

# Game Theory and Network Systems

Giacomo Como and Fabio Fagnani  
Department of Mathematical Sciences, Politecnico di Torino

Game theory, originally born to model socio-economic phenomena, has recently emerged as a powerful framework to efficiently solve optimisation and multi-agent decision problems in engineering and computer science. After presenting the basic concepts and notation from classical competitive game theory, the course will focus on network games and learning dynamics and their convergence properties. Particular emphasis will be on mechanism design. Starting from problems such as constraint satisfaction, resource allocation, Bayesian inference, the course will show how to design a game and a learning mechanism to solve them in an efficient and distributed fashion.

The course will consist of five three-hour seminars on the following topics:

1. Non-cooperative strategic games. Historical remarks. Basic examples: Prisoners dilemma, game of chicken, matching pennies, Rock-Scissor-Paper. Fundamental concepts: Best Response, Dominated strategy, Nash equilibrium, Price of anarchy. The majority game.
2. Important families of games: potential games, supermodular games, quadratic games. Positive and negative externalities. Strategic complements and substitutes.
3. Network games. Pairwise graphical games. Coordination, anticoordination, discoordination. Public goods games. Network formation games. Applications.
4. Learning rules. Best response and noisy best response dynamics. Fictitious play. Convergence analysis using Markov chains tools. How to use them to solve the graph coloring problem and other constraint satisfaction problems.
5. Mechanism design. Shaping the Nash equilibria of a game. Control intervention problems to push the system towards a desired Nash equilibrium. Application in traffic networks, social and economic networks.

**Prerequisites:** Good knowledge of basic math is assumed (calculus, linear algebra, graphs, elementary probability and Markov chains). All remaining concepts will be built within the course.