Cell Selection Algorithm Based on Competition of Users in Hierarchical Cellular Networks

Jung-Min Moon* and Dong-Ho Cho†
Department of Electrical Engineering
Korea Advanced Institute of Science and Technology (KAIST)
Email: jmmoon@comis.kaist.ac.kr*, dhcho@ee.kaist.ac.kr†

Abstract—One of the important issues in hierarchical cellular networks is to assign a user to a proper cell. If the user is located in the overlapping area of a macrocell and a microcell, both cells can be candidates as a serving cell. Thus, a cell selection should be carefully performed to increase performance in view of users as well as networks. In this paper, we propose a cell selection algorithm based on competition among a group of users. Through the competition, each user in the group decides its serving cell that causes the reduction of total transmit power required to achieve a given target SINR. Simulation results show that a proposed algorithm has performance improvement in terms of the maximum number of supportable users compared with a conventional algorithm, in which a user is assigned to a cell that requires smaller transmit power to achieve the target SINR.

I. INTRODUCTION

As a trend in the development of wireless communication systems, hierarchical cellular networks are mainly considered to improve system capacity and service quality [1]. In such kind of networks, two different types of cells are deployed in a hierarchical manner. The first type is a wide area cell that provides moderate data rates for users moving at high speed. The second type is a local area cell that covers a certain area with high traffic density for static or nomadic users [2]. One of the advantages of hierarchical architecture is the fact that the distance between a mobile station (MS) and a base station (BS) can be reduced by assigning each user to its closest BS. Thus, both stations are required to use smaller transmit power and experience a lower level of interference.

In addition, the users in the coverage of local area cells have an opportunity for selecting not only the local area cell but also the overlaid wide area cell as a serving cell. Therefore, efficient load balancing can be achieved by applying properly designed cell selection criteria [3]. In this context, the introduction of the hierarchical cell structure is accelerated and the coordination among macrocells, microcells, and even femtocells becomes an important issue in current cellular networks [1][7][8].

In this paper, we aim to develop a cell selection algorithm that leads to increase the maximum number of supportable users in the environment where a microcell is deployed in the overlapping area with a macrocell. Various factors, such as user mobility, channel condition, and type of service, are typically taken into account when a serving cell is determined. More specifically, T. Klein et al. [3] studied a cell selection problem for mobile data users based on their velocity and the amount of data to be transmitted. In their work, a cell selection is performed according to the optimal decision thresholds of the velocity and the amount of data. These thresholds are analytically derived to minimize expected system load. S. Lee et al. [4] proposed a vertical handoff algorithm to achieve the joint optimization of the battery lifetime of MSs and the fairness of the load across BSs. The objective function used to decide a target cell for handoff is obtained by considering power consumption and cell load. However, the mutual dependence between these parameters is not properly reflected on the objective function. K. Yang et al. [5] suggested a multi-dimensional algorithm using signal quality, required bandwidth, traffic cost, and network utilization. Even though it improves system performance in terms of throughput and dropping probability, much information about these elements should be provided in advance.

As a key factor to develop an efficient and practical cell selection algorithm, we choose uplink transmit power that is required to achieve a target signal-to-interference-plus-noise ratio (SINR). The multiple access scheme we consider is a code division multiple access (CDMA) employing universal frequency reuse. In this situation, uplink interference experienced by a user is determined by two components [6]. The first is the uplink signals from users in the same cell. In this case, their transmit power can be controlled by the serving cell in accordance with the target SINR and the current amount of interference. The second is the uplink signals from users in other cells. Because the users in other cells decide their transmit power to achieve their own target SINR, the generation of inter-cell interference is unavoidable. Especially in the hierarchical cellular networks, the users who are connected to a macrocell and also closely located to a microcell cause substantial inter-cell interference to the microcell, so the performance of the microcell can be severely impaired by the uplink signals from them. This phenomenon indicates that a cell selection should be conducted by considering the pattern of the inter-cell interference observed in this kind of hierarchical cell structure.

Therefore, we propose an efficient cell selection algorithm by investigating the effect of each user’s uplink transmit power. We focus on users in the coverage of a microcell, so their connection can be established with either a macrocell or a microcell. In this circumstance, the main idea of the proposed algorithm is to perform a cell selection through competition among a group of users. The users participated
in the competition consist of two parties: (i) an incoming user who has just appeared as a handoff or new call in the coverage of the microcell and (ii) a certain number of users who are already assigned to the microcell and also have relatively good inter-cell channel gain from the macrocell. In addition, each user’s objective is to minimize total transmit power of the users in both cells. By using the cell selection algorithm based on the proposed competition, we observe the increase of the maximum number of supportable users and the decrease of each user’s transmit power compared to the case that a conventional algorithm is used, in which a user is assigned in a cell that requires smaller transmit power to achieve a target SINR [6].

The rest of the paper is organized as follows. In Section II, system model and conventional cell selection algorithms are described. In Section III, the development of a proposed cell selection algorithm is provided in detail. Next, simulation results are discussed in Section IV and the paper is concluded in Section V.

II. SYSTEM MODEL AND PROBLEM DEFINITION

In this section, we describe a system model for a CDMA-based hierarchical cellular network composed of a macrocell and a microcell, as shown in Fig. 1. Especially, we concentrate on analytical expressions for uplink SINR. Based on the system model, we clearly state the problem considered in this paper and briefly explain several cell selection algorithms that are conventionally used.

A. System Model

Let \( \gamma_m \) and \( \gamma_\mu \) denote target SINR values on the uplink of a macrocell and a microcell, respectively. Note that subscripts \( m \) and \( \mu \) indicate the macrocell and the microcell, respectively. Also, required power values at BSs to achieve their target SINRs are denoted by \( s_m \) and \( s_\mu \). Then, the target SINR values \( \gamma_m \) and \( \gamma_\mu \) can be expressed as follows [6]:

\[
\gamma_m = \frac{c \cdot s_m}{\eta_o + (N_m - 1)s_m + \sum_{i \in U_\mu} \left( \frac{h_{i,m}}{h_{i,m}} \right) s_\mu}
\]

(1)

\[
\gamma_\mu = \frac{c \cdot s_\mu}{\eta_o + (N_\mu - 1)s_\mu + \sum_{j \in U_m} \left( \frac{h_{j,\mu}}{h_{j,\mu}} \right) s_m}
\]

(2)

where \( c \) and \( \eta_o \) represent a processing gain value in a CDMA system and a background noise value at the BSs, respectively. In addition, \( U_m \) and \( U_\mu \) denote sets of users connected to the macrocell and the microcell, respectively, and the numbers of users in the corresponding cells are denoted by \( N_m \) and \( N_\mu \). The values of channel gain between user \( i \) and each cell are also denoted by \( h_{i,m} \) and \( h_{i,\mu} \).

As observed in (1) and (2), intra-cell interference, which is expressed by \((N_a - 1)s_a\), where \( a = m \) or \( \mu \), can be managed by adjusting the required power at the BSs. However, inter-cell interference is difficult to control, because it entirely depends on the required power at the other BS. One of the efficient approaches to reduce an overall level of interference is to carry out a cell selection for the users in the coverage of the microcell. According to their choices of serving cells, the required power at the BSs and the corresponding transmit power of the MSs should be varied. Consequently, it is evident that the level of interference is largely affected by the cell selection. Throughout this paper, system performance is evaluated in terms of the number of users that can be supported simultaneously in the macrocell and the microcell. Based on the relationship in (1) and (2), the numbers of users in the cells for the given target SINR can be represented as follows:

\[
N_m = 1 + \frac{c}{\gamma_m} \frac{\eta_o}{s_m} - \sum_{i \in U_\mu} \left( \frac{h_{i,m}}{h_{i,m}} \right) \frac{s_\mu}{s_m}
\]

(3)

\[
N_\mu = 1 + \frac{c}{\gamma_\mu} \frac{\eta_o}{s_\mu} - \sum_{j \in U_m} \left( \frac{h_{j,\mu}}{h_{j,\mu}} \right) \frac{s_m}{s_\mu}
\]

(4)

B. Problem Definition and Conventional Algorithms

The goal of our study is to design a cell selection algorithm that can increase the total number of users \( N_a = N_m + N_\mu \) in the system. For this purpose, a cell selection should be conducted in a way that following function will be minimized:

\[
F_N(s_m, s_\mu) = \sum_{i \in U_\mu} \left( \frac{h_{i,m}}{h_{i,m}} \right) \frac{s_m}{s_m} + \sum_{j \in U_m} \left( \frac{h_{j,\mu}}{h_{j,\mu}} \right) \frac{s_m}{s_\mu}
\]

(5)

In (5), \( p_{i,a} = s_a/h_{i,a} \), where \( a = m \) or \( \mu \), represents transmit power of the \( i \)-th user required to achieve a target SINR. The cell selection problem to minimize \( F_N(s_m, s_\mu) \) is challenging in that each user’s selection causes successive change in the amount of interference in both cells. In other words, the value of \( F_N(s_m, s_\mu) \) for a certain choice of a user can be higher compared with the case where the user selects the other cell, even though the user makes the choice to minimize \( F_N(s_m, s_\mu) \) based on the current values of \( s_m \) and \( s_\mu \). Thus, it is necessary to consider not only user assignment but also corresponding performance variation.
Conventionally, several methods for a cell selection have been suggested [6]. The most common method is based on the uplink transmit power $p_{i,a}$ required to achieve a target SINR. Thus, a user chooses a cell where smaller $p_{i,a}$ is needed. Even though this method aims to minimize transmit power of the user who performs the cell selection, it does not guarantee the power minimization of other users who are already connected. There are also methods using the number of users or downlink received power. So, a user is assigned to a cell that provides larger remaining resource or stronger signal strength. However, these methods does not contain any property of the hierarchical cellular networks.

III. PROPOSED CELL SELECTION ALGORITHM

In this section, we develop a new cell selection algorithm for hierarchical cellular networks. Based on the relationship in (1) and (2), required powers at BSs to achieve their target SINR can be expressed as follows:

$$\begin{bmatrix}
\eta_o \\
\eta_o
\end{bmatrix} = \begin{bmatrix} I_{11} & I_{12} \\ I_{21} & I_{22} \end{bmatrix}^{-1} \begin{bmatrix}
s_m \\
s_{\mu}
\end{bmatrix}$$

(6)

where $I_{11}$, $I_{12}$, $I_{21}$, and $I_{22}$ are written as follows:

$$I_{11} = \frac{c}{\gamma_m} - (N_m - 1)$$

(7a)

$$I_{12} = -\sum_{i \in U_\mu} \frac{h_{i,m}}{h_{i,\mu}}$$

(7b)

$$I_{21} = -\sum_{j \in U_\mu} \frac{h_{j,\mu}}{h_{j,m}}$$

(7c)

$$I_{22} = \frac{c}{\gamma_\mu} - (N_\mu - 1)$$

(7d)

The expressions in (6) and (7) correspond to the situation where all users are already assigned to either a macrocell or a microcell. If a user has just appeared as a handoff or new call in the coverage of the microcell, a cell selection must be performed. During the procedure of the cell selection, all users in the system are classified into three sets. Most of all, we define a user set $U_\nu^c$ who participates in competition as follows:

$$U_\nu^c = \{ u_{\mu,in}, u_{\mu,m}^{[1]}, \ldots, u_{\mu,m}^{[N_\nu^c]-1} \}$$

(8)

where $u_{\mu,in}$ represents a user who has just appeared in the coverage of the microcell. Also, $u_{\mu,m}^{[i]}$ represents the user who is already assigned to the microcell and has the $i$-th channel gain from the macrocell when the users in $U_\mu$ are sorted in descending order of their channel gain from the macrocell. A reason why $u_{\mu,m}^{[i]}$ is included in $U_\nu^c$ is that $u_{\mu,m}^{[i]}$ is an appropriate candidate for a cell re-selection when its connection change from the macrocell to the microcell is considered. Thus, we will treat a cell selection problem as not a choice of a single incoming user, but a kind of competition among the users in $U_\nu^c$ to increase performance in view of overall system. Moreover, we define a user set $U_m^c$ as the users who are already assigned to the macrocell, and a user set $U_\mu^c$ as the users who are already assigned to the microcell except those in $U_\nu^c$. Thus, $U_m^c$ and $U_\mu^c$ can be represented as follows:

$$U_m^c = U_m \text{ and } U_\mu^c = U_\mu \setminus U_\nu^c = \{ u_{\mu,m}^{[N_\nu^c]}, \ldots, u_{\mu,m}^{[N_\mu]-1} \}$$

(9)

Note that $N_m^c$, $N_\nu^c$, and $N_\mu^c$ denote the number of users in $U_m^c$, $U_\mu^c$, and $U_\nu^c$, respectively.

In the proposed competition for the cell selection, the action of each user in $U_\nu^c$ is to decide a probability of choosing a microcell as its serving cell. We represent these probabilities in a vector form as follows:

$$\bar{q} = \{ q_1, q_2, \ldots, q_{N_\nu^c} \}$$

(10)

where a subscript $i$ indicates a user index in $U_\nu^c$. Thus, an incoming user $u_{\mu,in}$ will be served by the microcell with a probability $q_1$ and a user $u_{\mu,m}^{[i]}$ will switch its connection from the macrocell to the microcell with a probability $1 - q_1$. According to these probabilistic choices of serving cells, the expected numbers of users in the macrocell and the microcell become $N_m^c + \sum_{i=1}^{N_\nu^c} (1 - q_i)$ and $N_\mu^c + \sum_{i=1}^{N_\nu^c} q_i$, respectively. Also, the expected amount of interference can be calculated based on the information about the expected number of users and their channel gains. As a result, required powers at the BSs when the behaviors of the users in $U_\nu^c$ are given by $\bar{q}$ can be expressed as follows:

$$\begin{bmatrix}
\eta_o \\
\eta_o
\end{bmatrix} = \begin{bmatrix} I_{11}^c & I_{12}^c \\ I_{21}^c & I_{22}^c \end{bmatrix}^{-1} \begin{bmatrix}
s_m \\
s_{\mu}
\end{bmatrix}$$

(11)

where $I_{11}^c$, $I_{12}^c$, $I_{21}^c$, and $I_{22}^c$ are written as follows:

$$I_{11}^c = \frac{c}{\gamma_m} - \left( N_m^c + \sum_{k \in U_\nu^c} (1 - q_k) - 1 \right)$$

(12a)

$$I_{12}^c = -\sum_{i \in U_\mu^c} \frac{h_{i,m}}{h_{i,\mu}} \sum_{k \in U_\nu^c} q_k \frac{h_{k,m}}{h_{k,\mu}}$$

(12b)

$$I_{21}^c = -\sum_{j \in U_\mu^c} \frac{h_{j,m}}{h_{j,\mu}} \sum_{k \in U_\nu^c} (1 - q_k) \frac{h_{k,m}}{h_{k,\mu}}$$

(12c)

$$I_{22}^c = \frac{c}{\gamma_\mu} - \left( N_\mu^c + \sum_{k \in U_\nu^c} q_k - 1 \right)$$

(12d)

Thus, distribution of user’s connections and corresponding variation of intra-cell and inter-cell interference can be expected by using (11) and (12). In particular, this approach based on the probabilistic selection of the users in $U_\nu^c$ provides a way to jointly perform not only the cell selection but also the load balancing between the cells.

Next, we devise a strategy for deciding the value of $q_i$ that corresponds to the action in the competition. In the proposed algorithm, each user in $U_\nu^c$ tries to select its serving cell that minimizes the sum of the required powers at the BSs, which can be expressed as follows:

$$F_s(\bar{q}) = s_m(\bar{q}) + s_{\mu}(\bar{q})$$

$$= \frac{\eta_o (I_{11}^c + I_{22}^c - I_{12}^c - I_{21}^c)}{I_{11}^c I_{22}^c - I_{12}^c I_{21}^c}$$

(13)
Because the transmit powers required to achieve the target SINR is proportional to the required powers at the BSs, the minimization of (13) means that the total transmit power of all users in both cells, which can be expressed as $\sum_i p_{i,m} + \sum_j p_{j,m}$, where $i \in U_m$ and $j \in U_m^c$, will be minimized. This kind of minimization of the total transmit power has been widely adapted as objective for power control [9][10]. However, this approach has not been used for cell selection, because cell selection has been conventionally viewed as the problem of just a single user. In order to overcome the drawback of this conventional method, the proposed algorithm forms a user set $U^c$, as explained in (8), and performs a cell selection to minimize the total transmit power of all users in both cells. The overall procedure of the proposed algorithm is summarized as follows:

Algorithm 1: Procedure of a proposed cell selection algorithm

1: sort users in $U_m^c$ in descending order of their channel gain from macrocell $h_{i,m}$, where $i \in U_m$
2: if user $u_{\mu,in}$ appears in the coverage of microcell then
3: $U_m^c = \{ u_{\mu,in}, u_{\mu,m}, \cdots, u_{\mu,m-N} \}$
4: $U_m^c = U_m \backslash U_m^c = \{ u_{\mu,m}, \cdots, u_{N_{m,m}} \}$
5: $U_m^c = U_m$
6: initialize a set of probabilities $\vec{q} = \vec{q}_0$
7: repeat
8: for $k = 1$ to $N^c_m$ do
9: calculate probability $q_k$ for cell selection such that $BR_k(\vec{q}_{-k}) = \arg \min_{q_k} F_k(q_k, \vec{q}_{-k})$
10: end for
11: until $q_k^* = BR_k(\vec{q}_{-k}^*)$ for all $k \in U_m^c$
12: users with $q_k^* \geq 0.5$ are assigned to microcell
13: users with $q_k^* < 0.5$ are assigned to macrocell
14: end if

In Algorithm 1, $\vec{q}_{-k}$ represents the probabilities decided by the users in $U_m^c$ except the $k$-th user. Also, $BR_k(\vec{q}_{-k})$ represents the minimum value of $F_k(\vec{q})$ that can be obtained by the selection of the $k$-th user when $\vec{q}_{-k}$ is given. The proposed algorithm can be implemented at the BS of the microcell, in which the channel gains $h_{i,m}$ and $h_{i,m}^c$, where $i \in U_m \cup U_m^c$, are collected and managed. Therefore, each user in $U_m^c$ makes an effort to minimize the total transmit powers required to achieve the target SINR. Consequently, the overall level of interference is reduced and the number of supportable users will be increased. Note that the value of $q_k$ will be updated in an iterative manner and the algorithm will be terminated when the condition $q_k^* = BR_k(\vec{q}_{-k}^*)$ is satisfied for all $k \in U_m^c$, which means that the probability of the cell selection will not further change. In addition, serving cell of the users in $U_m^c$ are finally determined according to the $q_{-k}^*$. So, the $k$-th user is assigned to the microcell if $q_k^* \geq 0.5$ and assigned to the macrocell if $q_k^* < 0.5$.

IV. SIMULATION RESULTS

In order to examine the performance of a proposed cell selection algorithm, we conduct simulation in the environment where a microcell is deployed in the coverage of a macrocell, so these two cells form a hierarchical cellular network. This situation is illustrated in Fig. 1. As a performance indicator, we adapt the number of users that can be supported simultaneously by both cells without violating their target SINR’s. The same arrival rate of incoming users is applied to both cells and each user is located at a random position that is uniformly distributed in each cell. However, departure rate is not considered, because we intend to observe the maximum number of supportable users. As a rule for a cell selection, an incoming user who appears in the area covered only by the macrocell will be assigned to the macrocell. On the other hand, if an incoming user appears in the coverage of the microcell, an algorithm for the cell selection is triggered and its serving cell is determined. In our proposed algorithm, which is named by Total UL Tx power in following figures, the size of a user set $U_m^c$ is set to 3. Thus, an incoming user and 2 additional users served by the microcell form a group for the cell selection. In addition, the initial values of $\vec{q}$ are set to 0.5 for all users in $U_m^c$. So, each user has an equal probability of being assigned to one of the cells at the beginning. Note that conventional algorithms, which are used to be compared with the proposed algorithm, are explained below and several related parameters for the simulation are listed in Table I.

- Individual UL Tx power: An incoming user is assigned to a cell that requires smaller transmit power to achieve its target SINR.
- DL Rx power: An incoming user is assigned to a cell that provides stronger downlink signal strength to the user.
- Cell load: An incoming user is assigned to a cell where a smaller number of users are connected.

Most of all, we look at the total number of users $N_{m} + N_{\mu}$ that can be supported simultaneously for different values of the target SINR. As shown in Fig. 2, the proposed algorithm outperforms the other conventional algorithms. In particular, the proposed algorithm has performance improvement of 14.2 % for the target SINR of 5 dB and 12.7 % on average for the target SINR ranged from 0 dB to 9 dB compared to the conventional algorithm based on Individual UL Tx power, which has the second-best performance. This result

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>PARAMETERS FOR PERFORMANCE EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_m = 700$ m</td>
<td>Radius of macrocell</td>
</tr>
<tr>
<td>$R_{\mu} = 100$ m</td>
<td>Radius of microcell</td>
</tr>
<tr>
<td>$D_{m,\mu} = 100$ m</td>
<td>Distance between macro and micro BS</td>
</tr>
<tr>
<td>$P_{m,tx} = 43$ dBm</td>
<td>Tx power of macro BS</td>
</tr>
<tr>
<td>$P_{\mu,tx} = 30$ dBm</td>
<td>Tx power of micro BS</td>
</tr>
<tr>
<td>$PL = 17.4 + 37.6 \log_{10}(d[m])$</td>
<td>Path loss model</td>
</tr>
<tr>
<td>$\sigma = 8$ dB</td>
<td>Standard deviation of shadowing</td>
</tr>
<tr>
<td>$\gamma_0 = -104$ dBm</td>
<td>Noise level at BS</td>
</tr>
<tr>
<td>$e = 128$</td>
<td>Processing gain in CDMA system</td>
</tr>
<tr>
<td>$\gamma_m = \gamma_{\mu} = 0 \sim 9$ dB (variable)</td>
<td>Target SINR of users</td>
</tr>
<tr>
<td>$N_{m} = 3$</td>
<td>Number of users in $U_m^c$</td>
</tr>
<tr>
<td>$q_{0i} = 0.5$ for all elements of $\vec{q}$</td>
<td>Initial vector of $\vec{q}$ for cell selection</td>
</tr>
</tbody>
</table>
can be achieved by two aspects of the proposed algorithm. (i) First, the minimization of total transmit power is performed, as represented in (13), rather than the minimization of the transmit power of an incoming user. (ii) Second, the users in \( U_c \) participates together in the proposed operation, so the cell selection and the load balancing are jointly performed. Therefore, overall level of interference is reduced and the number of supportable users is increased.

Next, the conventional algorithm based on DL Rx power has lower performance than the methods using uplink transmit power. A reason for this phenomenon is that there is large asymmetry in the transmit power of a macro BS and a micro BS. In other words, the transmit power of the macro BS is higher than that of the micro BS. So, it is possible that received signal strength from the macro BS will be stronger than that from the micro BS although a user is located in the coverage of the microcell. For this reason, the cell selection through the comparison of the received signal strength will not be useful in hierarchical cellular networks. Finally, the conventional algorithm based on Cell load has the worst performance, because this method solely depends on the number of users in each cell without considering channel gain or transmit power.

For the purpose of further investigating the effect of power minimization in the proposed algorithm, we compare required power at the BSs when the proposed algorithm and the conventional algorithm based on Individual UL Tx power are used. This result is represented in Fig. 3. Basically, the required power at BSs is increased as a target SINR is increased.
Moreover, when the proposed algorithm is used, a constant amount of the required power at the BSs is reduced for the target SINR ranged from 0 dB to 9 dB. The average values of the reduction are 2.3 dB in the case of a macrocell and 2.0 dB in the case of a microcell. This phenomenon indicates that each user can be operated with smaller transmit power in its serving cell that is determined by the proposed algorithm. Consequently, both the macro BS and the micro BS will experience a lower level of uplink interference and a more number of users will be supported.

Finally, we examine the number of supportable users in each cell separately. Fig. 4 and Fig. 5 show the number of users in the macrocell and that in the microcell, respectively. We can find that the proposed algorithm has performance improvement of 18% in the case of the macrocell and 6% in the case of the microcell compared with the conventional algorithm based on Individual UL Tx power. Here, the increment in the number of supportable users is higher in the case of the macrocell. It indicates that the performance improvement comes from the cell re-selection of the users denoted by $u_{[1]}^{[1]}$ in (8). That is, the connection change from the microcell to the macrocell of the properly selected users is helpful to reduce inter-cell interference. In addition, the conventional algorithm based on DL Rx power leads much more users to be connected with the macrocell than with the microcell. Thus, a large amount of intercell interference from the users in the macrocell makes it difficult for the users in the microcell to achieve the target SINR. Accordingly, large asymmetry in the number of users is observed. Fig. 6 shows the number of supportable users in each cell when the target SINR is given as 5 dB. From this figure, we can clearly recognize the advantages of the proposed algorithm: (i) the increased number of users that can be supported simultaneously and (ii) the efficient load balancing between the macrocell and the microcell that form the hierarchical cellular network.

V. CONCLUSIONS

In this paper, we have developed an efficient cell selection algorithm that is suitable for hierarchical cellular networks. Conventionally, the problem of the cell selection is viewed as a choice of a single user who needs to decide its serving cell. Accordingly, the user is simply assigned to a cell that requires smaller transmit power to achieve a target SINR or provides stronger downlink signal strength to the user. In these conventional methods, the effect of the user’s selection on dynamic change of both intra-cell and inter-cell interference has not been considered. Thus, our proposed algorithm has been designed based on the competition among a group of users. That is, a user set that consists of an incoming user and several users who have relatively good inter-cell channel gain is made. Then, each user in the set decides its serving cell to minimize the total transmit power of the users in both cells instead of minimizing the transmit power of just the incoming user. Through this procedure, we have obtained performance improvement such as the increased number of supportable users, the reduction of required power at BSs, the corresponding reduction of the transmit power of MSs, and the efficient load balancing between the cells.

REFERENCES