Abstract

Game theoretic concepts play a very important role in formal specification and verification of systems. Systems that involve multiple agents interacting with each other can be modelled as multi-player games. Game theoretic solution concepts can then be used to study the properties of such systems.

In a multi-player game, every player has a set of strategies to choose from. Players play from among the strategies available to them. A strategy profile is a combination of strategies, one for each player. A strategy profile decides the complete outcome of the game. For every outcome of the game, each player has an associated payoff. Players are rational and play to maximize their respective payoffs. Players may also be allowed to play mixed (randomized) strategies (where they assign probabilities to each of the available strategies and then randomly select a particular strategy). In such cases expected values of payoffs are used to characterize the game.

A Nash equilibrium is a strategy profile such that no player has an incentive on unilaterally deviating from its strategy. If mixed strategies are allowed, every game has at least one Nash equilibrium. The solution concept of Nash equilibrium is widely used to get stable configurations and strategy profiles of a multi-agent system. But, a Nash equilibrium is susceptible to deviations by more than one player. Players can form coalitions and deviate (to try increasing their payoffs) thus disturbing the stability of the system.

In this work, we consider non-deterministic multi-player concurrent reachability games and we study the solution concept of *k-resilient* Nash equilibrium in these games. A *k-resilient* Nash equilibrium is a strategy profile such that, if at most k players deviate from their respective strategies, none of the deviating player can benefit. The solution concept of *k-resilient* Nash equilibrium is resilient to deviations by upto at most k players, thus giving more stable configurations and strategy profiles. But a *k-resilient* Nash equilibrium may not exist in general.

In this work, we prove some properties associated with non-deterministic multi-player concurrent reachability games that characterize *k-resilient* Nash equilibria in these games when only pure strategies (non-randomized strategies) are allowed. These properties are then used to develop algorithms for checking existence of *k-resilient* Nash equilibrium in finite non-deterministic multi-player concurrent reachability games in untimed and timed settings when only pure strategies are allowed. Our algorithms are in 2-EXPTIME. The properties that we prove also contain all the necessary information to compute a *k-resilient* Nash equilibrium if it exists.