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Group Centrality Measures: Axioms, Algorithms and Applications

Description for the general public

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Nowadays, we can fondly remember the times when the word "net" primarily meant a tool for catching fish. In today's complex world, our entire life is based on large systems composed of many interconnected elements: electrical network, computer network, cellular network, airline network and transport network. The increasing understanding of the world allows us also to see the interaction between elements in places where they cannot be seen with the naked eye—both neurons in the brain create networks and people form social networks—about this social networking sites reminds us every day.

Regardless of what network we consider, one of the most important questions is to assess the importance of a specific vertex, i.e. an element of the network. How to indicate the most important player in the terrorist network? How to assess the significance of a given stop in the public transport network? There are many methods in the literature to determine the importance of the vertex—these methods are called *centrality measures*. The most popular measures are *degree centrality*, *closeness centrality* and *betweenness centrality*. In computer science, the most famous method is undoubtedly *PageRank*—a measure designed to create a ranking of websites in the Google search engine based on a network of hyperlinks on the Internet.

A much more complicated issue is the assessment of the group of vertices. In such a case, it is not enough to judge the individual elements, because their interdependence plays an important role—two vertices can add an additional value if they occur together or they can be mutually exclusive. To give an example, two people with the same set of friends are substitutable when considering their joint influence in the network. Similarly, a computer network may be resilient to the removal of a single device, but removing two specific devices may disconnect the network; hence, such a pair of devices is complementary from the security perspective.

The goal of our project is the comprehensive analysis of new and existing group centralities – tools that assess the role of groups in networks. Our analysis will allow us to answer important questions that cannot be answered in a satisfactory way with the existing tools; for instance: "how important is a given group in a criminal network?", "how well-linked is a given district in a public transport network?", or "to what extend are particular groups marginalized in the society?".

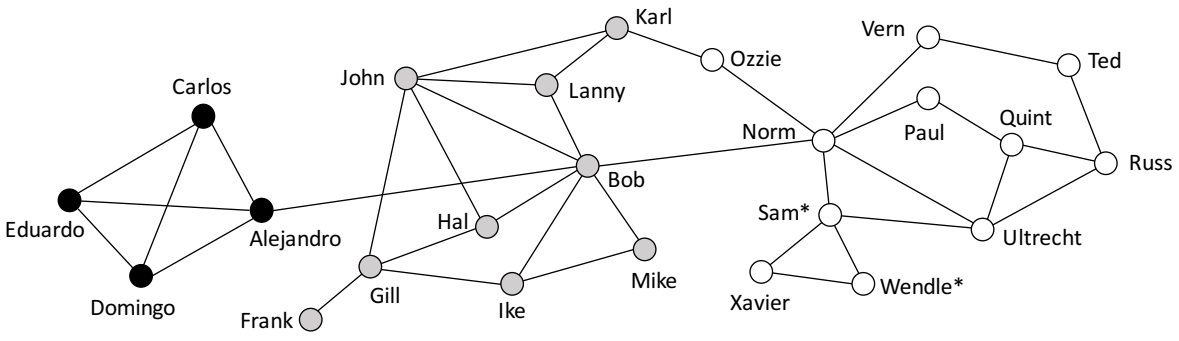

Figure 1: Social network of employees responsible for a strike at a forest products manufacturing facility (Michael, 1997). Three groups are visible: young Spanish-speaking employees (black vertices), young English-speaking employees (grey vertices), and old English-speaking employees (white vertices). Initially, Sam and Wendle were the negotiators, but would not Bob and Norm do a better job?