

Abstract

The design of optimal intervention policies by a central regulator in networked multi-agent systems is investigated in this dissertation. Modeled as games exhibiting strategic complementarities, these systems are characterized by interactions wherein an increase in the effort of one agent incentivizes corresponding increases among peers. While this specific class of interactions, formally defined as super-modular games, guarantees the existence of Nash equilibria, it is frequently observed to exhibit equilibrium multiplicity. Such multiplicity typically induces severe coordination failures and systemic inefficiencies. To address these inefficiencies, mechanism design principles are applied to compute minimum-cost interventions. These interventions are structured to guide decentralized systems deterministically toward socially optimal, maximal equilibria, without directly commanding the individual actions of the agents.

For finite, non-binary unimodal games, interventions are modeled as lower-bound restrictions on action sets, effectively raising the minimum effort required by agents. A distributed algorithmic approach leveraging time-reversible Markov chains is proposed, establishing that minimum sufficient interventions can be identified by iteratively tracing weak improvement paths from the maximal strategy profile. Furthermore, the scalability limitations inherent to large-scale binary network games are systematically addressed. In these environments, optimization problems such as Optimal Seeding and Least-Cost Influence are strictly NP-hard, and complete topological data is rarely accessible to a central planner. By applying a directed configuration model and Local Mean-Field approximations, these computationally intractable network optimization problems are rigorously reformulated as dimension-independent linear programs. This analytical transformation enables the design of near-optimal intervention strategies reliant exclusively on aggregate network statistics and degree distributions, thereby circumventing the requirement for exact topological knowledge.