Resource allocation in networks via coalitional games

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Chapter 5

Summary and perspective

In this thesis, we have used coalitional game theoretic solutions for resource management in OFDMA-based networks and smart power grids. In OFDMA networks, we studied radio resource allocation techniques in the uplink direction scenario, focusing in particular on the issue of fairness. In smart grids, we studied the problem of power trading coordination among micro-grids with the purpose of minimizing of the amount of dissipated power over transmission lines.

In OFDMA-based networks, the main concern in the identification of the game has been the best utilization of the network resources applying a low complexity algorithm. This has led us to introduce a utility function with which each active wireless terminal achieves its request data rate exactly. This fairness criterion satisfies the expectation of both the wireless service provider and each user's terminal. To cope with the non-convexity and non-concavity of the utility function we proposed a dynamic learning algorithm. The algorithm enforces every terminal to adapt its transmit power to approach the maximum value of the utility function. The proposed algorithm approaches a distribution of transmit powers over different assigned subcarriers for each user from which no terminal wishes to unilaterally deviate (the core set). We showed that the core set coincides with a sort of Nash equilibrium point for cooperative games. The convergence and stability of the algorithm was proved by using Markov modeling, and the complexity of the algorithm favorably compared to the existing literature.

In smart grids, a micro-grid acts as a seller or a buyer depending on its current generation and demand state. To model the cooperative behaviour of micro-grids in smart power grids, we proposed an algorithm based on coalitional game theory. The proposed algorithm aims at minimizing the amount of dissipated power during generation and transfer using an approach that combines coalitional game theory and dynamic learning. In particular, the coalitional game theory-based algorithm finds a set of coalitions of micro-grids that achieves a feasible power distribution condition where all the surplus power from micro-grids is absorbed by the network and, dually, all the deficit power of micro-grids is provided by the network. The dynamic learning algorithm, instead, modifies the set of coalitions in order to minimize the power loss. Members of each coalition will locally trade power among themselves. They can also trade power with the (traditional) central distribution unit, if it is necessary. We modeled the evolution of the algorithm using Markov chain and the convergence of the algorithm is proved using Kakutani fixed point theorem.

Let us draw some future works. In OFDMA-based networks, we plan a cooperative resource allocation game in a multiple-access OFDMA wireless network consisting of multiple terminals and multiple relays. The transmitted symbols by the source nodes reach the base-station and all relays. Each relay decodes/estimates the received signals on poor channels, encodes them, and forwards toward the base-station. The communication is full-duplex mode. The algorithm will consist of subcarrier assignment and power allocation at each node for maximizing the frequency spectral efficiency at the minimum cost of power consumption. At the relays and the base-station each subcarrier is allowed be shared by more terminals. There are different subcarrier assignments at each transmitter, and the relays are not constrained to transmit the same subcarriers over which receive the symbols. There are also separate power constraints on each subcarrier at every nodes. Taking into account the relaying strategy, we will introduce a condition under which source nodes discern the needed subcarriers to be assisted.

In smart grids, we plan to develop an interaction mechanism in which micro-grids can bargain with each other to achieve an agreement on both price and the amount of power. The strategies of each micro-grid correspond to determining the price at which it is willing to buy/sell energy and the quantity that it wishes to sell/buy. The objective of each micro-grid is to determine the optimal quantity and price over each transmission line at which it wants to trade so as to optimize its objective function. Our goal is to achieve a bargaining mechanism with a good tradeoff between the price at which the trade takes place and the amount of overall power loss in the whole network.