

Preface

This work proposes representations of multicast rate regions in wireless networks based on the mathematical concept of submodular functions, e.g., the submodular cut model and the polymatroid broadcast model. These models subsume and generalize the graph and hypergraph models. The submodular structure facilitates a dual decomposition approach for network utility maximization problems, which exploits the greedy algorithm for linear programming on submodular polyhedra. This approach yields computationally efficient characterizations of inner and outer bounds on the multicast capacity regions for various classes of wireless networks.

The revelation that submodularity is one of the key mathematical tools in studying the wireless broadcast advantage is the result of a long journey that I started in 2009 by studying the interaction of the wireless broadcast with physical layer techniques and random medium access and the wireless broadcast advantage in joint works with Michael Heindlmaier, Andreas Dotzler, Danail Traskov, and Wolfgang Utschick. It built upon the hypergraph model introduced by Desmond Lun et al. and a subsequent simplification of the original model by Danail Traskov et al. This simplification already exploits the inherent polymatroid structure of the hypergraph model. Nevertheless, I had not been able to efficiently deal with the complexities of the wireless broadcast advantage until I focused entirely on said polymatroid structure. Moreover, the full potential of the polymatroid structure, and submodularity in general, could be leveraged only by dropping the hypergraph model altogether since it introduces artificial constraints on the range of rate regions it is able to represent. This work, essentially complete in June 2015, marks the end of said journey and, as its result, introduces a general submodular cut rate region model for multicast communication in networks and shows its usefulness in describing and optimizing capacity region outer bounds and rate regions of achievable schemes.

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