ABSTRACT

Communication networks have become increasingly complex due to the involvement of multiple service providers that control different parts of the infrastructure. In such environments, efficient network operation requires not only optimal routing and resource utilization but also fair allocation of the benefits generated by cooperation among providers. Traditional network optimization approaches primarily focus on efficiency and do not adequately address fair profit distribution in multi-provider systems. This dissertation proposes a cooperative game-theoretic framework for the management of communication networks. The network is modeled as a weighted graph, where nodes represent communication points and edges represent transmission links controlled by different service providers. Coalitions are formed by groups of providers that combine their resources to serve communication demands. A characteristic function is defined to evaluate the value of each coalition based on feasible and economically viable routes, integrating network connectivity, transmission costs, and demand.

The study first analyzes a basic model with linear transmission costs and no capacity constraints to provide a clear understanding of coalition behavior, route control, and profit generation. It then extends the model by incorporating capacity constraints, allowing the analysis of congestion effects and limited network resources. The research also develops allocation mechanisms based on cooperative game theory, including the Shapley value, Myerson value, and S-value, to ensure a fair and stable distribution of profits among service providers. In addition, economic centrality measures are introduced to assess the importance of providers by considering flows, costs, and revenues under optimal control without having to consider the network structure in detail. The results show that cooperative game theory is a robust tool for analyzing multi-provider communication networks. The proposed model addresses both structural and economic aspects. It enables a deeper understanding of cooperation, efficiency, and fairness. Key contributions include a coalition-based modeling framework for these networks, an extension to capacity-constrained environments, the development of fair allocation mechanisms using game theory, and new economic measures of centrality. This research helps develop network management tools and lays a foundation for future studies on advanced, dynamic systems.

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