

Preface

With the explosive traffic demand and dense mobile devices, a new generation of cellular networks is required to support resource sharing among multiple mobile devices and manage their collisions properly. In this book, we focus on communication systems in which network devices are allowed to reuse the same resource so as to improve the overall performance. For example, mobile users with sparse code multiple access (SCMA) share the same codebook, or ultra-dense small cells with massive multiple-input-multiple-output (MIMO) share the same limited pilot sequences.

Conventionally, considering the topology of network devices, graph theory is a useful tool to seek the solutions of the resource sharing problem. In the graph representation of cellular network, each vertex represents a network device, and an edge exists between two vertices if they collide when sharing the same resource. Therefore, the resource allocation problem corresponds to finding the independent set in which the devices do not collide. By modeling the pairwise relations, the overall system performance increases.

However, in many scenarios of future wireless systems, the network needs to coordinate multiple devices in order to further improve the utilization of the scarce spectrum resources, and thus, the graph model is not accurate in modeling the relation among multiple devices. For example, in the subchannel allocation problem in non-orthogonal multiple access (NOMA), the mobile users share the same subchannel with multiple mobile users, and thus, these mobile users will bring cumulative interference, which cannot be captured by traditional graph. In this book, we introduce a mathematical framework from hypergraph theory, in which a hyperedge can be a subset of the vertex set. It provides a useful analytical tool for the readers to analyze how the relations among multiple mobile users affect the system performance, and thus, can be applied to address the resource sharing scenarios in future wireless networks.

First, in Chap. 1, we introduce the basic preliminaries of hypergraph theory in general and develop two hypergraph-based polynomial algorithms, i.e., hypergraph coloring and hypergraph clustering. Then, in Chaps. 2 and 3, we present two emerging applications of hypergraph coloring and hypergraph clustering in

Device-to-Device (D2D) underlay communication networks, respectively, in order to show the advantages of hypergraph theory compared with the traditional graph theory. Finally, in Chap. 4, we discuss the limitations of using hypergraph theory in future wireless networks and briefly present some other potential applications.

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