A Graph-Theory Approach to Joint Radio Resource Allocation for Base Station Cooperation

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Abstract—Base station cooperation (BSC) is an effective means to improve system throughput in wireless networks. In this paper, a novel, practical BSC method is proposed based on graph theory, in which the cluster of cooperative based stations is adapted according to the variation in channel conditions. However, cooperation behaviour would introduce additional problems in the conventional system, such as radio resource allocation conflict. Considering the problem of resource allocation in a cooperative scenario, the proposed base station cooperation method consists of two steps. An assist-graph is constructed to select the cooperative base station (BS) to mitigate the cell edge users’ interference in the first phase. After that, an available resource pool is proposed in resource management to avoid the conflict of resource allocation. The heuristic algorithm is proposed to solve the two-step-problem efficiently. Simulation to demonstrate the performance of the proposed algorithm has been carried out and the results indicate that the proposed scheme enhances the SINR significantly.

Keywords- Base station cooperation, graph theory, interference mitigation, radio resource allocation

I. INTRODUCTION

Compared with the current wireless cellular systems, the beyond-third-generation (B3G) wireless communications network requires higher data rate and wider coverage. Due to the scarcity of the spectrum resources, reusing the same spectrum in all cells is desirable (i.e., with the frequency reuse factor equal to one). To mitigate the intra-cell interference, orthogonal frequency division multiple access (OFDMA) has become widely adopted in the next-generation cellular systems such as 3GPP Long Term Evolution (LTE) and IEEE 802.16m advanced WiMAX. By allocating radio resources orthogonally, the intra-cell interference is removed. Since there will be channel reuse in a multi-cell environment, inter-cell interference (ICI) from other cell is inevitable when mobile stations (MSs) or users share the same channel in adjacent cells. Therefore, how to guarantee a high data rate in the presence of inter-cell interference limiting the system performance [1] is necessary and this requires a good radio resource management (RRM) scheme.

Cooperation has attracted significant research attention due to its efficiency [2][3][4]. Some explanations and examples of BSC were described in [3][4]. BSC allows multiple BSs to transmit signals to multiple MSs concurrently sharing the same resource. It is specifically used in cell-edge MSs within the transmission rages of multiple BSs. Since users in the cell edge region suffer the most severe ICI in OFDMA system, the BSC scheme can transmit the ‘damage’ from neighbouring BSs so it becomes part of desired signal. There are two methods of cooperation control techniques, static clustering [5][6] and dynamic clustering [7][8]. In the conventional static clustering BS cellular system [6], a centralized controller is assumed to collect the channel information from each BS. However, since the cooperative cluster is predetermined, static grouping of BSs still suffers from cooperative-cluster interference. Enlarging the size of the static cluster will reduce the inter-cluster interference, but the complexity increases [9].

In [10], a dynamic clustering method is proposed. The cooperation behaviour is determined by signal-to-interference-and-noise (SINR). A similar approach was adopted in [8], extending cooperation cases and simplifying how cooperative users are determined. Two geographic regions are formed to categorize cooperative users and non-cooperative users without considering multi-path fading and shadowing.

Cooperation also will introduce additional problems to conventional cellular network system, such as RB allocation synchronization and RB allocation conflict. To tackle this problem, a two level method is proposed in [11] [12], where the first level reduces ICI by using inter-cell interference coordination (ICIC) while the second level performs resource block (RB) assignment. The clusters were formed according to the position and diversity set.

In this paper, a two-step joint BSC and resource allocation scheme is proposed, the main goal of the joint algorithm being to design a cooperation set for each user in order to achieve improvements in system throughput, ICI mitigation and RB allocation. In the first step, a quantized value is generated according to the MS position and its SNR-judged diversity set [13]. This value will construct the users’ weight in all cells; a modified max matching and assignment algorithm is used to form the cooperative set according to the weight. In the second step, after the cooperative set is formed, instantaneous channel conditions are taken into consideration in order to optimize system throughput during RB allocation. A concept of
available RB pool is proposed to avoid the RB allocation conflict in RB allocating for cooperative cellular network.

The rest of the paper is organized as follows: after building and describing the system model in section II, we introduce the resource allocation problem and formulate the problem in section III. The details of the proposed algorithm are described in section IV. Section V shows the simulation results with the conclusion being given at the end of the paper.

II. SYSTEM MODEL

A downlink OFDM based cellular network is considered. Each cell is served by one BS at the centre of the cell. The BS that serves the MS in its cell is the anchor cell. For simplicity, we assume the signal from the anchor BS and from the cooperative BS will be received by the MS at the same time. In the channel model we consider the propagation loss and shadow fading in large-scale fading as well as frequency selective and time varying fading in small-scale fading.

There are $n$ BSs, each with $N_r$ transmit antennas; each BS can exchange information with every other BS. For simplicity, the delay of mutual information is not considered in this paper.

A total of $m$ MSs, each with $N_t$ receive antennas, are distributed across all cells. Define $h_{ij}$ as the channel gain between the transmit antenna $i$ and the receive antenna $j$. $H_{nm}$ represents the channel condition matrix for MS $m$ from BS $n$, and $C^{M \times N}$ denotes the field of channel conditions. The channel conditional matrix is given by $H_{nm} = [h_{ij}] \in C^{M \times N}$ for MS $m$. Assuming $h_{ij}$ is quasi-stationary and time-invariant during transmission of a packet, the received signal can be written as:

$$y_{nm} = H_{nm}X_n + N_m$$  (1)

Matrices $X_m$ and $Y_{nm}$ represent transmitted signals from BS $n$ and received signals for MS $m$ from BS $n$ respectively. $N_m$ represents the Additive Gaussian White Noise (AGWN), with covariance $E[n_{mn} h_{nm}] = \delta^2 I$, where $I$ denotes the identity matrix.

To obtain the system SINR, we assume the total available power is limited, and the transmit power per BS is a constant value. Therefore, the received signal power at MS $m$ from BS $n$ is given by $p_s h_{nm} h_{nm}^T$, where $p_s$ denotes the transmit power per BS. According to (1), in the downlink multi-cell scenario, the SINR of the received signal at MS $m$ from BS $n$ is given by

$$\text{SINR} = \frac{p_s h_{nm} h_{nm}^T}{p_s \sum_{l \neq n} h_{lm} h_{lm}^T + N_m W}$$  (2)

Since OFDMA is used here, there is no intra-cell interference in the system. The inter-cell interference only affects the same spectral resource allocated to adjacent BSs. In this system, we denote $C_m$ as the cooperative cluster for MS $m$, and $C_m$ denotes the non-cooperative set for MS $m$, as shown in Figure 1.

The received downlink signal $y_m$ at the MS $m$ in the cellular environment is expressed as

$$y_m = \sum_{n \in C_m} H_{nm} X_n + \sum_{l \notin C_m} H_{nm} x_l + n_m$$  (3)

The desired data stream $X_n$ transmitted from the BS $n$ in the cluster is distorted by the inter-cluster interference aggregated in $x_l$. In this paper, it is assumed that all BS in cluster $C_m$ are simultaneously active.

To obtain the SINR expression for the cooperation scheme, we note that each MS communicates with more than one BS. Thus, the SINR expression for the cooperation scheme involves an additional term compared to (2). Then the received SINR at the MS $m$ in the cluster $C_m$ can be derived as

$$\text{SINR} = \frac{p_s \sum_{n \in C_m} h_{nm} h_{nm}^T}{p_s \sum_{l \notin C_m} h_{lm} h_{lm}^T + N_m W}$$  (4)

III. PREPARE YOUR PAPER BEFORE STYLING

A. Problem and Framework

The idea of BSC can be explained by Figure 2 part a), where we give an illustrative scenario composing 3 BSs and 3 MSs. MS1, MS2 and MS3 are communicating with BS1, BS2 and BS3 respectively. The downlink signal to MS1 causes interference at MS2, and vice versa. The same issue occurs between BS1 and BS2, BS2 and BS3 respectively. However, as BSC use the inter cell interference channel as a part of the desired signal channel, this operation can significant mitigate ICI [14].

Figure 1 An example of distributed MIMO system

Figure 2 BSC scheme with 3MSs and 3BSs
At the same time, a decision-making problem is indicated in Figure 2 part B). Since MS1 located in the overlap region, both BS2 and BS3 can transmit signal or interfering MS1. It is difficult to choose which BSs provide cooperative transmission most effectively. Furthermore, designing the size of cooperative set is another complication. Figure 2 part C) illustrates the problem on radio resource allocation. MS2, MS3 is served by BS1, BS3 and BS2, BS3 respectively. If BS1, BS2 allocate resource block 3 (RB3) to MS2, MS3 respectively, BS3 cannot allocate the same RB3 to both MS2 and MS3 simultaneously.

The previous problem is considered in the base station cooperation joint radio resource allocation method. The proposed algorithm optimizes the cooperative efficiency and avoids the conflict on resource allocation. The main objective is to improve the cell-edge users’ throughput.

The problem is decomposed into two phases. First, provision of more spatial diversity and ICI reduction is considered by choosing proper cooperation BSs. A cooperative cluster is formed by using a graph-assisted method. Then, once the cooperation set is selected, a novel resource allocation method is proposed to avoid the conflict. The instantaneous channel quality information (CQI) is exploited in order to maximize the SINR.

**B. Assist graph construction**

The first step of assist graph construction is to generate the weighted interference value graph, which is determined by the geographic position of MSs and the diversity set for each MSs. An example with 4BSs and 8MSs is shown in Figure 3. We can infer the interference intensity from MSs’ geographic location and construct a corresponding interference graph in Figure 4 part A). In this graph, which is denoted by $G = (\mathcal{V}, \mathcal{E})$, a node in set $\mathcal{V}$ denotes an MS and an edge in set $\mathcal{E}$ represents the potential interference between two MSs, $e_{ij}$ denotes the interference between node $i$ and node $j$. The higher the value of $e_{ij}$ the stronger the potential interference between MS $i$ and MS $j$. By calculating the $e_{ij}$ at MS $i$ from the whole MSs $j$ that are located in the BS $\ell$, we can obtain the weight of MS $i$ in the BS $\ell$. Therefore, an assist graph can be constructed to indicate the relationship between BSs and MSs, which is shown in Figure 4 part B). We assume every edge has a nonnegative real number. We take two vertex sets: one for MSs and the other for BSs. Figure 4 part B) shows two sides of vertex sets for the case of 8 MSs and 4 BSs. The edge $w_{ij}$ represents the potential weight of interference from BS $\ell$ to MS $i$.

The assist graph is constructed by quantized SINR measurements. Using quantized measurements not only decreases the overhead exchange, but also the accurate SINR is hard to evaluate instantaneously in a realistic system. The basic idea is to determine the weight of edges corresponding to the potential interference between two MSs.

<table>
<thead>
<tr>
<th>Table I Simulation Assumption</th>
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<tbody>
<tr>
<td>MS No</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>MS0</td>
</tr>
<tr>
<td>MS1</td>
</tr>
<tr>
<td>MS2</td>
</tr>
<tr>
<td>MS3</td>
</tr>
<tr>
<td>MS4</td>
</tr>
<tr>
<td>MS5</td>
</tr>
<tr>
<td>MS6</td>
</tr>
<tr>
<td>MS7</td>
</tr>
</tbody>
</table>

Table I indicates the useful information that is related to interference between MSs. The anchor cell denotes the cell in which the MS is located; diversity set means the cell which can provide cooperation behaviour. Each MS has an anchor BS and several possible cooperative BSs if the SINR is under a threshold, i.e., MS will be set to be a cooperation MS if the SINR of direct link is under a threshold value. We can infer the interference intensity between any two MSs from this table. We will give an explanation below. First, MS0 and MS1 are both located in the same anchor cell and have severe interference, unless allocated different RBs. Second, MS1 may endure heavy ICI from MS4 unless it uses BSC, not only because the anchor cell of MS4 is in the diversity set of MS1 but because both MS1 and MS4 are cell-edge users. Third,
since the anchor cell of MS3 is in the diversity set of MS1, and MS3 is a cell centre user, MS3 will slightly interfere to MS1 from a different cell. Fourth, although ICI will exist between MS1 and MS6, BSC cannot establish a connection from MS6’s anchor cell to MS1. e.g., MS6’s anchor cell is not included in MS1’s diversity set. From these cases; we can evaluate the weight between any two nodes.

There are five possible weight values between every pair of nodes.

\[ e_N, e_0, e_1, e_2, e_s, \]

Where \( e_N, e_s \) denotes weights associated with non-BSC and intra-cell interference respectively. \( e_0, e_1, e_2 \) correspond to the weights of possible BSC depending on the geographic location of two MSs. e.g., \( e_0 \) (weakest ICI) denotes the weight of the possible BSC between two centre MSs; \( \omega_1 \) (medium ICI) denotes the weight of a possible BSC if one is a cell-edge user and the other one is a centre user; \( e_2 \) (severe ICI) denotes the weight of a possible BSC between two cell-edge users. As a result, the five weight values can be sorted as

\[ e_N < e_0 < e_1 < e_2 < e_s \]  \hspace{1cm} (5)

Since the intra-cell interference \( e_s \) is the largest interference, we would like to assign different RBs to avoid the interference. Inter-cell interference \( e_N \) will inflict the smallest damage; the system can accept interference at such a level. Inter-cell interference \( e_0, e_1, e_2 \) will depend on the system requirement to choose whether to endure the interference or provide BSC. The weight evaluation procedure is given as following. Especially, \( e_s \) should be significant large such that

\[ \forall \delta > 0, \exists N \in \mathbb{Z}^+, \forall n > N \Rightarrow n(e_s - e_2) - e_s > \delta \]  \hspace{1cm} (6)

The generated matrix is illustrated the weight between any pair of BS to MS, which will be used in the next section.

IV. PROPOSED HEURISTIC ALGORITHM

A. Solution of cooperation set selection

The Hungarian algorithm [15] can be used for solving the one to one matching problem. The optimal solution for cooperation set selection could be obtained from a modified Hungarian algorithm, but this is computationally prohibitive for large graphs, i.e., a huge number of MSs. Thus, a suboptimal heuristic algorithm is proposed instead.

The heuristic algorithm is described in the next subsection. Denote \( \mathcal{N}_{\text{coop}} \) and \( \mathcal{N}_{\text{Re}} \) as the size of cooperation set and number RBs respectively. Define \( \rho_{\omega_{nj}} \) as a binary value, where if \( \omega_{nj} \) is the weight between BS j and MS n, which is shown in Equation (5). The proposed algorithm tries to find a cooperation set for each user based on the MSs’ weight in each BS using the procedure described below:

\[ \begin{bmatrix} \omega_{00} & \omega_{01} & \cdots & \omega_{08} \\ \omega_{10} & \cdots & \cdots \\ \omega_{20} & \cdots & \cdots \\ \omega_{30} & \cdots & \cdots \end{bmatrix} \]

The interference weighted graph for Figure 3 is illustrated in Figure 5, where each edge connected between BS to MS contains a quantized interference weight.

**Figure 5** the interference weighted graph
If $\sum_{i}p_{w,i} < N_{BB}$, then mark the row with $\Delta$.

For each column

$$\theta_j = \theta_j + 1, \left( \sum p_{w,i} < N_{coop} \right)$$

Step 4: If each row is marked by $\Delta$, then go to step 5, otherwise return step 2.

Step 5: For each element, $c_{ij}$ is marked by $\times$ only under the following condition, first, $c_{ij} = 0$; second, the number of marked element in the row is smaller than $N_{BB}$, i.e., each BS cannot allocate more than its can serve; third, the number of marked element in the column is smaller than $N_{coop}$, i.e., each MS cannot be served by more than the required number of cooperative BS.

Step 6: The elements $c_{ij}$ marked by $\times$ denote the MS served by BS $j$.

Matrix $C$ is the suboptimal assignment solution.

The properties of the scheme presented below show that the proposed algorithm will produce desirable results.

**Property 1:** for any cooperative MS, the maximum number of cooperative BSs is $N_{coop}$.

**Proof of property 1:** First, we note that the weight of each edge is generated by diversity set and user position. The size of diversity set is larger or equal than $N_{coop}$. Second, each MS cannot be served by more than the number required BSs according to the algorithm. Therefore, an MS can be only connected with at most $N_{coop}$ other BSs.

**Property 2:** Any MSs will be served by its anchor BS.

**Proof of property 2:** First, the weight is assigned to MS’s anchor BS by (6), which has the maximum weight of all. For each user, define $w_{an}$ as the weight between MS $m$ and its anchor BS, $w_{a}$ as the weight between MS $m$ and its potential cooperative BSs. Assume $w_{a} > w_{an}$, (7) can be derived as

$$\sum_{\theta} e_{n} + \sum_{\theta} e_{0} + \sum_{\theta} e_{1} + \sum_{\theta} e_{2} > \sum_{\theta} e_{3}$$

(8)

Based on the relationship in (6), without loss of generality, for simplicity

$$\sum_{\theta} e_{2} > \sum_{\theta} e_{3}$$

(9)

We have $w_{a} > w_{a}$ according to (9), which contradicts with (6). Therefore, an MS will be served by its anchor BS.

**Property 3:** the number of assigned MSs to each BS should be smaller or equal than the number of RBs.

**Proof of property 3:** The heuristic algorithm would stop if the number of assigned MSs is smaller than or equal to the number of RBs. Otherwise, the algorithm carries on. Therefore, property 3 is proved.

**Property 4:** the number of available RBs should be larger or equal than the maximum size of the cooperative set.

**Proof of property 4:** BSC is feasible only under two conditions. First, more than one BS can serve the MS base on the geographical location. Second, BSs have enough available RBs to serve each cooperative MS. BSC events may occur in one of three possible scenarios indicated in Figure 6. For simplify, we only discuss the scenario of each MS with two cooperative BSs. Figure (a) and (b) indicates “BSC clique”. BSC cliques are feasible for both cooperation and radio resource allocation.

The third scenario where a BSC event occurs is called “BSC circle” as shows in Figure 6 (c). The “BSC circle” achieves the first condition: each MS in the “BSC circle” receives transmissions from more than one BS which provides cooperative operation. Define $M_{coop}$ as the number of served cooperative MSs. One possible topology that corresponds to Figure 6 (c) is shown in Figure 7. Each node represents three different BS. The edges denote the MS connected by two cooperative BSs. Then the RB allocation problem transfers into an edge colouring problem. Let the smallest number of colours needed in the colouring problem be $x'(G)$ and, let $\Delta(G)$ denote the maximum degree. A well-known property of the edge colouring problem is: $x'(G) > \Delta(G)$. Therefore, $N_{BB} > M_{coop}$. Accordingly property is obviously established.

**B. RB allocation**

After the first step, MSs are formed into their cooperative set. The cooperation set matrix $C$ is generated with two constraints. First, the size of cooperation set; second, the limitation of available physical radio resource. In the second step, a heuristic algorithm is proposed to avoid resource conflict during radio resource allocation.

Denote $h_{nm}$ as the channel gain from BS $n$ to MS $m$ on RB $y$. B is the bandwidth of each RB. Considering (4), the Shannon Equation can be derived as
\[ T_n = B \cdot \log_2\left(1 + \frac{P_s \sum_{n \in \mathcal{C}_m} h_{nm}^y (h_{nm}^y)^T}{P_s \sum_{l \in \mathcal{L}_m} h_{lm}^y (h_{lm}^y)^T + N_m W}\right) \]  

(10)

Let \( \mathcal{R}_n \) be the set of available RBs for each BS \( n \), then find an assignment solution \( y_{RB} \) such that

\[ y_{RB} = \arg \max_{y_{RB} \in \mathcal{R}_m} \sum_{m=1}^{M} \sum_{y \in \mathcal{R}_m} T_n \]  

(11)

If RB \( y \) is allocated to MS \( m \), then this RB will be removed from \( \mathcal{R}_m \) for each cell which is serving MS \( m \). Thus, other MS would not evaluate the capacity on the RB which is already allocated. The procedure of the RB allocation algorithm is described as follow:

START:

Step 1: Initialize the RB pool for each BS \( n \), let \( \mathcal{R}_m = \{1, \ldots, N\} \).
Step 2: For each user calculate its capacity on each RB according to (10).
Step 3: Assign RB \( y \) to MS \( m \) according to (11).
Step 4: Update the available RB set by \( \mathcal{R}_m = \mathcal{R}_m - n \) for BSs which serve MSs.
Step 5: Repeat step 2-4 for all nodes.
END

V. RESULT AND ANALYSIS

This section, considers the performance of the proposed scheme by simulation, the assumptions being given in Table II being from the 3GPP SCME channel model resulting in frequency-flat MIMO channels[16]. We assume the transmitter uses the SVD scheme for precoding; a MMSE frequency-flat MIMO channels\[16\]. We assume the transmitter uses the SVD scheme for precoding; a MMSE scheme is used at the receiver to estimate the receiving signal.

### Table II Simulation Assumption

<table>
<thead>
<tr>
<th>Issue</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of BSs</td>
<td>19</td>
</tr>
<tr>
<td>Distance between BSs</td>
<td>500m</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>10MHz</td>
</tr>
<tr>
<td>Num of subchannel</td>
<td>10</td>
</tr>
<tr>
<td>Noise PSD</td>
<td>-174dBm/Hz</td>
</tr>
<tr>
<td>MIMO</td>
<td>2*2</td>
</tr>
<tr>
<td>Transmit time interval</td>
<td>1ms</td>
</tr>
</tbody>
</table>

First, to examine the system performance with different quantized weights for each edge, we use four sample values with different quantized methods and thresholds as shown in Table III. The results show the simulation result of sample 3 is better than others.

Second, we obtain the best cooperative size through simulation. Table III reveals the system throughput increases first and then decreases with increasing cooperative size. Due to the hexagonal BS structure, a MS can be covered by three BSs at most. Although a cooperative size of 3 may be used more RBs than a cooperative size of 2 during transmission, the improvement in system is higher. However, if the size of the cooperative set is larger than 3, it not only uses more RBs, but also introduces additional interference.

It should be noted that the proposed algorithm is not very sensitive to the chosen weight values and the size of cooperation set. Thus, the algorithm could be used in different situations with different service requirement. However, in this paper, we choose sample 3 as the weight value and 3 to be the maximum size of cooperative set to analyse the best performance of the algorithm.

### Table III Evaluation of System Parameters

<table>
<thead>
<tr>
<th>Weight value</th>
<th>Sample1</th>
<th>Sample2</th>
<th>Sample3</th>
<th>Sample4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput(10^9)</td>
<td>1.65</td>
<td>1.63</td>
<td>1.79</td>
<td>1.69</td>
</tr>
<tr>
<td>Size of cooperation</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Throughput(10^9)</td>
<td>1.61</td>
<td>1.72</td>
<td>1.31</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Figure 7 and Figure 8 show the cumulative distribution function (CDF) of SINR for three test schemes under different traffic load conditions (with 45 and 4 uniformly distributed MSs per cell respectively). The three schemes are (i) non-BSC, (ii) traditional ICIC and (iii) the proposed BSC algorithm. Figure 9 and Figure 10 both indicate the proposed scheme gives a significant improvement on the SINR performance compared with the non-BSC scheme. Furthermore, we can see the SINR of the proposed BSC scheme is higher better than the ICIC scheme, because the proposed BSC scheme not only decreases the inter-cell interference but also increases the signal power. Because the interference is more severe in high load conditions, the SINR decreases with an increase in the number of MSs.

Also the variation in SINR for the three candidate schemes is tested and the BSC joint RB allocation algorithm is much more stable. Since the algorithm varies the cooperation set according to the location of MSs and the change of diversity set, the cooperation set for each user will only change if the MS changes its geographic location or diversity set.

![Figure 7 SINR distribution for heavy traffic load (45 MSs per cell)](image)
The distribution function for SINR is indicated in Figure 9. The solid line denotes the distribution of SINR for the BSC scheme and the dashed line for non-BSC. In Figure 9, we can see the non-BSC scheme has a much larger probability of having a low SINR (from -30dB to 3dB). In addition, the probability of the SINR for BSC scheme being in middle range (from 4dB to 25dB) is larger than for the non-BSC scheme, because the cell-edge users always suffer a high level of interference in the conventional system. The BSC scheme prefers to choose cell-edge users as cooperative users. Therefore, most of the cell-edge users see their SINR improved from a low level to the middle level. The two schemes have nearly the same probability for the high SINR range (from 32dB to 50dB). Because users can always achieve a high SINR performance at the cell-centre (so the cell-centre users are always picked as non-cooperative users in BSC scheme). Therefore, the BSC scheme adds little contribution at high level SINR area.

VI. CONCLUSION

In this paper, we presented a framework for base station cooperation together with radio resource allocation in a multi-cell cellular network. Considering the feasibility of information exchange, base station cooperation sets are generated based on the geographic location and diversity set. By utilizing an available RB pool, the proposed algorithm avoids the resource allocation conflict in cooperative scenarios. Therefore, the whole system maintains a high spectrum efficiency. The simulation results show the proposed approach can significantly improve the system SINR compared with non-cooperative scheme and ICIC scheme. Furthermore, due to the inherent of graph construction, the variation in the algorithm is stable.

REFERENCES