Dynamic Group PCI Assignment Scheme

Xu Zhang[1], DiBin Zhou[2],Zhu Xiao[3] Enjie Liu[1], Jie Zhang[1] and Andres Alayon Glasunov[4]
[123]Institute for Research in Applicable Computing, [4]Electromagnetic Engineering
[1]University of Bedfordshire, [2]Hang Zhou Normal University, [3]Hunan University, [4]School of Electrical Engineering
[1]Luton, UK, [2]Hang Zhou, China, [3]Chang Sha, china,[4]Stockholm, Sweden
Email: [1][xu.zhang1,Enjie.Liu, Jie.Zhang]@study.beds.ac.uk, [2]dibinz@zju.edu.cn, [3]zhxiao@hnu.edu.cn,[4]aag@ee.kth.se

***Abstract*—The Physical Cell Identity (PCI) is used to identify femtocell in LTE femtocell as the physical layer identity. Due to the fact that a) the PCIs are normally allocated without planning; and b) the limitation of the number of PCI, the cross-tier PCI confusion problem has arisen. The current solution in 3GPP Release 9 is to use Cell Global Identity (CGI) associated with PCI to solve this problem of confusion. However, using CGI has many serious drawbacks. Especially CGI might cause the inbound-handover is failure. In order to mitigate the CGI problem, this research proposes a dynamic PCI assignment scheme of DG-PCI in the macrocell and femtocell environment. The proposed scheme is tested by using system-level simulation. The simulations showed that the approach offers an optimal PCI distribution between macrocell and femtocell. The test showed that the CGI problem can be solved, and hence increase the successful rate of inbound-handover.** [1]

***Index Terms*—PCI, CGI, LTE femtocell, Graph Colouring, PCI release**

I. INTRODUCTION

A femtocell is a small cellular base station used by operators to extend indoor service coverage and enhance overall network performance. Since 2008, it has gradually become a mainstream technology supported by industrial standardization bodies such as the 3rd Generation Partnership Project (3GPP). As a consequence, an explosive deployment has been anticipated by industry leaders, which pose new challenges [1].

In the LTE femtocell systems, the Physical Cell Identity (PCI) is used by User Equipment (UE) to identify a femtocell. Unfortunately, the number of PCIs is limited to 504 and they are normally allocated without planning and network operator intervention. Reflecting this, the PCI assignment problems which are called single-tier PCI collision and confusion (conflict) have recently been addressed for LTE network [2][3]. In LTE femtocell system, if a large number of femtocells are deployed under a macrocell coverage area and there are more than one femtocell-neighbour cells assigned with the same PCI due to PCI reuse, the network is unable to identify the femtocell in the measurement report. This may cause inbound-handover (handover from macrocell to femtocell) preparation to be directed to a wrong target and results in handover failure [4]. This is called cross-tier PCI confusion. Moreover, the PCIs reuse in femtocell identification is very common and the cross-tier PCI confusion problem could potentially become quite destructive.

The remainder of this paper is as follows. Section II introduces some related work on PCI allocation; Section III introduces the proposed approach and some useful definitions; Section IV gives the scheme discussion and also proposed a method as Unutilised femtocells PCI release; Section V is the performance evaluation for the scheme. In Section VI, we have the conclusion.

[1]Our work is supported by the Fundamental Research Funds for the Central Universities (531107040276) and State Key Laboratory of Integrated Services Networks Open Project (ISN12-05).

II. RELATED WORK

Some related works are described as below:

A. Review on the Latest Standardisation

In order to solve the cross-tier PCI confusion, a Cell Global Identity (CGI) has been proposed to identify the cells in 3GPP release 9[5]. This approach temporarily solves the cross-tier PCI confusion problem. However, compared to PCI, using CGI has many serious drawbacks.

Firstly, PCI is a reference signal sequence which means that the UE reads the identity of the target cell in a very short time - up to 20ms in LTE. Yet, CGI is not a reference signal sequence, and it needs to be obtained by reading the system information which requires a large measurement time gap (e.g., up to 160 ms (milliseconds) for LTE) [5][6].

Secondly, during this relatively long measurement gap (e.g. 160ms), the UE cannot receive or transmit any data to or from the serving cell, thus, it probably leads to unnecessary service interruption, such as a call drop in the situation where the signal strength fades rapidly [5]. This becomes more critical in a busy and dense network scenario and causes many handover failures [7].

Lastly, a long measurement time is required to obtain the system information which causes concerns regarding the UE battery life[4]. The UE battery life is important for battery-hungry multimedia applications.

It is therefore preferable to use PCI rather than CGI to identify cells. However, as mention previously, the PCI has a conflict problem. This research aims to solve the drawbacks of CGI and meanwhile, mitigate PCI conflict in the cross-tier network environment, with co-existence of macrocell and femtocell.

Copyright (c) IARIA, 2011. ISBN: 978-1-61208-140-3

B. Review of the Literature

In [8], the authors proposed a solution for PCI conflict problem in single-tier LTE networks. A Graph Colouring-based mathematical method has developed for the PCI auto-configuration of LTE network. Each nodes ID (PCI) is assigned a color, and the neighboring nodes get different ID based on graphic coloring theory.

In [2], the authors proposed to use mobile measurements to update the Neighbour-Cell-List (NCL) in single-tier LTE networks, in order to detect PCI conflict. The solution proposes that if the PCI conflict appears, the mobile send this information to Core Network (CN) and Operation Support System (OSS) will require the involved conflict cells to change their PCIs.

In the above papers, the authors analysed the PCI conflict issue in single-tier LTE system. However, none of them have included the impact of the layered structure of a heterogeneous network with a combination of macrocell and femtocell (cross-tier network) on the PCI auto-configuration.

In [9], the authors proposed an automation PCI allocation system (APCIAS) and APCIA method to allocate the PCI in a cross-tier LTE networks in order to reduce the planning time of PCI. In the paper, the researchers used the cell information which includes cell state information, type information and neighbour list information to create the PCI resource and also allocate the PCIs.

In [10], the authors proposed an automatic assignment of femtocell PCIs depending on different access modes for network optimization in order to reduce the operational expenditure for PCI allocation. The proposed scheme autonomously detects the neighbour cells of target femtocell and sends the neighbourhood information to the centre controller. By using a centre controller, the PCIs can be assigned in an optimal way.

In [6], the authors proposed an approach to reduce the time spent on femtocell cell selection/reselection. This approach uses two groups of PCIs, a femtocell group which is a reuse-PCI-group and a macrocell group which is a unique-PCI-group When the UE moves into a new marcocell service, it automatically obtains the network information of this macrocell, which sets certain PCI numbers for macrocell and femtocell. During the handover process, the UE easily detects whether the target device is a marcocell or a femtocell by using this informations and leading to a reduction in unnecessary signalling with the CN and identification time.

In the above papers, the authors proposed the cross-tier PCI allocation scheme. However, none of them solve the cross-tier confusion problem.

III. DYNAMIC GROUP PCI ASSIGNMENT SCHEME

This scheme is described as below:

A. Busy Femtocell

In Dynamic Group PCI Assignment Scheme (DG-PCI), the traffic density information is the most important features to describe the network situation. Busy Femtocell (BFemtocell) concept is introduced to describe this. The principle of this concept is that there might be some femtocells which have a higher numbers of inbound-handovers than others during the same time period. For the operators, more attention should be paid to these BFemtocells in order to maintain a high quality of service since they have a potentially higher probability to be involved in cross-tier PCI confusion and result in handover failure due to CGI drawback.

B. Dynamic PCI Group Assignment

In the proposed DG-PCI, PCIs are categorised into three groups - CSG group (Closed Subscriber Group), non-GSG group, and marcocell groups. Furthermore, in CSG and non-CSG groups, PCIs are further categorised into two sub-groups - unique and reuse group, shown in Fig. 1. The PCIs are set according to their group and sub-group, it would be updated depending on the various environments.

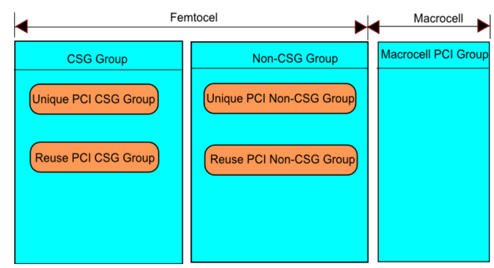


Fig. 1. Proposed Dynamic PCI Group Structure

Since this dynamic PCI group method is similar to the profile of proposed the PCI distribution in [6] and [11], it inherits their advantages such as the fast CSG cell, non-CSG cell and macrocell selection/reselection.

The unique PCI group is used to offer unique PCI to BFemtocells. As we know cross-tier PCI confusion may happen when reusing PCIs under the large range of macrocell service, thus, if an approach guarantees unique PCIs being allocated to femtocells, there will be no confusion in inbound-handover. For obvious reason, it is sensible to offer the unique PCI to BFemtocells whenever the system has unique PCI available.

C. The Scheme used for Different Access Policys

3GPP defined three types of cell access modes: closed, hybrid and open mode. The following section discusses applying the scheme in different access scenarios.

1) The cross-tier confusion case in different access modes:

a) For the closed and hybrid access modes: Cross-tier PCI confusion occurs as follows: during inbound-handover, after UE has determined that this cell is a closed or a hybrid cell, the UE needs to obtain the PCI of the target femtocell to achieve handover. Since there might be multiple femtocells within the coverage of the Serving Radio Network Control (SRNC) that have the same PCI ID,cross-tier confusion may occur.

Copyright (c) IARIA, 2011. ISBN: 978-1-61208-140-3

b) For the open access mode: Cross-tier PCI confusion occurs as follows: during the inbound-handover, after the UE has determined that this cell is an open cell, the UE needs to obtain the PCI of the target femtocell to achieve handover. As the femtocell with open access mode operates just like a normal LTE cells, these cells' PCI could be included in NCL of the macrocell. There might be multiple same femtocell PCI within the NCL of the macrocell which involve the cross-tier confusion issue.

c) Comparing these confusion cases in different modes: Three modes contain almost the same process involving the PCI confusion by using the same PCI. Therefore, giving a unique PCI to identify BFemtocells in order to mitigate the drawbacks of CGI is fit for both of the confusion cases.

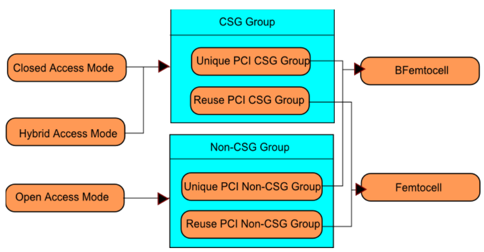


Fig. 2. PCI Distribution in femtocell PCI Group

2) The PCI IDs in different access modes distribute in CSG/non-CSG sub-groups:

a) According to release 9, the System Information Block Type1 (SIB1) uses two parameters: CSG-Indication and CSG-Identity: The closed mode cells have a CSG-Identity and CSG-Indication bit set to TRUE, hybrid model cells have a CSG-Identity and CSG-Indication bit set to FALSE, open mode cells do not have the CSG-Identity and CSG-Indication bit set to FALSE.

b) The PCI IDs in different access modes distribute in CSG/non-CSG sub-groups: Since the CSG-Identity ID involves using the PCI ID [14] and both of the hybrid and close cell mode support CSG-identity ID, closed and hybrid access mode can be treated as the same CSG group, using the set range of PCI IDs (CSG-identity ID). The open access mode is called non-CSG-group also using the set range of PCI IDs (CSG-identity ID). Moreover, there are two sub-groups in each CSG-group/non-CSG group, the PCI in unique PCI sub-groups is used in identification of the BFemtocell which may be CSG or non-CSG mode in order to mitigate the drawbacks of CGI, and also the reuse PCI sub-group is used in identification of the normal femtocell which may be in CSG or non-CSG mode as shown in Fig. 2.

D. The Proposed Scheme

The DG-PCI Flow Chat is shown in Fig. 3.

In the graph, $P_{CSG-unique}$ is the number of unique PCIs for CSG cells; $P_{CSG-reuse}$ is the number of reuse PCIs for

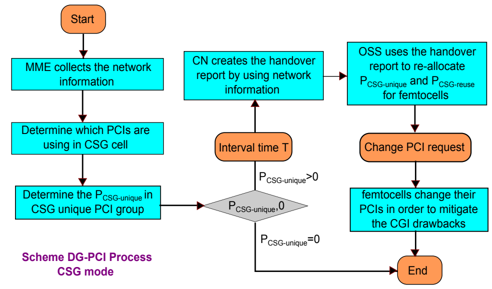


Fig. 3. DG-PCI Flow Chat

CSG cell. Since non-CSG and CSG have most of the same PCI confusion mentioned early, the process in the proposed scheme for non-CSG and CSG cell scheme can be considered the same process. The author provides the CSG mode flow chat of the proposed scheme process instead of the chat of both the non-CSG and CSG mode.

IV. DISCUSSIONS OF THE PROPOSED SCHEME

In this section, we will analyse some important issues for DG-PCI.

A. Determination of the BFemtocell in LTE Femtocell System

In a real network scenario, the handover procedure is associated with the Mobility Management Entity(MME). During the inbound-handover, severed femtocell PCI or CGI information is stored in MME. Due to the fact that PCI is dynamically allocated and CGI is statically allocated, in order to ensure the data on the list is available at any time, it is desirable to use CGI ID for data recording.

MME is connected with a Home Subscriber Server (HSS), which is responsible for femtocell management, authentication and authorization, the mapping of PCI to the unique CGI and the NCL of each femtocell could be obtained from them [12]. This CGI list will be build by using HSS in order to find the corresponding CGI ID depending on the temporary PCI stored in the MME.

After a interval time of T, the MME will send the recorded CGI list to CN. CN will build the BFemtocell list (Inbound-Handover Report) according to the CGI list and permit OSS [2] to send the updating PCI request to the BFemtocell.

B. Graph Colouring-Based Method in Single-Tier PCI Conflict Free

The number of unique PCIs is quite an important issue in our scheme. The PCI_{unique} is equal to the total number of PCIs take off the PCI_{reuse} and PCI_{reuse} depends on the single-tier conflict. Reflecting this, the PCI_{unique} is relative to single-tier conflict. We support using Graph Colouring-based mathematical for PCI assignment in order to find the minimum ofPCI_{reuse} and also avoid single-tier PCI conflict in cross-tier LTE femtocell. The method is described as below:

Copyright (c) IARIA, 2011. ISBN: 978-1-61208-140-3

```
Begin
    Do Sort the new femtocells in order by which femtocell has the highest nNeighbours
    For (set i=0; i<=Cell_list.size();i++)          // Choose a new cell from the list Cell_list in order;
        Do D_set = function Build_PCIset(Cell_list[i].dNeighbours);
        Do N_set = function Build_PCIset(Cell_list[i].nNeighbours);
        Do NN_set = function Build_PCIset(Cell_list[i].nnNeighbours);
        If   (NN_set\{D_set && N_set}!=null)
            Do P_set=NN_set\{D_set&&N_set};
            Do call function PCI_assinment(P_set);
        Else
            If (U_set\{D_set&&N_set}!=null)
                Do P_set=U_set\{D_set&&N_set};
                Do call function PCI_assinment(P_set);
            Else
                If (A_set\{D_set&&N_set}!=null)
                    Do P_set=A_set\{D_set&&N_set};
                    Do call function PCI_assinment(P_set);
                Else
                    Do process failure;       // PCI run out
        //start loop again;
    End
    Function Build_PCIset(Neighbours)  //function to find the PCI_set for different Neighbours list;
        For (set j=0; j<=Neighbours.size();j++)
            If   (in Neighbours[j], there are some new cells without PCIs)
                Do PCI_set will not collect this cells' PCI;
            Else
                Do  PCI_set collect there PCIs in Neighbours;
        End
        Returen PCI_set;
    Function PCI_assinment(P_set)     //function to assign the PCI to new cell;
        Do Sort P_set in C_PCI descending order;
        Do Select the first value;
        Do PCI assignment success;
End
```

The main idea of this method is that to find the proper PCI IDs in the NN_{set} of the target femtocell. If we find the PCI IDs in the D_{set}, it will result in the single-tier conflict and if we find the PCI IDs N_{set}, it will result in cross-tier confusion. Since the PCI ID are reused to alocate the femtocells, this method could find the minimum of PCI_{reuse}.

TABLE I
PARAMETERS IN PROPOSED METHOD

Name	Meanning
dNeighbours	New cell's direct neighbours
nNeighbours	New cell's dNeighbours' neighbours
nnNeighbours	Neighbours or nNeighbours
A_{set}/U_{set}	All available/used PCI in the network
D_{set}	PCI set of dNeighbours
N_{set}	PCI set of nNeighbours
NN_{set}	PCI set of neighbours of nNeighbours
P_{set}	Result set which PCI is choosing from
PCI_{set}	Number of PCI in target Neighbours list
C_{PCI}	Number of times the PCI is used

C. Dynamic PCI Group using in PCI Assignment

Femtocells are plug-and-play devices, if a new femtocell joins the network, it might interfere with the system balance which would result in the single-tier conflict. Therefore, ideally the PCIs should be able to transfer between different groups to cope with the dynamic number of femtoells. However, the number of PCIs in a marocell PCI group is set at the system level [6], thus this transfer will not be considered in this research. In this sub-section, we will only consider the PCI transfer between unique PCI and reuse PCI group.

Unique PCI transfer to reuse PCI group. If there are not enough reuse PCI to sign new femtocells, the unique PCI group dynamically transfers its PCIs to reused PCI group in order to ensure the network has enough PCIs to remain single-tier conflict free. However, if the unique PCI numbers run out, thats means all PCIs need to be used to ensure the system is conflict free. Unfortunately, our approach does not work in this extreme case, yet this kind of scenario is rare.

Reuse PCI transfers to unique PCI group. When some femtocells are turned off, the number of reused PCIs could be more than the system requested, therefore, some of the reuse PCIs should be released, this will be analysed in detail in the next section.

D. Unutilised femtocell PCI Release Method

The PCI release is the decisive feature to obtain unique PCI resource for scheme DG-PCI. A PCI release method is proposed in this research to tackle this problem.

This method includes unique and reuse PCI released. The unique PCI release method releases the femtocells that have unique PCIs identity. The reuse PCI release is used in dynamic PCI group to release reused PCIs. The proposed PCI release is described as below:

```
Begin
    Do Determing the Femtocell_off list;
    Do Determing the Femtocell_on list;
    For (set i=0; i<=Femtocell_off.size();i++)     // Choose a femtocell from the list
        For (set j=0; j<=Femtocell_on.size();j++)
            Do Set a=true;
            //Check the PCI_c in femtocell_off is used in femtocell_on list;
            If   (PCI_c in femtocell_off[i]==PCI in femtocell_on[j])  // PCI_c is the PCI of choosen femtocell;
                Do break;            //jump out current loop;
            Else
                //Check the PCI_c in Femtocell_off is also used by other members in Femtocell_off;
                For (set k=0; k<=Femtocell_off.size();k++)
                    If   ((i!=k)&&(PCI_c in femtocell_off[i]==PCI in femtocell_off[k]))
                        Do Set a=false;
                        Do break;          //jump out current loop;
                End
            If   (a==false)
                Do break;  //jump out current loop;
            Else
                Do PCI_t = PCI_c in femtocell_off[i];  // PCI_c is the unique PCI
                Do Add PCI_t to List_unique;
        End
    End
End
```

However, there is a problem. If the femtocell is normally in turn off mode, the CN can easily detect this femtocell and also execute the PCI release procedure. If the femtocell is not in normal turn off mode, meaning that the users just unpluged the power socket to shut down the femtocell, it is difficult for CN to identify the femtocell statics and results in a failed reuse PCI release procedure.

In order to solve this problem, ping can be used to check the femtocell status. Since ping transmits in very small packages, it will not cause any large signal overload. The MME could ping the registration femtocells at small constant intervals of time to check their statics and then report to CN.

V. PERFORMANCE EVALUATION

A dynamic simulator developed by CWIND [13] group is used to evaluate the proposed scheme. The goal of the performance evaluation is to see if the proposed scheme mitigates the drawbacks of CGI and improves the inbound-handover quality in a realistic LTE Femtocell network.

Copyright (c) IARIA, 2011. ISBN: 978-1-61208-140-3

A. Simulation Scenario

Since the femtocell is a free plug-and-play device, we have set the scenario based on the number of active (means switched on) femtoells during 24 hours (shown in Fig. 4) which is similar to the human life timetable. Moreover, there is not a femtocell traffic model found in the literature, so, the inbound-handover events are also following the the same pattern, shown in Fig. 5.

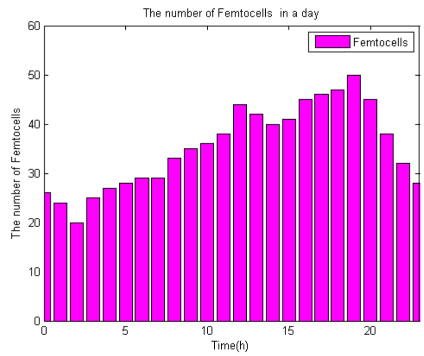


Fig. 4. The Various Number of Femtocells in 24 hours

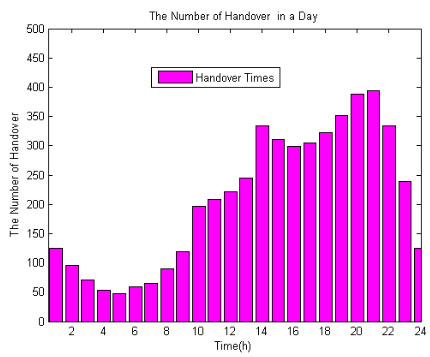


Fig. 5. The Various Number of Inbound-handover Events in 24 hours.

Since this scheme is aiming to reduce the usage of CGI in the handover procedure, the number of CGI readings in an hour is chosen to evaluate the performance of this scheme. In the simulation, the UEs and femtocells will both randomly occur in the coverage of a macrocell (radius: 400 meters). If an UE occurs in the coverage of a femtocell, this UE would be determined as it is doing inbound-handover. Reflecting this, the MME would store the PCI and CGI which are from the serving femtocell and build the inbound-handover List for this network. The PCI updating interval time is initially set to 900 seconds, this time gap will be further analysed in future research. Some parameters are listed in Table II.

Moreover, two types of Femtocell access modes have been set in this simulation, CSG and non-CSG mode. The difference between the two modes is that when an UE has been detected as doing inbound-handover, the CSG femtocells will check if this UE is accessible or not; where as the non-CSG femtocells won't check it. Two distances of femtocell coverage are simulated: 15 and 50 meters. The different values of coverage have impacted on amount of single-tier conflict between neighbouring femtocells, the higher the value of coverage distance, the greater the conflict. Public femtocells such as ones intalled in shopping malls belong to the non-CSG mode and have 50 meters coverage. Residential femtocells install in homes are mostly CSG mode which can serve up to 4 users and have 15 meters coverage, but some non-CSG residential femtocells are also simulated.

The evaluations are undertaken in two cases: Case 1 is a CSG mode only simulation, Case 2 simulates both CSG and non-CSG modes. In Case 1, the number of femtocells is up to 50. In Case 2 , the number of shopping Mall femtocell is 3, the number of non-CSG residential femtocells will increase from 10 to 27 and the number of CSG residential femtocells will increase from 10 to 20.

TABLE II
PARAMETERS FOR SCHEME DG-PCI SCHEME

Parameter	Value
Coverage of macrocell/femtocell	400/15 meters
Coverage of shopping Mall/public place femtocell	50 meters
T	900 Seconds
Number of CSG fetocells (Case 1)	20-50
Number of shopping Mall/public place (case 2)	3
Number of non-CSG fetocells (Case 2)	10-27
Number of CSG fetocells (Case 2)	10-20

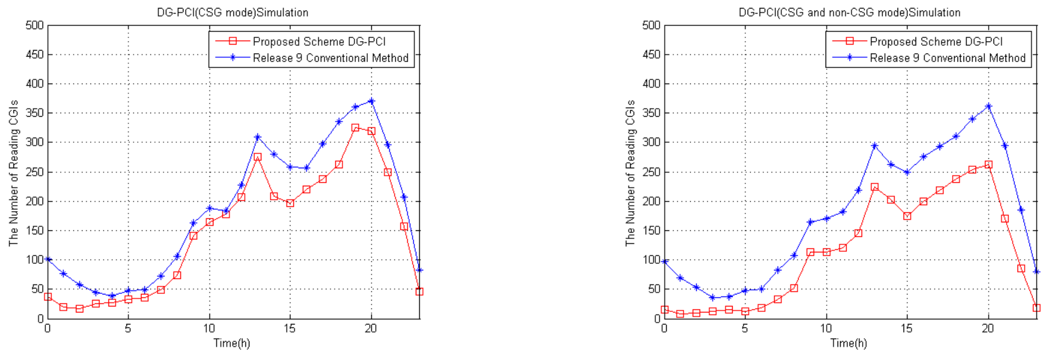
B. Simulation Analysis

As can be seen in Figs. 6a and 6b, across the board, in both cases, the proposed DG-PCI scheme consistently performs better compared to the conventional approach. We also observed that the performance differs according realisticallyto the time of the day. This is due to the fact that, when there are less inbound handovers, the boundary of determining the busy or not busy femtocell is unclear, which results in inaccurate judgement.

From Figs. 7a and 7b, our scheme obviously reduces the number of CGI reading compared to the conventional method. One can observe that the performance does not proportionally increase with the number of femtocells, but with the number of inbound handovers. This is perfectly understandable, because inbound-handover is what we are concerned with regarding to PCI allocation.

Comparing Case1 and Case 2, the performance in case 2 is better than case 1. First, this is due to the number of the UEs that a femtocell supports. In case 1, for home usage, again, the boundaries of busy or not busy femtocell are not clear. Reflecting this, the scheme is more suitable for open access which is currently high favoured femtocell deployment. Second, in case 2, we assigned fixed unique PCI to open access femtocells. Therefore, we suggest that in the reality, the network system should offer some independent unique PCIs for the openly accessed femtocells. We also suggest that unique PCIs could be considered as a commercial resource

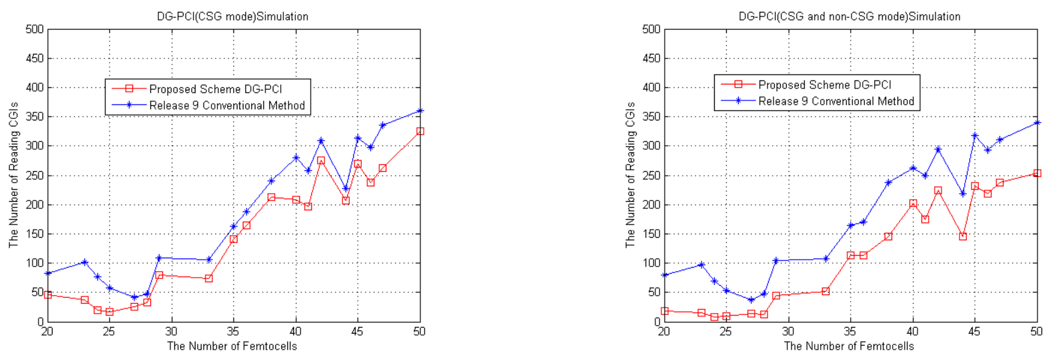
Copyright (c) IARIA, 2011. ISBN: 978-1-61208-140-3



(a) Case I

(b) Case II

Fig. 6. DG-PCI and Rel. 9 simulation based on Time



(a) Case I

(b) Case II

Fig. 7. DG-PCI and Rel. 9 simulation based on Number of Femtocells

which Shopping Malls would need to purchase in order to have better quality of wireless service for customers.

VI. CONCLUSION AND FUTURE WORK

This paper proposed the DG-PCI scheme which based on the concept of the BFemtocell and dynamic PCI allocation and Graph Colouring-based mathematical method to mitigate the CGI problems and avoid cross-tier PCI confusion. The proposed scheme is tested by simulation. The results showed that the approach out-performs the existing approach in: reducing the number of CGI reading, hence reducing the possible of handover disconnection. The approach achieved dynamic PCI allocations in the cross-tier environment.

In terms of the future work, work will be carried out to optimise the PCI allocations, especially for released PCIs. Work will also be carried out on optimising the parameter T, which is the time interval representation of PCI updating, used in the scheme.

REFERENCES

[1] Jie Zhang and Guillaume de la Roche, "Femtocells: Technologies and deployemnt", 1st ed, 2009.

[2] Mehdi Amirijoo, Pal Frenger, Fredrik Gunnarsson, Harald Kallin, Johan Moe and Kristina Zetterberg, "Neighbor Cell Relation List and Physical Cell Identity Self-Organization in LTE", IEEE International Conference on Communications (ICC), pp. 37-41, 2008.

[3] 3GPP TS 36.211 V8.6.0, "Physical Channels and Modulation", 2009.

[4] Assen Golaup, Mona Mustapha and Leo Boonchin Patanapongpibul, "Femtocell Access Control Strategy in UMTS and LTE", IEEE Communications Magazine, Vol. 47, No. 9, pp. 117-123, 2009.

[5] 3GPP TS 36.300, "E-UTRAN Overall Description", 2009

[6] Poongup Lee, Jangkeun Jeong, Navrati Saxena and Jitae Shin, "Dynamic Reservation Scheme of Physical Cell Identity for 3GPP LTE Femtocell Systems", Journal of Information Processing Systems, pp. 207-220, 2009.

[7] David Lopez-Perez, Alvaro Valcarce, Akos Ladanyi, Guillaume de la Roche and Jie Zhang, "Intracell Handover for Interference and Handover Mitigation in OFDMA Two-Tier Macrocell-Femtocell Networks", EURASIP Journal of Wireless Communications and Networking, Vol. 2010, pp. 1-6, 18-21, 2010.

[8] Tobias Bandh, Georg Carl and Henning Sanneck, "Graph Coloring Based Physical-Cell-ID Assignment for LTE networkss", ACM International Conference on Wireless Communications and Mobile Computing (IWCMC), pp. 116-120, 2009.

[9] Ting Wu, LanLan Rui, Ao Xiong and ShaoYong Guo, "An Automation PCI Allocation Method for eNodeB and Home eNodeB Cell", Wireless Communications Networking and Mobile Computing (WiCOM), pp. 1-4, 23-25, Sept. 2010.

[10] Yi Wu, Hai Jiang, Ye Wu and Dongmei Zhang, "Physical Cell Identity Self-Organization for Home eNodeB Deployment in LTE", Nokia Siemens Networks wicom-meeting, pp. 1-6, 2010.

[11] 3GPP TS 25.367, "Mobility procedures for Home Node B (HNB)", 2009.

[12] 3GPP TR 23.830, "Architecture aspects of Home NodeB and Home eNodeB (Release 9)", 2009.

[13] D. Lopez-Perez, A. Valcarce, G. De La Roche, E. Liu, and J. Zhang, "Access methods to wimax femtocells: A downlink system-level case study.", In IEEE International Conference on Communications Systems, pp. 1657-1662, 2008.

Copyright (c) IARIA, 2011. ISBN: 978-1-61208-140-3