Selfish Greedy Routing in Sensor Networks

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April 9, 2008

1 Introduction

Routing is a challenging issue in ad hoc and sensor networks due to the large size and limited resources. One family of solutions to this problem are the algorithms that use the geographic location of the nodes, namely Geographic Routing algorithms. In the simplest of these algorithms, Greedy Routing, each node forwards the packet to a neighbor closer than himself to the destination. So, there exist a greedy path from s to t if $s = v_1, v_2, ..., v_k = t$ is a path in the graph, and $|v_i, t| > |v_{i+1}, t|$ for $1 \leq i < k$. However, this may not accomplish according to the structure of the network. Moreover, finding the location of each node may not be an easy task.

Assigning virtual coordinates to the nodes is a solution proposed by [1]. Later, [2] introduces the concept of greedy embedding together with a conjecture. They call a greedy embedding for a graph to be a virtual coordination in which each node is accessible from every others using greedy routing. Their conjecture is: every 3-connected planar graph has a greedy routing. Recently, [3] shows that the conjecture is right for planar triangulations.

Another interesting perspective of this problem may arise in a network of selfish agents. In such an environment, each node likes to maximize its own paths rather that the total number of paths in the network. As a result, it may have the incentive to declare a fake virtual coordination of himself to increase its own paths. Therefore coordinations in which no node has the unilateral incentive to move (Nash Equilibrium) are interesting.

Overall, we like to find if NE points exist for each graph in d-dimension ($d \in \{1, 2\}$) space, and if exists how much they are good compared to the optimum solution (Prices of Anarchy and Stability).

2 Problem Formulation

We show the Virtual Coordination (VC) game with the tuple $(V, G(V, E), S_i, u_i)$. Each vertex of the graph presents a player in this game. The set of strategies for player i is all possible virtual coordinates it can choose ($S_i = (0, 1)^d$ in d dimensional game). Assuming player i has selected the action $a_i \in S_i$, the VC of all nodes will be $a = (a_0, ..., a_n) \in S = S_0 \times ... \times S_n$. Before defining u_i we go through two definitions.

Definition 1: We say that u has a Directed Greedy Path to v in a VC if there exists a sequence ($u = v_0, v_1, ..., v_{k-1}, v_k = v$), such that $(v_t, v_{t+1}) \in E$ and $|a_{v_t}, a_v| > |a_{v_{t+1}}, a_v|$ for $0 \leq t < k$.

Definition 2: We say that u has an Undirected Greedy Path (UGP) to v in a VC if there exists a sequence ($u = v_0, v_1, ..., v_{k-1}, v_k = v$), such that $(v_t, v_{t+1}) \in E$, $|a_{v_t}, a_v| > |a_{v_{t+1}}, a_v|$, and $|a_{v_t}, a_u| < |a_{v_{t+1}}, a_u|$ for $0 \leq t < k$.

In the game, each sensor likes to maximize its own paths to the other nodes. Considering that we define two different utility functions, inspired from directed and undirected paths respectively. u_i^D (u_i^U) is the number of vertices that i has a directed (undirected) greedy paths to them.

These two different utility functions will result in two different games $(V, (0, 1)^d, u_i^D)$ and $(V, (0, 1)^d, u_i^U)$, namely

Directed VC (DVC) and Undirected VC (UVC) respectively. Clearly, the social utility in DVC is the total number of ordered node pairs with a greedy path from the first one to the second. Similarly, social utility in UVC is the number of pairs having undirected greedy path to each other.

Here, we like to know if NE exists for each of the above games in d-dimension ($d \in \{1, 2\}$), and also the prices of anarchy and stability.

3 References

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[3] R. Dhandapani. Greedy routings of triangulations. SODA 2007.