Chapter 6

The Combination of Resource Allocation and Interference Alignment for Ultra–Dense Heterogeneous Cellular Networks

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ABSTRACT

Different with the traditional resource allocation problems, the consistency of resource occupation and the diversity of interference of participants in interference alignment (IA) clusters bring about the complexity in the combination of resource allocation and IA. Therefore, this chapter gives a transformed conflict graph-based solution framework which considers the low complexity of chordal graph, where the selection criteria of IA clusters are determined by the influence of IA on the resource occupation and the interference. The simulation results show that the proposed schemes can improve the network performance.

INTRODUCTION

The scarcity of spectrum resources and the exponential growth of user data traffic drive the future wireless network increase the spectrum efficiency, therefore, the ultra-dense deployment of heterogeneous cellular networks has been regarded as a promising way by spectrum reuse (Zahir, Arshad, Nakata,
& Moessner, 2013; Andrews, Claussen, Dohler, Rangan, & Reed, 2012). However, without proper configuration, the interference will be severe and then hinder the improvement of spectrum efficiency. Hence, the interference management is a critical issue for ultra-dense heterogeneous cellular networks.

Resource allocation and interference alignment (IA) are the two key techniques of interference management. The former allocates the orthogonal resources to the interfering users while decreases the spectrum efficiency. Moreover, in the ultra-dense heterogeneous cellular networks, resource allocation cannot absolutely mitigate the serious interference without rejecting a portion of users. The latter aligns the interferences into special signal dimensions and then the left signal dimensions are interference free where the useful signals can be transmitted (Cadambe & Jafar, 2008; Jafar, 2011). In the multi-input multi-output (MIMO) system, the IA via precoding can increase the degrees of freedom in the interference channel (Cadambe et al., 2008; Jafar, 2011). However, the number of users is restricted by the feasible constraint of IA. Therefore, the intensive interference in the ultra-dense heterogeneous cellular networks cannot be completely eliminated just by IA, and it is needed to select the users to form IA cluster and mitigate the interferences of users out of the IA cluster. In addition, the additional signal dimensions of each participant users are occupied for compressing interference form the other users of the IA cluster. Therefore, compared with the non-participant user, the participant user in IA cluster occupies more resources to achieve the equivalent degree of freedoms. In summary, each of resource allocation and IA has its own advantages and limitations. To improve the performance of ultra-dense heterogeneous cellular network, the joint interference management combing resource allocation and IA become an emerging area of research (Meng, Li, Li, & Pan, 2015; Li, Meng, Li, & Suo, 2015).

The rest of this chapter is organized as follows. In Section 2, we introduce the background by surveying the related works. In Section 3, we analyze the influence of IA on resource allocation. In Section 4, we formulate the graph-based solution framework of the resource allocation combing with IA. In Section 5, we show the simulation results. Finally, we conclude this chapter and give the possible research directions in the future.

THE BACKGROUND

Due to the significance of the joint interference management combing resource allocation and IA, there are many prior works have been studied. This section will introduce the related works from three parts, including the IA feasible constraint, the classification of interference network and the method of IA cluster formation.

The number of users is restricted by the IA feasible constraint. In MIMO network, let \( (M \times N, d)^K \) denote the K-user interference channel where the transmitter equipped with \( M \) antennas, intend to send \( d \) independent data streams, to the receiver equipped with \( N \) antennas. According to the work of Jafar (2011), the interference channel setting above needs to satisfy the following condition:

\[
d \leq \frac{M + N}{K + 1}
\]  

(1)

Therefore, for the given number of antennas \( M \) and \( N \), the maximum number of users in a feasible IA cluster can be expressed as follows: