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Welcome Message from the General Chair

Greetings!

It is my great pleasure and honor to welcome you to APCC 2012, Jeju Island, where we are going to exchange information about our recent researches and enjoy meeting friends and colleagues while relaxing in the comfortable environment of Jeju Island.

This is the 20th year of APCC history. APCC was first held in 1993 in Daejon, Korea, and then started traveling over many countries in the Asia Pacific region. It has been steadily sponsored by IEEE Communications Society (Asia Pacific Region), Chinese Institute of Communications (CIC), Institute of Electronics, Information, and Communications Engineers (IEICE) Communications Society, and The Korean Institute of Communications and Information Sciences (KICS), together with other local institutes. Throughout the journey of 20 years we have been refreshing technical information in broader communications field, while expanding human networking among Asia Pacific communications engineers.

Today, the trend of digital convergence encompasses a broader set of communications, including computing, broadcasting/media, OS platform/software, content/applications, and even print media and advertising. It has brought in platform and eco-cluster based competition among the converged communications players. It will eventually lead us to a smart society, with human beings living a smart life. Smart life will further be complemented by a green life -- a simple, healthy and sustainable life style that minimizes consumption of resources and energy and sustains the ecological system and climate. There are many issues to resolve until we can build such smart and green society, including technology, infrastructure, traffic, spectrum, privacy/security, energy-efficiency, nature-friendly development, life style change, and others. These are the issues awaiting communication engineers' challenge and conquest, and they are the issues for discussion in APCC, today and tomorrow.

In APCC 2012, you will find a well-organized set of technical programs elaborated by our Technical Program Committee (TPC) and a fine set of local and social programs prepared by our Organizing Committee (OC). I would like to take this opportunity to thank all the members of TPC and OC, whose hard work has made this well-prepared premier conference possible.

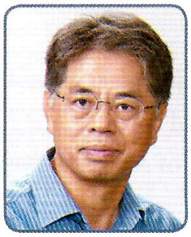
I look forward to seeing you in Jeju in October!

General Chair

Byeong Gi Lee

Professor, Seoul National University, Korea

Welcome Message from the TPC Chair



On behalf of the Technical Program Committee (TPC), it is our great pleasure to welcome you to APCC 2012, the 18th Asia-Pacific Conference on Communications, to take place in Jeju, the most beautiful island in Korea. In this year, APCC 2012 will be co-located with ICTC (International Conference on ICT Convergence) 2012.

Under the theme of "Green and Smart Communications for IT Innovation", APCC 2012 provides a forum for researchers and engineers from academia and industries in Asia-Pacific region to present and discuss topics related to innovative information and communications technologies, leading to a green and smart society.

This year we have received 381 paper submissions from 30 countries. After the rigorous reviews, 150 papers were accepted for oral presentation, and 55 papers for poster presentation. The 150 oral papers are organized into 30 technical sessions with five parallel tracks. The program covers a variety of topics on both of wireless and wired communications and networking technologies. Most important, five keynote speakers and two tutorial speakers from Korea, China, Japan, England, and USA have been invited to present their ideas and researches to this conference. Also, we organized industrial sessions to share research and development activities from industries.

In addition to the contributions of prominent authors from over 20 countries, I believe that this year's interesting program is made possible by the efforts of TPC members. I am indebted to all of the 102 TPC members as well as numerous anonymous reviewers for their volunteering reviews at their precious time. I also would like to thank all of the Organizing Committee (OC) members for their self-sacrificing support.

I hope that all of you will enjoy the technical program of APCC 2012 as well as the beautiful scenery and attractions of Jeju island.

TPC Chair

Youze Cho

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Handover Technique Between Femtocells in LTE Network Using Collaborative Approach

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Abstract—**A great problem for LTE networks employed large number of femtocells using the self optimization and configuration capabilities is to reduce the operational efforts. The handover process is a key element that has to be considered to improve efficiently the performance of the adopted femtocell technology and LTE network. This paper is devoted to a femtocell-to-femtocell handover approach based on simple feedback technique and existence of interface working as signalling system (SS). This interface allows us to exchange the priority lists and other signalling messages between femtocells, and helps us to overcome the drawbacks to use the public internet serving as control messages paths to handle the handover process.**

Keywords: femtocell-to-femtocell handover, LTE netwotk, feedback technique, collaborative distributed approach.

I. Introduction

Early implementation of the femtocell in the long term evolution LTE networks promises to provide high quality voice services and to be an attractive alternative for data intensive services, additionally. Under mass deployment scenarios of a large number of femtocells and taking the self organizing network (SON) [1,2] into consideration, many problems related to the efficient physical radio resource blocks (PRBs) scheduling or radio resource management (RRM) [3], quality of service (QoS), fairness, femtocell coverage problems (coverage gap and overlapping), load balance among femtocells, inter-femto interference caused by unplanned deployment, and higher latency femtocell-to-femtocell handover procedure have to be solved.

The handover (or handoff) approaches in wireless networks are classified by different classes based on the main factor used to formulate the handover decision. The main factor can be considered as the power level handover (PLH), user population handover (UPH), bandwidth handover (BWH), and fuzzy logic handover (FLH) [4]. In the case of LTE networks that are based on macro-femtocell topology, there are three types of femtocell handover, namely, 1) inbound- the handover occurs from the macrocell to the femtocell; 2) outbound- the handover occurs from the femtocell to the macrocell; 3) femtocell-to-femtocell- the handover occurs between one femtocell and another femtocell close by.

The basic difference between the macrocell and the femtocell is the respective backhauls. According to the current implementation, the femtocell backhaul is simply an interface to the mobile core network (MCN) through the public internet network, while the macrocell backhaul is a dedicated line to the MCN. In practice, it takes less than 100 ms for a handover process between macrocells [5], but the required time to transmit a single message via the public internet network could be over 200 ms which leads to slowly femtocell-to-femtocell- handover process (high delay). Owing to the small size of femtocell in comparison with the size of macrocell the number of handovers (handover frequency) will be increased, especially, for fast moving user equipment (UE). Thus, the UE has more difficulties to stay connected with the fast passing femtocells.

Recently, many suggested ideas about the femtocells handover are considered as important contributions toward the possible solutions, for example, the proactively triggering handover procedures by predicting mobility of users [6], reducing the scanning time to identify associable femtocells by catching the recently visited cell records or information [7], and reducing the unnecessary handovers by modifying the architecture and signal flow [8,9]. As was shown in [10], the UEs are classified into two modes based on the speed to insert the UE velocity in the handover decision function to apply the fast handover based on prefetch process. The first mode is called the swift mode, when the UE speed is higher than a pre-defined threshold. Thus, the UE is moving too fast spending a short time in the femtocell range. The second mode is called the free mode. That means the handover decision function allows a UE to handover to a femtocell only if it belongs to the free mode. The approximate UE speed is estimated based on measurement reports sent by UE. The femtocell-to-femtocell handover is carried out based on parts of the legacy handover process that are segregated to prefetch high layer data to all home evolved node Bs (HeNBs) in the proximity of the UE.

This paper deals with a proposed femtocell-to-femtocell handover approach constructed based on, firstly, a simple feedback technique from the UEs to the HeNBs, and secondly, a femtocell-to-femtocell interface that allows us to exchange the initial priority lists of UEs created by each HeNB, and helps the HeNBs to handle the handover procedure between femtocells and to balance the load also. This handover approach works appropriately with all femtocell access modes, namely, closed, open, and hybrid.

The reminder of the paper is arranged as follows. Section II presents the macro-femtocell network structure and the legacy femtocell-to-femtocell handover procedure. The proposed feedback technique and the femtocell-to-femtocell handover approach based on a distributed collaborative mode are introduced in section III. The simulation results are presented in section IV. Finally, the conclusion remarks are discussed in section V.

II. Macro-Femtocell Network Structure and The Legacy Handover Process

A. *Marco-Femtocell Structure*

In general, there are two main possible structures for macro-femtocell in LTE networks. These structures are shown in Fig. 1. One option has the home eNB (HeNB) interfacing directly with the mobility management entity (MME) and serving gateway (SGW) in the LTE network evolved packet core (EPC) via the interface S1 (eNB-Core Network). The second option has the HeNB interfacing through the HeNB gateway (HeNB-GW) which has a direct interface with MME/SGW emulating the wideband code division multiple access (WCDMA)/high-speed packet access (HSPA) femtocell architecture standard.

The base station router (BSR) of the femtocell or the HeNB concept combines all functions of a radio access network and core network in a single network element, for example, NodeB, radio network controller (RNC), serving general packet radio service (GPRS) support node (SGSN), and gateway GPRS support node (GGSN) [11].

B. *Legacy Femtocell-to-Femtocell Handover Procedure*

Any UE periodically scans and examines all available channels or PRBs in order to measure the signal power and reports the measurements that are a feedback to its associated eNB or HeNB in a report message. A handover procedure is triggered by a positive handover decision which is happened every time when the measurement report (or the feedback) suggests that the best signal received by the UE is not from the current HeNB but from another HeNB (the UE is not associated with this HeNB). When the current HeNB (C-HeNB) in the femtocell makes a positive handover decision, it sends a handover request message to the target HeNB (T-HeNB) which is the femtocell that the UE is to be handed-over to via the mobility management entity (MME). Then the T-HeNB performs an admission control for the UE and responds with a positive handover response message. When the C-HeNB receives the handover response, it sends the handover command to the UE. After that the UE disconnects or detaches from the associated femtocell and tries to handover to the new femtocell (T-HeNB). The handover decision is completely independent of the speed of the mobile UE unlike the handover procedure in [10]. In this paper, the proposed handover approach is also independent on the UE speed.

III. Feedback Technique and the Handover Approach

There is a universally adopted standard that every eNB is assigned by a signature sequence called the physical cell ID (PCI).

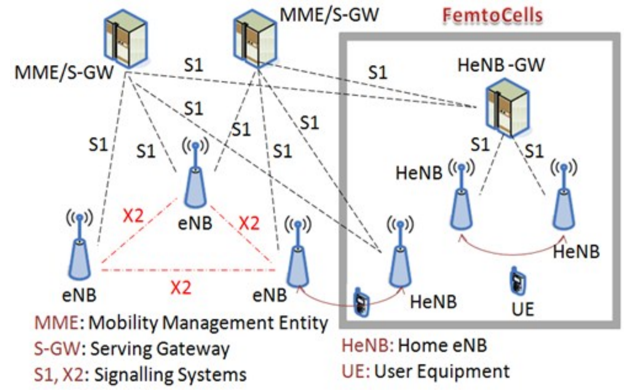

Figure 1. Macro-femtocell LTE Structure.

According to the LTE standards (3GPP TS 36.211-840), there are approximately 504 unique physical layer cell identities grouped into 168 unique physical layer cell identity groups and each group consists of three unique identities. The PCI of any eNB can be constructed based on primary and secondary synchronizing IDs as follows [12]:

$$PCI = 3ND_{ID}^{(1)} + ND_{ID}^{(2)}, \qquad (1)$$

where $ND_{ID}^{(1)}$ covers the range 0~167 representing the physical layer cell identity group, and $ND_{ID}^{(2)}$ covers the range 0~2 representing the physical layer identity within the physical layer cell identity group (PCI planning). By the same way, a closed subscriber group identity (CSG id) is adopted for femtocells identification in the LTE network. A closed subscriber group (CSG) describes a limited set of users (UEs) with connectivity access to a femtocell. Three major access modes to the femtocell are supported by this feedback scheme. In the closed mode, only UEs included in the femtocell access control list are allowed to use the femtocell radio resources. The femtocell can also operate in open access mode, in which any UE is permitted to access to the femtocell. The hybrid access mode allows all the UEs to access the femtocell, but UEs belonging to the CSG are entitled to access with priority. The UEs can obtain the CSG ids by different methods, for example, CSG id distribution methods when CSG ids are provided to the HeNBs from the operation and maintenance (O&M) centre and then broadcast them to the UEs. Each UE stores and keeps operations to update the information about eNB (PCI) and CSG ids.

A. *The Proposed Feedback Technique*

In the macro-femtocell network topology, the HeNBs receive a feedback from the UE (see Fig. 2). This feedback presents one among predetermined values for a specific network parameter, namely the effective signal-to-interference and-noise ratio (SINR). All these values are well known by the UEs, eNB, and HeNBs [13].

The feedback values are obtained as quantized versions of the estimated effective SINR defined by performing nonlinear averaging on the available PRBs or scheduling blocks (SBs) in the sub-band of the femtocell as follows:

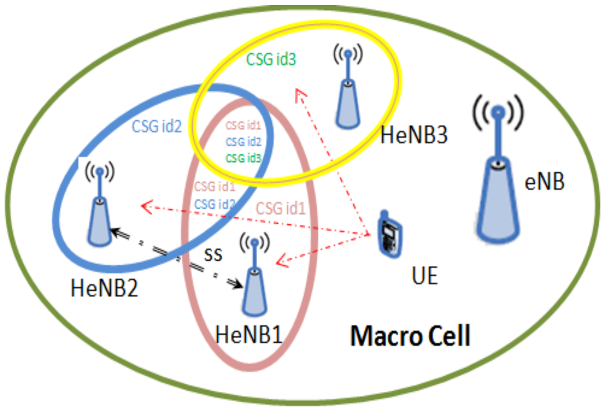

Figure 2. UE sends feedback to multiple HeNBs.

$$\delta = SINR_{eff} = -\beta \ln\left(\frac{1}{K}\sum_{i=1}^{K} e^{-\frac{SINR_i}{\beta}}\right) , \quad (2)$$

where K is the total number of the sub-carriers to be averaged, β is a parameter calibrated by means of link level simulation to fit the compression function to the block error rate defined in additive white Gaussian noise (AWGN), and $SINR_i$ is the signal-to-interference-and-noise ratio of the *i-th* UE computed for each *j-th* SB and determined as:

$$SINR_i = \frac{P_{R,i,j}}{(FN_0 B) + I} , \quad (3)$$

where F is the noise figure (default value is 2.5), N_0 is the noise power spectral density (default value is -174 dBm), B is the bandwidth of the resource block (for SB is 180 kHz), $P_{R,i,j}$ is the received power of the *i-th* UE for the *j-th* SB depending on the propagation loss model and the explored wireless channel model under simulation, and I is the interference representing the total power received from the HeNBs that share the same frequency resources. In the proposed scenario, it is possible to relate the number of feedback bits (n) that present the quantized value of the $SINR_{eff}$ and form the feedback indicator (FI) and the number of the femtocells. At the same time, we can assume that any UE sends feedback to multiple femtocells related to the same eNB simultaneously (Fig. 3). This relation can be presented in the following form:

$$N_{femto} = 2^n , \quad (4)$$

where n is the number of the feedback bits, and N_{femto} is the number of the femtocells belonging to the same eNB and including in the UE white list. For example, if $n = 1$, the UE should sent feedback to two HeNBs or femtocells.

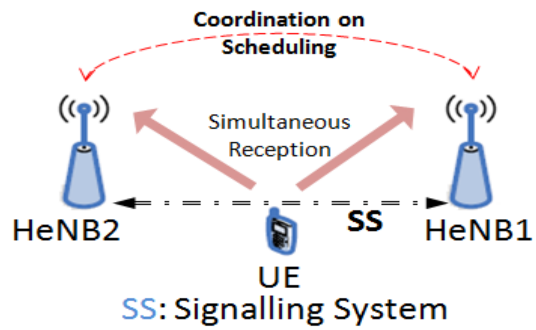

Figure 3. Simultaneous feedback reception.

B. *Proposed Femtocell-to-Femtocell Handover*

This feedback scheme leads to automatic selection of the serving femtocell representing a specific CSG from the UE white list and helps the HeNB to update its priority list and reschedule the SBs assuming that all the HeNBs in the UE white list receive the feedback simultaneously. These HeNBs exchange the signalling information via the signalling system SS (femtocell-to–femtocell interface) to run the collaborative mode to process the handover operation between the femtocells for a moving UE. The UE velocity does not play any role.

The femtocell-to-femtocell handover approach discussed in this paper consists of two operation levels. The first level is applied locally in each HeNB of the related femtocell to create a list of UEs sending feedback that would be served in the upcoming time transmission interval (TTI). Some of these UEs have been served by the same HeNB in the previous TTI. In this list, the UEs are ranked by ascending arrange of the FIs. The second level is applied between the femtocells in order to exchange the lists created by each HeNB from the first level. Every HeNB sends this initial list to other HeNBs in the same macrocell and receives back the initial priority lists from other HeNBs via the SS. After that, each HeNB creates the final version of UEs list based on completion of comparison between local UEs list and the received lists from other HeNB to drop and update the positions of UEs in the final list. The changes take place only for the UEs appeared in more than one list or belonged to more than one CSG.

Thus, if one UE has the same position in the priority lists of two HeNBs, it is stored in the list of the HeNB in the case if this UE was served by the same HeNB in the previous TTI (no handover), and dropped from the other list. If the UE has two different ranks in the priority lists, it must be dropped from the list of the lower priority position (lower FI). Thus, if this UE was served by the HeNB possessing the highest FI, the UE should be served by the same HeNB and the handover is not needed. In the case if the UE was served by the HeNB with lower FI, it must be served by the other HeNB and the handover is performed. The handover process of the UE among the HeNB is carried out using the presented collaborative mode of the proposed UEs feedback.

For simplicity, we study the scenario when we have two HeNBs (HeNB1 and HeNB2) and the number of active users $N = 6$ to explain clearly the simple handover approach

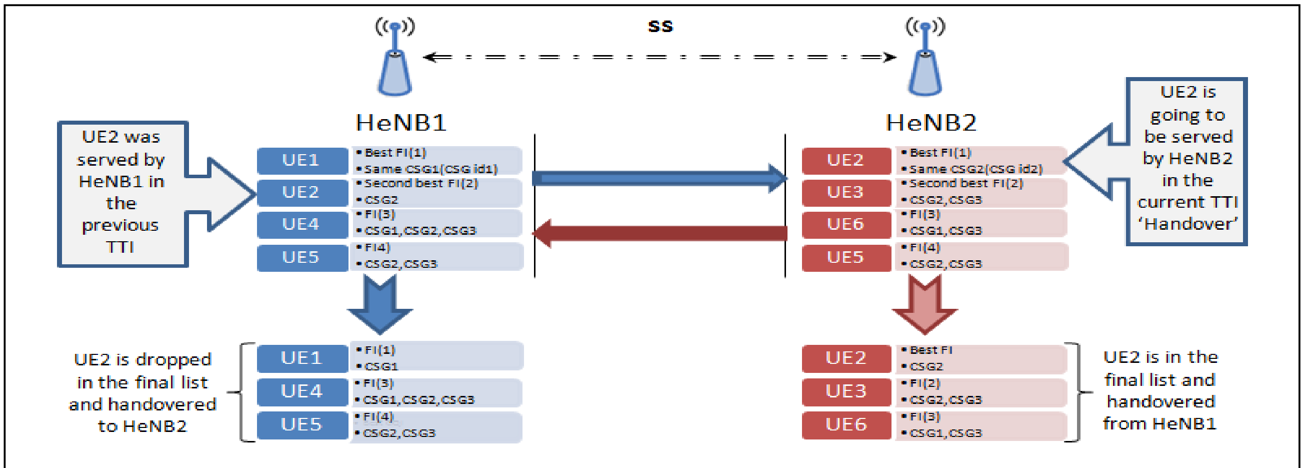

Figure 4. The handover approach.

(Fig. 4). The UEs send feedback to two different femtocells with different FI values. In the current TTI, when each HeNB has to schedule the available radio resources, HeNB1 puts UE2 in the second position in the list according to its FI. It is known that UE2 was served by this HeNB in the previous TTI. Thus, we consider the HeNB1 as C-HeNB. On the other hand, HeNB2 puts UE2 in the first position in the priority list because UE2 has high FI for this HeNB. The HeNB1 and HeNB2 exchange the priority lists and each HeNB compares the created list with the received one. HeNB1 will drop the UE2 from the list because it has the better position in the received list. In this case, the handover is needed to the HeNB2 which is considered as T-HeNB. The handover process should be fully automated without any need for handover control messages if the other factors, namely, the load balance, the interference management, and PRBs scheduling are not to be considered in the handover approach. If there is a need for handover control messages, for example, handover request, handover response, etc, the interface between the femtocells (SS) can handle these messages.

The case concerning the UE5 (see Fig. 4) is interest for us because it has the same ranking in both lists. If UE5 was served by HeNB1 in the previous TTI, there is no need to handover and HeNB1 continues to serve UE5. In the case when UE5 was served by HeNB2, there is a handover from HeNB2 to HeNB1, since HeNB2 knows that the number of UEs served by HeNB1 will be less if UE5 service is continued. Thus, the last positive handover decision is made for load balancing between these two HeNBs. In the case of open access mode, if UE5 is a new user for both HeNBs, there is no handover and HeNB1 decides to serve the UE2 to have the same number of UEs as HeNB2. This problem can be solved when more strict regulations about feedback are applied as in (4) when the number of feedback bits n defines the maximum number of femtocells for which any UE can send feedback. Thus, UE should send different feedback values to different femtocells. In this case, UE5 will send feedback only to HeNB1 or HeNB2 and not both of them since the FIs values are the same.

It is important to note that the transmitted signal power defines the femtocell coverage area and has an impact on the interference, the handover process and signaling, and the UEs service off rate. In the downlink, the pilot signal power and the maximal transmit signal power used to limit the interference must be configured. In the proposed approach, the pilot signal power and the number of feedback bits for FI affect the performance of the handover procedure. The pilot signal power defines the femtocell range. Thus, for any moving UE with random initial position in the coverage area of multiple femtocells, the number of HeNBs in the UE white list varies from one position to another. The femtocell transmit power P_{femto} has an average value equals to the power received from the closest macrocell at the target cell radius r subjected to maximum power $P_{\max}$. The femtocell transmit power is defined in the following form:

$$P_{femto} = \min(P_{macro} + G(\theta) - L_{macro}(d) + L_{femto}(r),\ P_{\max}) \ , \quad (5)$$

where P_{macro} is the transmit power of the sector in which the femtocell is located, $G(\theta)$ is the antenna gain in direction of the femtocell where θ is the angle to the femtocell with respect to the sector angle, $L_{macro}(d)$ denotes the average macrocell path loss at the femtocell distance d excluding any additional wall losses, and $L_{femto}(r)$ is the line of sight path loss at the target cell radius r excluding any wall losses and given by

$$L_{femto}(r) = 38.5 + 20log_{10}(r) \ . \quad (6)$$

IV. Simulation Results

According to the standards (TS36.213, V8.2.0), the UE shall perform periodic and aperiodic feedback. A single channel quality indicator (CQI) corresponds to an index pointing to a value in the CQI table. The CQI index is defined in terms of a channel coding rate value and modulation scheme. Table 1 shows the corresponding parameters to each CQI index (4-bits CQI table).

TABLE I. 4 BITS CQI TABLE.

CQI Index	Mod	Coding rate X 1024	Efficiency
0	Out of Range		
1	QPSK	78	0.1523
2	QPSK	120	0.2344
3	QPSK	193	0.3770
4	QPSK	308	0.6016
5	QPSK	449	0.8770
6	QPSK	602	1.1758
7	16QAM	378	1.4766
8	16QAM	490	1.9141
9	16QAM	616	2.4063
10	64QAM	466	2.7305
11	64QAM	567	3.3223
12	64QAM	666	3.9023
13	64QAM	772	4.5234
14	64QAM	873	5.1152
15	64QAM	948	5.5547

In LTE networks, the adaptive modulation and coding (AMC) have to ensure a block error ratio (BLER) value that is smaller than 10%. Thus, the signal-to-noise ratio SNR and CQI mapping (SNR-CQI mapping) is required and can be obtained by plotting the BLER curves and choosing the SNR values corresponding to BLER-10%. Fig 5 shows the mentioned BLER and SNR curves.

By the same way, for the proposed feedback scheme and the handover approach, it is possible to obtain a SINR-FI mapping model based on the calculation of the effective SINR as in (2) ($SINR_{eff}$) for a specific femtocell transmit power (P_{femto}) and then create the SINR- FI mapping model. Fig. 6 presents a simple example for the required mapping when the number of bits $n=3$ and maximum $SINR_{eff}$ value is 3 dB.

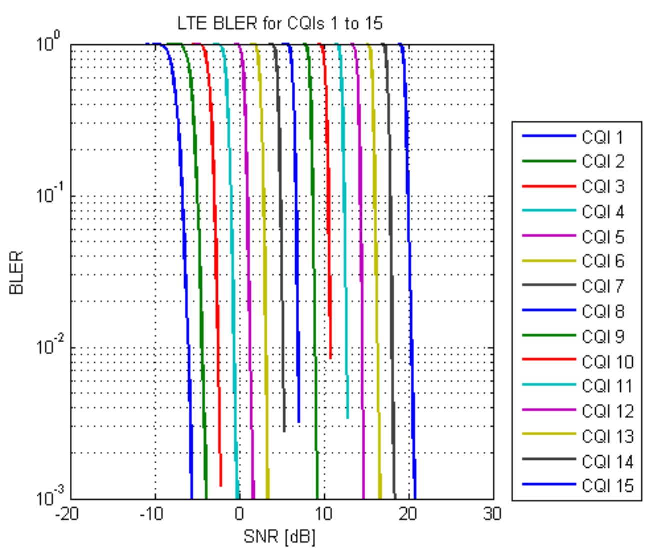

Figure 5. LTE BLER for CQI mapping.

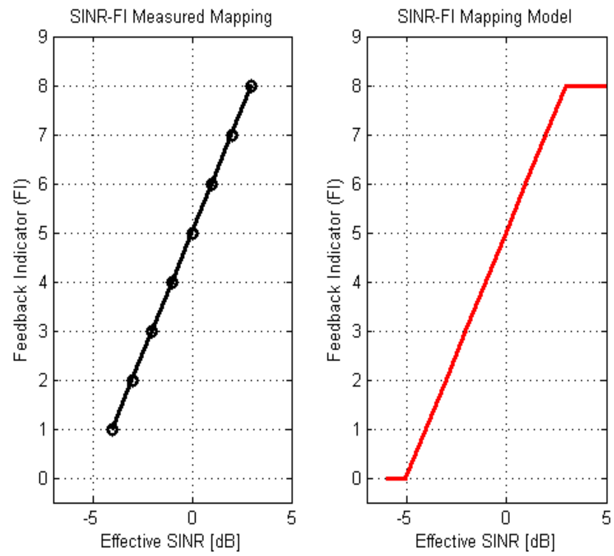

Figure 6. LTE BLER for CQI mapping.

The simulation results for the collaborative handover and signalling model with the suggested power assignment method as in [14] are presented in case when the number of femtocells $M = 6$, the number of users $N = 30$, and the target signal--to-interference-and-noise ratio $SINR = 3\,dB$ with and without the collaborative mode between the femtocells (Fig. 7). When the collaborative mode is not applied between the femtocells (HeNBs), there are some service off UEs. In the case of the collaborative mode, all the UEs are served. Thus, the proposed feedback scheme and femtocell-to-femtocell handover approach helps us to reduce the number of service off UEs.

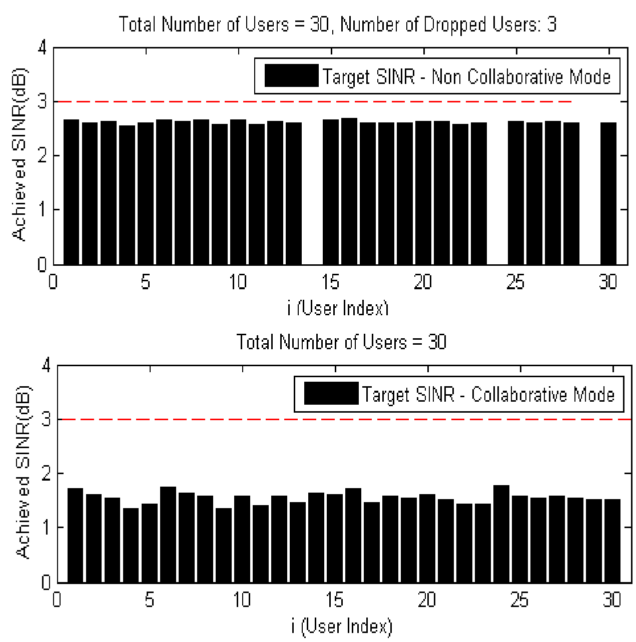

Figure 7. Collaborative handover mode performance.

V. CONCLUSIONS

Recent studies show that the majority of mobile voice and data usage is indoors. Thus, the implementation of femtocells in the LTE networks enhances the data rates for users, extends and improves effectively the system coverage, increases the whole network throughput, and brings the network closer to the users. For large scale and high density deployment of femtocells, many serious problems have to be considered, namely, the femtocell-to-macrocell, the macrocell-to-femtocell, and the femtocell-to-femtocell interference, the femtocell converge problems (gap and overlapping), and the handover between the macrocell and femtocells as well as the handover between femtocells.

The legacy femtocell-to-femtocell handover procedure uses the femtocell backhaul which is an interface to the MCN through the public internet network. The required time to transmit a message via the internet network is high in comparison with the required handover process between macrocells (this time can be over 200 ms). The small size of the femtocells leads to more frequent handovers for moving UE, in addition to the fact that handover control messages are sent via public internet. All these factors make the handover procedure slow and not efficient for fast UE mobility. As a result, the modifications of femtocell-to-femtocell handover are needed.

Since the optimization of the handover procedure will improve the performance of the LTE network, the proposed femtocell-to-femtocell handover approach with the simple feedback scheme helps us to speed up the handover process, to manage the load between the femtocells, to overcome the drawback of using the slow public internet paths, to enhance the self optimization and self configuration capabilities, and can be integrated with radio recourses scheduling and power allocation techniques. The assumed interface between femtocells in the absence of specific standardized features can be completely over the air (wireless link) or fast wired link between HeNBs (like X2 link). This interface makes the signalling between HeNBs fast, easy, and more efficient regardless to UE velocity.

Further improvements can be achieved with respect to the proposed handover approach by interference management, load balancing, and many other aspects.

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