A Distance based Physical Cell ID Assignment for Self-Organizing LTE Femtocells

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Abstract

The femtocells, which are small base stations in cellular network, will be deployed randomly and in large numbers; therefore, to integrate themselves in the existing network, it requires them to form a network in a distributed manner, i.e. self-organizing network (SON). In this paper, we propose a distance based physical cell ID (PCI) assignment scheme for LTE femtocells. Because of a number of femtocell base stations, reusing PCI will be inevitable. Our algorithm minimizes the number of used PCIs while removing the collision and confusion between the neighbor cells. Simulation result shows the minimization of used PCIs based on our proposed scheme.

Ⅰ. Introduction

Physical cell ID (PCI) is used to identify a cell physically. LTE standards defines total of 504 unique PCIs [1]. The reference and synchronization signals including primary and secondary synchronization signals are generated from sequences with direct mapping to the PCI [2, 3]. PCI plays an important role at physical layer and it is the first parameter which should be assigned to a base station (BS) before doing any communication with the user equipment (UE).

The LTE network specifications support automated PCI planning as part of self-organizing network (SON) functionality [4]. It is really important for a femto BS (FBS) to have a locally unique PCI. Since the number of PCIs in LTE is limited and these are further divided in smaller groups for use in macro, and femto cells respectively, we need to reuse them properly [5].

The important challenge in automated PCI assignment is that it should be collision and confusion free (jointly referred as conflict free in this paper).

A. Collision free: Two neighboring cells should not have the same PCI as shown in Fig. 1.

B. Confusion free: A cell should not have two neighbors with the same ID as shown in Fig. 2.

In this paper, we propose a centralized algorithm which assigns PCI to FBS based on their location information.

The paper is organized as follows. In Section II, related works are highlighted. Section III describes system model and our proposed PCI assignment scheme. We show our simulation results in Section IV, and conclude in Section V.

Ⅱ. Related Work

The previous works use UE measurements to ensure conflict free PCI assignment. Liu et al. [6] used the downlink eNB receiver to measure the neighbor's signals and then assign PCI in a distributed manner based on consultation between BSs using X2 interface. Bandh et al. [2] used graph coloring method for PCI assignment and minimize the number of used PCIs. In [3], the authors highlighted the problem of PCI for HeNB, and proposed a solution based on the

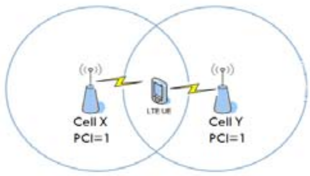

Fig. 1 PCI collision scenario

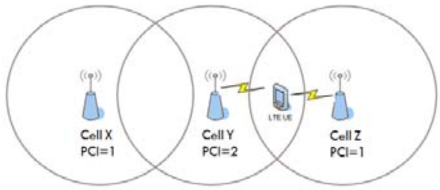

Fig. 2 PCI confusion scenario

downlink receiver measurements. Since the previous works depend on either UE or downlink receiver measurements, they have shortcomings that they are *coverage* or *UE presence* limited. However, our work is based on the geo-location information of the FBS resolving the requirement for measurements and hence reducing overhead.

Ⅲ. System Model and Approach

Femtocell network forms a two tier network with macrocell network representing the other layer. The basic network infrastructure is shown in Fig. 3. We assume that the location of the FBS is known to the system, and femto gateway (FGW) manages operation and maintenance (OAM) information such as identification and location [7, 8].

We also assume a central PCI management server, i.e. FGW manages the whole allocation process. Therefore, our proposed algorithm runs in FGW. We assume that all the FBSs transmit at maximum transmit Power P_{max} and correspondingly have coverage of d_{max}. Any FBS can have many neighbors may be with overlapping coverage area or just tangentially touching each other (like cell A and cell B as shown in Fig. 4). The maximum distance between two farthest neighbors which may cause a PCI collision is $2*d_{max}$.

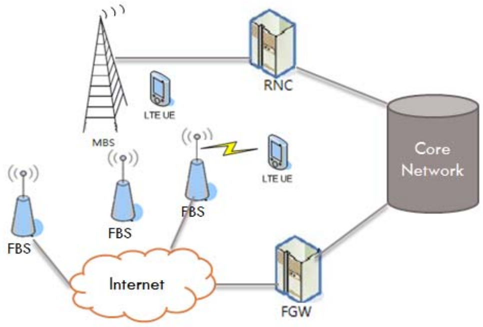

Fig. 3 Femtocell network architecture

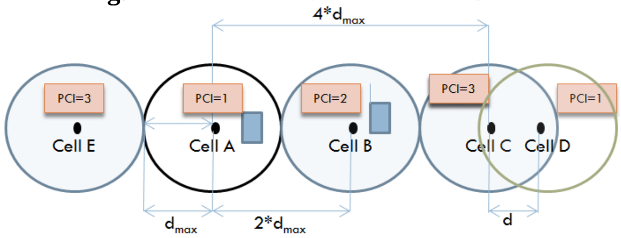

Fig. 4 An example of distance based PCI allocation

Algorithm1: Distance based PCI assignment

Input : newFBS location, P_{max}, Set of reserved PCIs for FBS (R_{PCI}), existing PCIs in the network (PCI)

Output : Assigned PCI of the newFBS (PCI_x)

Function (newFBS, P_{max}, PCI, R_{PCI}):

1. calculate distance, $D=\{d_1, d_2, d_3, \cdots, d_n\}$; for ‘ n’ FBSs
2. for all i,

   if $d_i \leq 4*d_{max}$,

   $U_{PCI} = U_{PCI} \cup PCI_i$
3. $A_{PCI} = [\, R_{PCI} - U_{PCI}\,]$; // Determine available PCIs,
4. if $A_{PCI} \neq \varnothing$,

   $PCI_x = A_i$ where $i = \arg\min_j d_j$

   else,

   $PCI_x = PCI_i$ where $i = \arg\max_j d_i$
5. *Return* PCI_x

We define d as the relative distance between any two FBSs. If $d \leq 2*d_{max}$, the system add them to neighbor list and if $d \geq 4*d_{max}$, they reuse the PCI with a conflict free PCI assignment. In Fig. 4, we can see that PCI, 1 and 3 are reused again when $d \geq 4*d_{max}$.

Our proposed PCI assignment scheme is explained in Algorithm 1. It calculates the relative distances between FBSs and, based on that, finds the used PCIs; hence subtracting the used PCIs from the reserved we may get available PCI set. If there is no PCI available we should reuse a PCI which is the farthest from the new FBS.

Ⅳ. Performance Evaluation

We consider a macro-cellular area of 300 x 300 m and varied the FBS density to observe the number of used PCIs. For the case of 961 femtocells which is dense deployment scenario, only 22 PCIs are used. The result shows that our proposed scheme efficiently reuses PCIs.

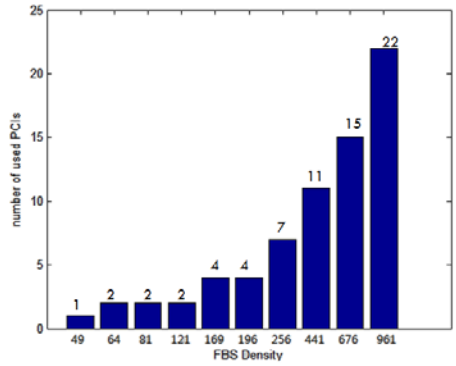

Fig. 5 Number of used PCIs vs. FBS density

Ⅴ. Conclusion

We presented a self-organized PCI assignment algorithm in femtocell networks. Our proposed algorithm is based on geo-location information of FBS. Our results have shown that the proposed algorithm is really efficient in terms of number of used PCIs compared to the density of deployment without generating any conflict.

ACKNOWLEDGMENT

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