Finding Influential (Central) Groups in Networks using Betweenness Centrality

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Abstract. Graph-theoretical models arise in a variety of application areas due to their elegance and inherent ability to logically represent (as edges) important relationships, e.g., communication, social and transportation links, between structural elements (i.e., nodes) of complex systems. The notion of betweenness centrality allows us to rank all nodes (or groups of nodes) according to their significance to the network structure under the assumption that all node-to-node communications are performed through shortest paths. Besides social networks, betweenness centrality has found a number of other application domains, both as a direct tool for network analysis or as an important building block within various types of network algorithms. In this talk we consider the problem of identifying the most influential (or central) group of nodes (of some predefined size) in a network by assuming that such group has the largest value of betweenness centrality or one of its variants, e.g., the length-scaled or the bounded-distance betweenness centralities. We demonstrate that this problem can be modeled as a mixed integer program (MIP) that can be solved for reasonably sized network instances using off-the-shelf MIP solvers. We also discuss interesting relations between the group betweenness and the bounded-distance betweenness centrality concepts. In particular, we exploit these relations in an algorithmic scheme to identify approximate solutions for the original problem. Furthermore, we generalize our approach for identification of not only the most central groups of nodes, but also central general groups of graph elements (either nodes or edges exclusively, or their combination according to some pre-specified criteria) satisfying, if necessary, some additional cohesiveness properties (e.g., the targeted group should form a clique or a k-club). We conduct extensive computational experiments with different types of real-life and synthetic network instances to show the effectiveness and flexibility of the proposed optimization framework. Our experiments reveal some interesting insights into the properties of influential groups of graph elements modeled using the maximum betweenness centrality concept or one of its variations.