Journal of Network and Computer Applications 34 (2011) 1861–1868

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

A cross-layer resource allocation scheme for ICIC in LTE-Advanced

Zhaoming Lu*, Yan Yang, Xiangming Wen, Ying Ju, Wei Zheng

Beijing University of Posts and Telecommunications, Beijing 100876, China

ARTICLE INFO

Article history:
Received 30 June 2010
Received in revised form
17 December 2010
Accepted 26 December 2010
Available online 18 January 2011

Keywords:
Cross-layer
Potential games
Particle swarm optimization
Inter-cell interference coordination
Power allocation

ABSTRACT

As a new technology, inter-eNB coordination has been included in LTE-Advanced study items. Moreover, the network architecture in LTE-Advanced system is modified to take into account coordinated transmission. In our study, we explore the problem of jointly optimizing the power level and scheduling of resource blocks for LTE-Advanced network based on orthogonal frequency division multiplexing (OFDM). We propose a distributed optimization scheme based on evolutionary potential games, and in the process of objective function modeling we employ the Lagrangian multiplier method to solve the constraint objective optimization problem. Then particle swarm optimization (PSO) method is adopted to find the optimal power allocation and scheduling for each resource block in the multi-cell framework. Numerical results prove that proposed algorithm notably improves the overall throughput, while user fairness is guaranteed. Importantly, additional computation and communication cost introduced by cross-layer optimization is also evaluated.

1. Introduction

Inter-cell interference (ICI) makes a main dent in system throughputs for cellular mobile networks based on OFDM. Inter-cell interference coordination (ICIC) that is a research highlight currently has the task to manage radio resources such that inter-cell interference is kept under control (3GPP TS 36.300, 2009). Through effective resource allocation, ICIC technology reduces the probability of time slot and spectrum resource conflict of users from different cells, and decreases the interference level, improves signal to interference plus noise ratio (SINR) as well as system throughput and spectrum efficiency for users. There are many achievements in this area, such as power allocation method for ICIC (Hui et al., 2009; Castellanos et al., 2008; Pischella and Belfiore, 2008), soft frequency reuse (Nortel, 2007), intelligent scheduling based on SINR (Elayoubi et al., 2008; Simonsson, 2007), opportunity scheduling technology (Svedman et al., 2007; Hu et al., 2008), and MIMO (Boudreau et al., 2009).

ICIC is inherently a multi-cell radio resource management (RRM) function that needs to take into account information (e.g. the resource usage status and fairness of different users) from multiple cells. Inter-eNB coordination is proposed in LTE-Advanced, in which eNBs communicate with each other through fiber connected enhanced X2 interface. Rapid and dynamic information exchange can be achieved via this enhanced X2 interface. Hence, cooperative games theory can be explored in inter-eNB coordination based wireless networks for ICIC. This is because the resource allocation strategies of cells affect each other's performance and game theory provides an effective mechanism for this interplay situation. In addition, enhanced X2 interface supplies a rapid information communication channel for eNBs, which brings the perfect information game into practice.

Actually, there are dependencies between most of the strategies for ICIC. It is almost impossible to optimize the application's performance by determining the strategies just in sight of single layer without knowledge of other layers in the time-varying and resource-limited wireless environment. An effective approach to figure out this problem is using cross-layer design and optimization technique (Srivastava, 2005). However, it is a great challenge to find the optimal solution for the cross-layer optimization problem. It is difficult to solve the optimization problem regarding the throughput and fairness as objective functions, because these functions are nondeterministic and nonlinear. As a simple evolutionary algorithm with rapid convergence, PSO method is an applicable scheme for objective function solving.

In this paper, we draw concepts from potential game theory to develop a cross-layer ICIC framework that converges to a desirable state in wireless networks. Specifically, we design a cross-layer optimization scheme including power allocation in physical layer and resource block (RB) scheduling in media access control (MAC) layer. A potential game model was also used (Neel, 2006) to design dynamic frequency selection algorithms, and paper (Candogan et al., 2010) showed that the power control game could be approximated by a potential game. However, these approaches are only for single strategy such as power allocation or resource scheduling. In Lacatus and Popescu (2007), convex

* Corresponding author. Tel.: +86 18901381605.
E-mail address: lzy_0372@163.com (Z. Lu).

1084-8045/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jnca.2010.12.019