EXACT AND APPROXIMATE EQUILIBRIA FOR NETWORK FORMATION AND CUT GAMES

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ABSTRACT

In this thesis, we develop several interesting network formation and cutting games and study the existence and computability of exact or approximately stable solutions.

We first introduce the survivable version of the game theoretic network formation model known as the Connection Game. We prove the existence of cheap Nash equilibrium solutions and give polynomial time algorithms to compute them. We provide the first work where arbitrary sharing is used as a cost-sharing mechanism for the formation of complex, i.e., not acyclic, graphs. In order to obtain the results, we have also proven some structural properties of survivable networks, which are of interest in traditional contexts as well.

Later we define a network game called *Group Network Formation Game*, which represents the scenario when strategic agents are building a network together. In this game, players correspond to nodes of a graph and the players can have extremely varied connectivity requirements. For example, there might be several different types of nodes in the graph, and a player desires to connect to at least one of every type (so that this player's connected component forms a Group Steiner Tree). Or instead, a player might want to connect to at least k other player nodes. The first example is useful for many applications where a set of players attempt to form groups with complementary qualities. The second example corresponds to a network of servers where each server want to be connected to at least k other servers so that it can have a backup of its data; or in the context of IP networks, a set of ISPs that want to increase the reliability of the Internet connection for their customers, and so decide to form multi-homing connections through k other ISPs. Many other types of connectivity requirements fit into our framework and in this thesis we give algorithms to efficiently compute cheap exact and approximate Nash equilibria.

Finally, we define a network game called *Network Cutting Game*, which considers a dual approach to network formation games, i.e., players are not trying to connect to certain parts of a network, rather they want to disconnect themselves

from certain nodes of a graph by cutting edges. This game models the scenario, where a set of players are trying to protect themselves from a diffusive process, like a computer virus, or disinformation, contamination in the water suply, etc. Cutting the edges may not mean destroying the edges, rather it corresponds to taking security actions, like putting sentries or installing firewalls on routers. In this thesis, we investigate the game-theoretic version of several standard cut problems like, s-t cut, Multicut and Multiway cut and give algorithms that return cheap exact or approximate Nash equilibrium. At the end of the thesis, we list some interesting open problems and future directions for researchers.

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