment

Additional HSCSSCs method add exclusive hot-spot cell specific CSSCs to the CPICH-based method which uses a three-step cell search algorithm. In the first step, the OFCDM symbol timings are detected utilizing the correlation property of the guard interval (GI). In the second step, frame timing and CSSC groups are detected. In the third step, the CSSC is identified and then a MS receives the BCH to recognize the cell type from the most desirable cell. The conventional cell search with exclusive hot-spot CSSCs method using the exclusive CSSC assignment does not need the BCH, the CSSCs or the timing information of the surrounding cells. The cell search time of this method is reduced by using the physical layer without decoding the control signaling of the BCH. Figure 1 shows the additional HSCSSCs method which is based on a three-step cell search [4] except for the exclusive hot-spot CSSC assignment. Figure 2 shows the CSSCs assignment of the additional HSCSSCs method. In Figure 2, Group #N which is assigned to the hot-spot cell has some exclusive hot-spot

CSSCs and this group will be one or more, depending on the requirement for hot-spot cells.

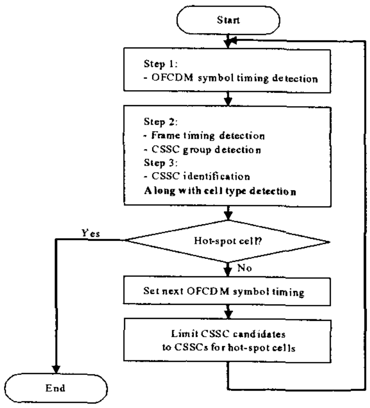


Fig.1 Additional HSCSSCs method

Ⅲ. The Proposed Suitable Cell Search Algorithm with Separated I/Q Channel CSSCs Assignment

A suitable cell search algorithm is proposed for the forward CPICH, using a separated I/Q channel of the CSSCs assignment, in which the exclusive hot-spot CSSCs are assigned to the quadrature pilot channel of all hot-spot cells, and the cellular CSSCs are assigned to the in-phase pilot channel of all cellular cells. Figure 3 shows the propose CPICH structure. If CCSSCs are assigned to the I-channel, then the Q-channel has 0. Or If HSCSSCs are assigned to the Q-channel, the I-channel has 0. Con-sequently, a MS only checks one channel according to a demand (CCSSCs or HSCSSCs).

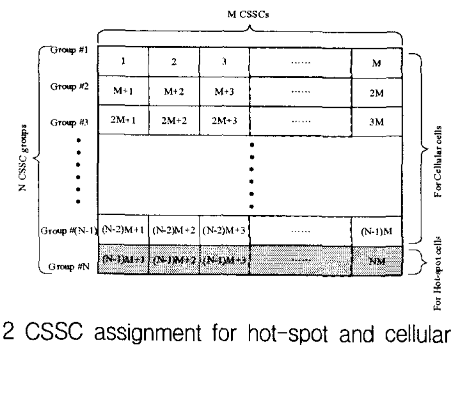


Fig. 2 CSSC assignment for hot-spot and cellular cells

Figure 4 shows a suitable cell search algorithm with a separated I/Q channel of the CSSCs assignment. And finally, Figure 5 shows HSCSSCs and CCSSCs. In the future broadband wireless access system, cells in the conventional cellular system with higher trans-mission power, as well as hot-spot cells with lower trans-mission power must coexist and should be seamlessly supported. The additional exclusive HSCSSCs method [5] was proposed to solve this problem. However, this method has a problem about two cases. First case; according to hot-spot cell increases, HSCSSCs also increase. Second case; according to hot-spot and cellular cells increase, all CSSCs (CCSSCs + HSCSSCs) increase. Therefore, the probability of the cell search completion is low compared to using a separated I/Q channel CSSCs assignment. This occurs because the wrong selection probability of the proposed algorithm is less than that of the additional HSCSSCs method. Under these circumstances, the effect of the increase of CSSCs is not small anymore. So additional HSCSSCs method does not satisfy a good time performance anymore. Thus, we pro-pose a three-step cell search algorithm that utilizes the CPICH of the separated I/Q channel CSSCs assignment. Our propose algorithm has the advantage of high detection with a hot-spot cell which receives low signal power, against that of the cellular cell in the coexisting environments with cellular and hot-spot cells. For instance, if a MS needs to select a hot-spot cell to use mobile internet between cellular cell and hot-spot cell, the received signal power of the hot-spot cell is lower than that of the cellular cell. In such a case, a MS only checks the HSCSSC group in the Q pilot channel. As a result of the simple check, we find the most desirable hot-spot cell. Usually, the HSCSSC group is found by similar techniques as [4]. The HSCSSC group of the proposed algorithm is similar to group #N in Figure 3. This group will also be one or more, depending on the requirement for hot-spot cells.

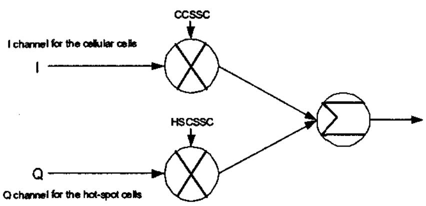


Fig. 3 Proposed CPICH structure

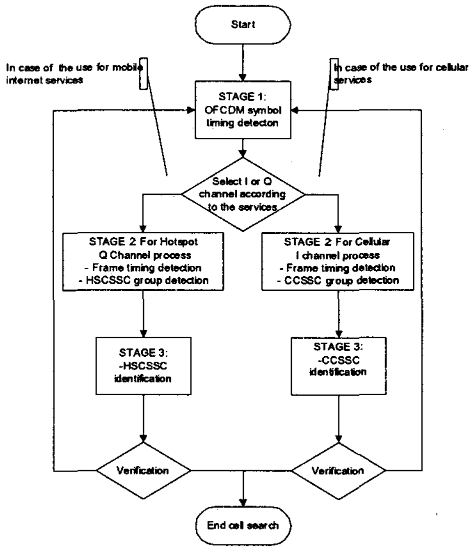


Fig. 4 A suitable cell search algorithm for hot-spot and cellular cells

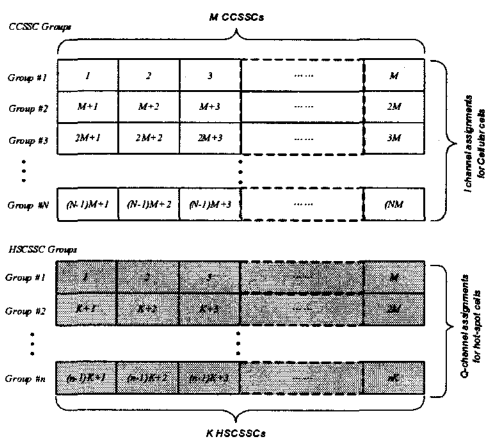


Fig. 5 Proposed CSSC assignments

Ⅳ. Computer Simulation

A. Simulation Model

The cell search time of the proposed algorithm was evaluated by computer simulation. The parameters and propagation model parameters used in the simulation are given in Table 1. We referred to [3], [4], and [5] for some of the parameters and the OFCDM frame format like in Figure 7. The number of sub-carriers is 768 and the total bandwidth is 101.5 MHz. A frame comprises 54 OFCDM symbols, each of which comprises effective data (1024 samples) and guard interval (226 samples). The OFCDM symbols at the beginning and end of a frame are the CPICH and the other 52 OFCDM symbols are allocated to the TCH.

The spreading factor is (SFTime x SFFreq) = (1 x 16) and a Walsh-Hadamard sequence with a code length of SF = 16 was used as the channel specific orthogonal code (CSOC) of the TCH in the frequency domain. The CPICH sequence along the frequency axis is also a truncated Gold sequence with the length of Nc.

The transmission power ratio of the CPICH to a one code channel of the TCH is set to RCPICH as shown in Figure 7. The number of CCSSCs was 512 and HSCSSCs were grouped into Ngrp = 32 CCSSC groups and HSCSSC group, respectively. The CSSC pattern is also a truncated Gold sequence with the length of Nc and its phase shifted by L = 1 chip every OFCDM symbol. To evaluate the performance of the proposed algorithm, we assume 19-hexagonal cellular cells and 1 hot-spot cell layout as in Figure 6. The hot-spot is located apart from the center cell of the 19 cellular cells by 0.5 R (R is the cell radius of the cellular cell). We set the transmission power ratio of the hot-spot cell, signal power ratio the hot-spot cell, Δ_{RX} ,to the cellular cell. Cell search completion time is simulated in the region of weak received power according to the location of the MS between cellular and hot-spot cells. Δ_{TX} ,to the cellular cell and the received The propagation model used in the simulation has distance-dependent path loss with the decay factor of 4.0 and lognormally distributed random path loss (or lognormal shadowing) with an 8 dB standard deviation. The corelation coefficient of the shadowing between cells is assumed to be 0.5.

Table. 1 Simulation parameters

Number of FFT/IFFT points		1024
OFCDM symbol dura -tion(Effective data + Guard interval)		9.259μsec (7.585 μsec +1.674 μsec)
Number of symbols		54 OFCDM symbols / frame
Spreading factor		16 (12 codes are multi-plexed in TCH)
Spreading code	CSSC	768-chip truncated Gold sequence
	CSOC	Walsh-Hadamard (SF=16chips/symbol)
Number of CSSCs / CSSC group		16 codes
Number of sub-carriers		Nc = 768
Data modulation / Spreading		QPSK / QPSK
Number of CSSCs		512(for the cellular) +16(for the hot-spot)
Cell arrangement		19 hexagonal cells + 1 hot-spot cell
Path model		9 exponential decay paths (Fig.8)
Doppler frequency		$f_D = 80\,Hz$
Path loss exponent		4.0
Shadowing		Log-normal distribution (σ = 8.0dB, correlation coefficient between cells is 0.5)
Number of cell sites		19 cellular cell sites + 1 hot-spot cell sites
Number of CSSCs		512 CCSSCs + 16 HSCSSCs

The multipath channel has 9 propagation paths, each path being subject to independent Rayleigh fading at different average powers, as depicted in Figure 8.

The median signal to the background noise power ratio per one code channel of the TCH at the cell edge was set to − 6.0 dB. 12 code channels are code-multiplexed in the TCH and the number was assumed constant in this paper. In each trial, we generated a random MS location and random path loss due to shadowing. During the cell search process, only the Rayleigh faded channel gains varied. The distance dependent and random path losses remained constant. The CSSC and frame timing of each sector was randomly determined in each trial. The averaging time for each step became 1 frame, 1 frame, and 2 OFCDM symbols, respectively. The best cell site is the one that provides the least path loss (the sum of the distance-dependent and random path losses).

However, in this simulation, the desired optimum cell site is defined as the cell site with the least path loss. When the frame timing and CSSC of one of the desired optimum cell sites was detected, then the cell search was deemed successful, otherwise the cell search failed. Single antenna reception (no antenna diversity) was used at the MS receiver.

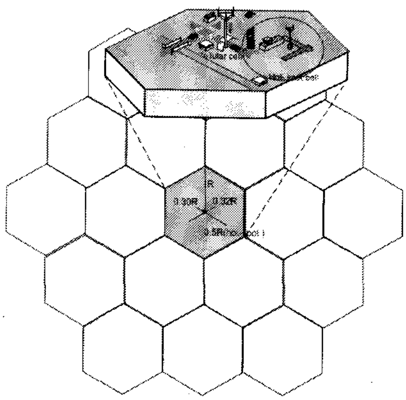


Fig. 6 Simulation cell layout

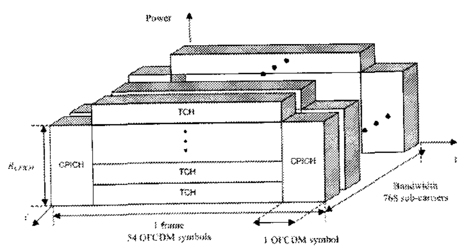


Fig. 7 OFCDM frame structure

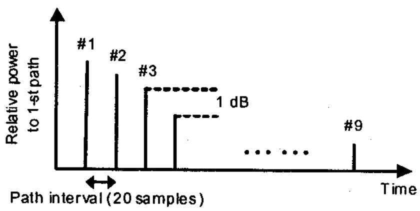


Fig. 8 Path model

B. Simulation Results

In this paper, we only compare the cell search time performance of the proposed algorithm with two algorithms, the additional HSCSSCs and the CPICH-based method. Figure 9 shows the probability of the cell search completion according to the MS location between cellular and hot-spot cells. We set the MS location, $\Delta_{MS\,location}(from\,cellular\,cell, from\,hot-spot\,cell)$, from the cellular and hot-spot cells.

Figure 9 indicates the MS is located in $\Delta_{MS\,location}(0.32R, 0.18R)$. Thus, Δ_{RX} is -8.0 dB and the MS receives strong signal power from the cellular cell against the hot-spot cell. Therefore, the MS mistakes the desirable hot-spot cell for the cellular cell, therefore the MS needs many candidates. To solve this problem, the proposed algorithm only checks into the one channel (I channel or Q channel). Consequently, the cell search time is completed within approximately 3 msec at the probability of 90 % in 0.32 R from the cellular cell.

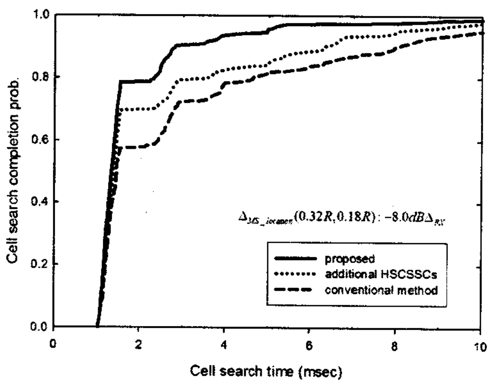


Fig. 9 Effect of the MS location(0.32R, 0.18R)

In Figure 10, The received signal power from hot-spot cell is weaker than that of the MS location in Figure 9. Thus, the cell search time is longer when the MS is close to the hot-spot cells. Therefore, the cell search time at the probability of 90 % cell search completion increases to approximately 10 msec.

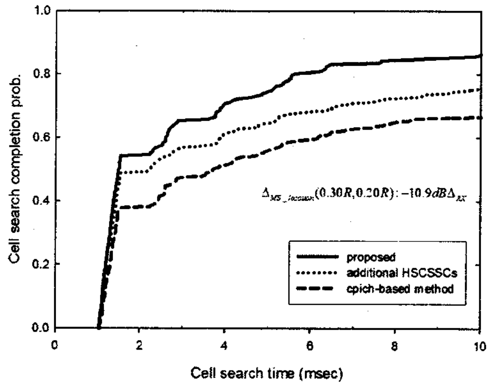


Fig.10 Effect of the MS location(0.30R, 0.20R)

V. Conclusions

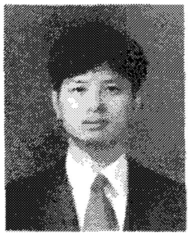
In this paper, the cell search time performance was evaluated by system level simulations. We presented a suitable cell search algorithm using separated I/Q channel CSSCs assignments for a system with coexisting cellular and hot-spot cells in the broadband OFCDM system. This algorithm is superior to the additional HSCSSCs method assignment, in that the use of the separated I/Q channel CSSCs assignment allows the proposed algorithm to offer high flexibility and fast cell search time performance for the increase of the hot-spot cells. Furthermore, the results show that it could accomplish the cell search in approxi-mately 3 msec at the probability of 90 % cell search completion in 0.32 R from the cellular cell.

Reference

[1] Dong In Kim and Yu Ro Lee, "I/Q multiplexed code assignment for fast cell search in asynchronous DS/CDMA cellular systems", IEEE Communications

Letters, vol. 2,159 - 161, Jun. 1998
[2] H. Atarashi, S. Abeta, M. Sawahashi, "Variable spreading factor-orthogonal frequency and code division multiplexing (VSF-OFCDM) for broadband packet wireless access", IEICE trans. commu., vol. e86-b, no. 1, Jan. 2003
[3] Y. Ishii, K. Higuchi, M. Sawahashi, "Three-step cell search algorithm employing synchronization and common pilot channels for OFCDM broadband wireless access", IEICE trans. vol. e85-b, no. 12, dec. 2002
[4] M. Tanno, H. Atarashi, K. Higuchi, and M. Sawahashi, "Three-step fast cell search algorithm utilizing common pilot channel for OFCDM broadband packet wireless access", IEEE VTC2002-Fall, vol. 3,1575 - 1579, Sept. 2002
[5] M. Tanno, H. Atarashi, K. Higuchi, and M. Sawahashi, "Fast cell search algorithm for system with coexisting cellular and hot-spot cells suitable for OFCDM forward link broadband wireless access" IEEE VTC 2003-Spring, vol. 1,pp. 133-138, April 2003

저자소개



김대용(Dae-Yong Kim)

1998. 2. 영남대학교 전자공학과 공학사
2001. 2. 영남대학교 정보통신공학과 공학석사
2002. 2 ~ 영남대학교 정보통신공학과 박사과정

※관심분야 : 이동통신, 4G

권혁숭(Hyeog-Soong Kwon)

1985. 2. 영남대학교 전자공학과 학사
1988. 2. 영남대학교 전자공학과 석사
1995. 8. 영남대학교 전자공학과 박사
1992. 9. ~ 1996. 2. 대구과학대학 전자통신과 조교수
1996. 3. ~ 현재 밀양대학교 정보통신공학부 부교수
2002. 2. ~ 2003. 8. Oregon state university 방문교수

※관심분야 : 대역확산통신방식, 이동통신시스템