Project Description

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Most of the existing protocols and distributed algorithms seem to rely on the assumption that the various "components" executing the protocol are willing to *altruistically* contribute to the success of the protocol. Such an assumption is often unrealistic. For example, a node of a network (being an Autonomous System or a user with its laptop) is interested in having *its own* traffic being routed, but may not want to act as a router and forward traffic of *other nodes* (since this typically has some cost). Consider the scenario in which we have a *distributed algorithm* for selecting a "good" set of nodes to be the routers (for the other nodes). This algorithm will be run by the nodes *themselves*, and thus a single node may find it convenient to "alter" the execution of the algorithm trying to be *not* included as a router. In such situation, nodes cannot be assumed to altruistically follow the algorithm, but rather their own interests. Trying to incorporate game-theoretic considerations in the design and analysis of efficient protocols (algorithms) is the main focus of *Algorithmic Game Theory* [8], a research area that lies at the intersection of the two important fields of *Algorithmics* and *Game Theory*.

The present project lies at the intersection of theory of *distributed algorithms* and *(algorithmic) game theory*. In particular, it centers around the question of understanding the impact of such *selfish* behavior on the performance of *distributed* algorithms. Here the term "distributed algorithm" should be considered very broadly, including both (1) classical distributed algorithms designed to achieve a good system performance, or (2) a simple game dynamics modeling in a natural way the rational behavior of the players:

Incentive Compatibility of Distributed Algorithms. Nisan and Ronen [5] suggest a *mechanism design* approach to mathematically formulate that a certain protocol cannot be manipulated. In this setting, players can manipulate the protocol by misreporting certain information to a *centralized* algorithm, and compensations (payments) must guarantee a property called *truthfulness* (essentially, cheating is never convenient for the players).

In distributed settings, where the players run the algorithm, truthfulness is no longer sufficient because they can manipulate the algorithm *directly* (and not only by misreporting information). We plan to study the limitations that this will impose on the algorithm (and ultimately on the performance of the system), compared to the centralized mechanisms design approach. As a concrete starting point, we plan to study the class of *maximal-in-range* algorithms which lead to truthful mechanisms [7]. We feel that this kind of (centralized) mechanisms is rather appealing also in the *distributed setting* because it exhibits certain robustness conditions (namely, manipulation is convenient for a node only in the event that the resulting outcome is globally better). Other techniques developed in the centralized mechanism design setting (e.g., partial verification [10] or randomization [1]) may be considered.

Game Dynamics. Game dynamics can be regarded as a very natural kind of distributed algorithms implemented by a set of players. Most notably, best-response dynamics are essentially a greedy-type distributed algorithm that, in some cases, is guaranteed *convergence* and *incentive compatibility* [6, 4]. Moreover, they provide an alternative characterization of several truthful centralized mechanisms [9].

In this project, we plan to study distributed algorithms from the point of view of a game dynamics, thus trying to understand if there is any incentive compatible dynamics that is guaranteed to converge to the desired outcome (solution). One key aspect that this project aims at understanding is how to *break symmetries* (e.g., the existence of two or more Nash equilibria) in *asynchronous* settings (e.g., if several players move simultaneously [2]).

Game dynamics are also a natural candidate to explain the formation of social networks which typically exhibit highly "non-random" structures. In particular, it would be interesting to explain certain *core-periphery* structures [3] in terms of a natural game dynamics. Interestingly, such core-periphery structures can be characterized as the networks whose nodes are able to perform efficiently certain tasks in a distributed fashion [3].

References

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