

Chapter 17

Game Theory for Co-Tiered Interference Mitigation in 5G Small-Cell Networks

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ABSTRACT

Small-cell technologies are seen as one of the most promising solutions for the rapid growth of wireless data services and 5G requirements. However, because most SBSs are deployed with minimum intervention from the end users and the service providers, it is hard to mitigate co-tiered interference. It is significant to study the self-organized distributed co-tiered interference mitigation and resource allocation. Game theory is an effective distributed approach towards handling the distributed co-tiered interference mitigation problem without a central controller. This chapter is to address the application of game theory and distributed learning solutions for distributed co-tiered interference mitigation. Two potential game models for static and dynamic co-tiered interference mitigation are presented and discussed for small-cell networks with fixed loads and dynamic loads separately. In addition, two distributed learning algorithms are presented and results are discussed. Finally, some future research directions are given.

INTRODUCTION

The drastic increase in the population of smart terminal devices and mobile data traffic with ubiquitous connectivity for the users will create a huge demand for wireless networks. However, there is a huge gap between the growth of wireless data traffic demand and the capacity growth rate of the fourth genera-

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tion (4G) wireless technology which has been deployed in the world most recently. As a result, the 5G mobile and wireless communication technologies are expected to resolve such a problem (Hu & Qian, 2014; Xu et al., 2014; Wang et al., 2014; Jo et al., 2014). In the future 5G wireless communication systems, the wireless capacity can be improved by node density increase, cooperative and collaborative radio technologies.

Therefore, the use of low-power, very dense, short-range, small-cell networks is seen as a promising option to handle the future data rate demands. With the ultra-dense small-cell deployments, the distance between the small-cell base stations (SBSs) and end users is reduced, leading to higher achievable data rates. On the other hand, the reuse of time-frequency resources across multiple cells can highly increase the spectrum efficiently. In this regard, SBSs, commonly known as femtocells, can improve the network coverage, especially in the interiors of houses and buildings and to provide ubiquitous high speed connectivity to the end users. Thus, a lot of SBSs are installed and managed by users in residential areas and small offices and provide better service performance for users in poor indoor coverage regions or dead zones.

On one hand, some SBSs can be connected to cellular core networks over digital subscriber line and exchange information with each other through the backhaul or gateway. In this way, SBSs can achieve an effectively and conveniently network deployment and radio resource management. SBSs can also exchange information over the X2 interface and allocate the radio resource with limited and time-insensitive information exchanged over the X2 interface with other SBSs. However, the information exchange overhead may be huge during network deployment and resource management. On the other hand, some other SBSs are deployed in an ad-hoc manner with minimum intervention from the end users and the service providers. In this way, SBSs deployment is difficult to perform centralized planning or be well controlled as macro-cell base stations (MBSs), and can't exchange information conveniently.

As more and more SBSs are randomly distributed in a surrounding area, users in the coverage of different cells overlapped may interfere with each other. There is a lot of necessary to mitigate interference to exploit the benefits promised by SBSs. Due to the random deployment, dynamic, flexible connection to cellular core networks and flat system architecture, it is difficult to perform central control to mitigate interference (Xu et al., 2014). It is very challenging and meaningful to develop efficient distributed algorithms for the radio resource allocation. Distributed self-organizing resource allocation and interference mitigation without information exchanging (or with limited information exchanging) is necessary for small-cell networks.

This chapter focuses on the mitigation of co-tiered interference with game theory approaches in 5G small-cell networks. The main contributions of this chapter are summarized as follows:

1. The motivation, issues and challenges for using game theory in co-tiered interference mitigation are presented and discussed. A summary of common game models for resource allocation in 5G small-cell networks is provided. Potential game is introduced which can be used for co-tiered interference mitigation without information exchanging in a non-cooperative manner.
2. A noncooperation interference minimization game for static co-tiered interference mitigation is presented and discussed in fixed load small-cell networks. Without central controllers and information exchange, fading memory joint strategy fictitious play with inertia with inertia is presented to achieve NE of the game.

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