Mean field games and their application to energy systems

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Game theory has since long been the mathematical language used to analyze interacting multi-agent systems driven by often mutually conflicting objectives. Games quickly become computationally intractable when the number of interacting agents is large. This is because any change in the position of a single agent induces, in general, reactions from all the other agents. However, if as the number of agents grows, their individual influence on other agents becomes vanishingly small, then in the limit, a decoupling occurs whereby the group's behavior gains inertia thus becoming insensitive to the isolated actions of an individual. At that point, each individual optimally reacts to some assumed immutable behavior of the group, and the infinite regress of mutual influences is broken. This is the situation analyzed in so-called mean field games, a recent theory independently and about the same time, developed in Canada and France. Besides optimal control theory, it relies on the ideas of statistical mechanics to help anticipate the aggregate group behavior under the optimal control laws of individuals.

The talk will be divided in two parts. In the first part, we draw inspiration from the motion of fish schools to develop a simplified engineering view of how collective motion can be achieved through decentralized control actions. In the process, the intuitive ideas underlying mean field game theory are brought forth. In the second part, we illustrate the application of this body of ideas to energy systems: An approach for aggregator coordinated decentralized control of large numbers of heating-cooling electric loads is presented. It is meant as an environmentally friendly way of helping to mitigate the increased generation volatility brought about by a higher penetration of wind and solar energy sources in today grids' generation mixes.

This is joint work with Arman Kizilkale and Rabih Salhab.