Advanced Science and Technology Letters
Vol.134 (ACN 2016), pp.82-86
http://dx.doi.org/10.14257/astl.2016.134.14

A New Resource Allocation Algorithm in LTE-Tier Networks

Jianfei Zhou[1], Na Liu [1],

[1]School of Information Engineering, Chongqing Industry Polytechnic College, Chongqing, China
{fn219, na814}@ qq.com

Abstract. This paper mainly studies the resource allocation algorithm in LTE-A two-tier network. First of all, the research background of LTE-A techniques and Game theory is introduced. Then a distributed algorithm based on coalitional formation Game for femtocell resource allocation and interference management is proposed, which mainly focuses on cooperative strategies to optimize the coalition utility. The simulation shows that this algorithm applies the self-organizing characteristic of the femto base station, and the femtocells choose the optimal cooperators to form coalitions, thus reducing the interference, improving the network capacity and the throughput of the user.

Keywords: LTE-A two-tier network, femto base station, resource allocation, game theory

1 Introduction

The main purpose of LTE-A is to meet the requirements for 4G standard or higher of ITU-R. Also, LTE-A is required to be backwards compatible, which reduce the cost of operators in upgrading the original network [1].

Due to the complex architecture in the two-tier network, the optimization and planning scheme of the traditional network is no longer suitable for the femtocell network. Therefore, we need to study interference coordination mechanism for the femtocell network. In the process of femto base station standardization, the interference coordination scheme research becomes one of the major problems. This paper will study the resource allocation algorithm for femtocell resource allocation and interference management based on cooperative Game.

2 An algorithm for resource allocation

The previous section summarizes the application of resource allocation algorithms based on Game theory in the wireless communication network; however, some disadvantages still exist in these algorithms. Aiming at these disadvantages, we put forward a resource allocation and interference management algorithm based on cooperative Game, mainly to reduce the downlink interference of the femto base

ISSN: 2287-1233 ASTL

station from its surrounding users, ensure the QoS and improve the spectral efficiency at the same time.

2.1 LTE-Advanced two-tier network model

The two-tier network model is shown in Figure 1, the femto base stations in LTE-A two-tier network are connected into Internet through back haul link, and the downlink applies OFDMA multiple access method. The deployment rate and available rate are represented by P_d and P_e. The total bandwidth is B, which is divided into C RB (Resource Block). RB is the minimize spectrum resource unit, and C={1,…,C} represents for the RB set.

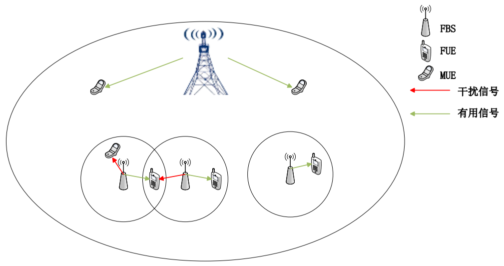

Fig. 1. LTE-A two-tier network model

2.2 Coalitional Game formulation

This section introduces the coalitional Game formulation with the framework in cooperative Game [2].

(1) Femtocell coalitional Game

In order to improve the system capacity of the femtocell network, the appropriate cooperative strategies should be designed. The cooperative model in femtocell can be regarded as the coalitional formation Game, in which femto base station is the player. For each FBS^i in the coalition S, the utility, x_i(S) $x_i(S)$, of each player is:

$$x_i(S) = R_i(S) - \alpha P_i^T(S) \tag{1}$$

$$P_i^T(S) = P_i(S) + P_i^c(S) \tag{2}$$

$$P_i(S) = \sum_{c=1}^{C_i} p_{iic} \tag{3}$$

$$R_i(S) = \sum_{c=1}^{C_i} B_c \log_2[1 + \frac{p_{iic}h_{iic}}{\sum_{j=1,j\neq i}^{N} p_{jic}h_{jic}+\sigma^2}] \tag{4}$$

in which $P_i^T(S)$ $P_i^T(S)$refers to the transmit power of FBS^i, the power consumption in coalition formulation and the power for communication. $\alpha$$\alpha$ is a weigh factor, and $R_i(S)$$R_i(S)$ refers to the throughput of FBS^i in coalition S.

For coalition S, its utility function vν(S) refers to the total utility of all the players in S:

$$\nu(S) = \sum_{i \in S} x_i(S) \tag{5}$$

The coalitional Game with non-transferable payoff [3] is defined as ($\mathcal{N}$, V), in which N refers to the players set, and V refers to the mapping. For each $S \in \mathcal{N}$, ν(S) is a closed convex subset of R^S, including the utility vector of all players in coalition S.

With the above definition, we get the coalitional Game model in partitions with non-transferable payoff of femtocell.

(2) The problem formulation

Elements in the coalition set $\mathcal{B} = \{S_1, \dots, S_l\}$ are mutually disjoint, namely that different coalitions can reuse the spectrum. The coalition structure is determined by the femtocell network deployment. With some external reasons, such as inter-layer interference, femtocell may get coalitions in any form. The utility function of $Femtocell^i$ refers to its throughput, with the power consumption in the negotiation process considered.

The utility maximization problem of femtocell can be expressed as:

$$\max \sum_{S_i \in \mathcal{B}} \sum_{j \in S_i} x_j(S_j) \tag{6}$$

$$\text{s.t.} \quad P_{min} \le P_j(S_i) \le P_{max}, 0 \le P_j^c \le P_j^{th} \tag{7}$$

In order to solve the utility maximization problem, $femtoell^i$$femtoell^i$ sends the cooperation request to the interference sources, namely the neighbor femtocells, to form the coalition. In this coalition, femtocells can negotiate to use the spectrum resources and schedule the transmit power, thus to reduce the interference between them. In particular, as for the limited spectrum resources and the increase of power consumption in information communication, the coalition size is always not too large, and the players are always not too many.

2.3 The distributed coalition formulation algorithm

According to the definition of Pareto Sequence, when and only when at least the utility of at least one femtocell can be improved without impairing the utility of other femtocells, the coalition will merge and split. In coalitional Game, Femtocells form the coalition by interaction and finally converge to a steady partition state, in which all the femtocells get their optimized utility and no one wants to break it. The steps of this algorithm are as follows:

The initialization status:

At the beginning, the partition form is $\mathcal{S} = \mathcal{N} = \{1, \ldots, \mathrm{N}\}$, namely all the femtocells are in the non-cooperative mode. With some known techniques [4], each femtocell takes the interference sources as the potential cooperators.

The iteration process:

Each femtocell sends cooperation request to potential cooperators, and negotiate in pairs. Each femtocell determines the coalitions it may join in. Compute the utility in different coalitions of the femtocell. According to the merge and split strategy, the femtocells form coalitions and join in the coalition providing them the best utility. The generated coalitions will be included in a steady partition. Iteration the above steps until all femtocells are converged to a steady partition.

3 Algorithm simulation and experimental evaluation

We draw the femtocell network cooperation figure as Figure 2, in which the blue points refer to the femto base stations, the pink points refer to the femtocell users, and lines between femto base stations reply a cooperation between them.

Figure 3 shows the relationship between the coalition numbers and femtocell numbers. With the increase of femtocell numbers, the interference between femtocells become more sever, thus leading to the increase in the cooperation.

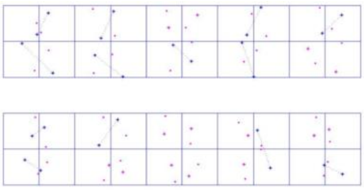

Fig. 2. Femtocell network cooperation

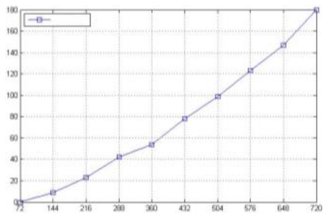

Fig. 3. Coalition numbers and femtocell numbers

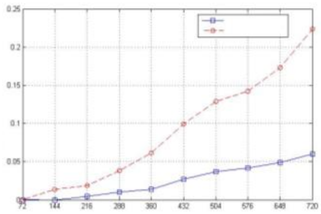

Fig. 4. Cutting off rate of femtocell users

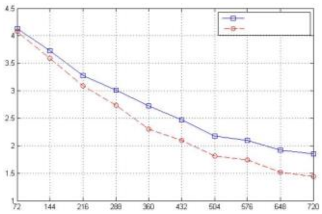

Fig. 5. Spectrum effectiveness of femtocell users

Figure 4 shows that the cutting off rate increases with the increase of femto base stations. With the increase of femto base stations, it shows smaller amplitude. It is because that the femtocell users form coalitions with the interference sources with the cooperative Game algorithm, thus reducing the interference. Figure 5 shows that our algorithm improves the spectrum effectiveness by 13% compared with the non-cooperative algorithm, especially deploying more femto base stations.

4 Conclusion

This paper proposes a distributed algorithm based on coalitional formation Game for femtocell resource allocation and interference management. It mainly applies the self-organizing characteristic of the femto base station. The experiment results show that the resource allocation algorithm based on cooperative Game in this paper prefers than the algorithm based on non-cooperative Game. It reduces the cutting off rate, improves the spectrum effectiveness and QoS of the femtocell users.

References

1. Parkvall, S., Dahlman, E., Furuskar, A.: LTE-advanced-evolving LTE towards IMT-advanced, Vehicular Technology Conference, pp. 1--5 (2008).
2. Saad, W., Han, Z., Debbah, M.: Coalitional Game theory for communication networks. Signal Processing Magazine, vol. 5, pp.77--7 (2009).
3. Myerson, RB.: Game theory: analysis of conflict. Harvard university press, (2013).
4. López-Pérez, D., Valcarce, A., De La, R.G.: OFDMA femtocells: A roadmap on interference avoidance. Communications Magazine, vol. 9, pp. 41--48, (2009).

