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Research Paper

ENHANCE THE ENERGY LIFETIME OF WIRELESS SENSOR NETWORKS USING GAME THEORY APPROACH

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Energy constrained in wireless sensor networks attained many research attention in recent years and energy efficient routing protocols for communication in environments help to minimize the energy consumption. Energy efficient routing algorithm based on game theory for wireless sensor networks and the performances are analyzed in terms of energy consumption. The main concept of Game theory are routing protocol design, power control and energy saving, topology control, quality of service control, data collection, packet forwarding, spectrum allocation, bandwidth allocation, coverage optimization, WSN security and other sensor management tasks. Game theory is used to select the cluster heads and having sufficient residual energy and high trust level. In this paper we proposed an energy-efficient node selection by cooperative and non cooperative scheme for wireless sensor networks is proposed and also energy harvesting technologies and different energy saving techniques for wireless sensor networks are to be discussed.

Keywords: Game theory, Cooperative game theory, Non cooperative game theory, Wireless sensor networks, Cluster heads, Routing protocols

INTRODUCTION

A wireless sensor network is an “exciting emerging domain of deeply networked systems of low-power wireless nodes with a small amount of memory and CPU, and large federated networks for high-resolution sensing of the environment. Wireless sensor networks are having a lot of sensors these sensors are having a variety of functions, purposes and capabilities. A sensor network is composed of a large number of sensor nodes that are deployed in a open space; on a battle field beyond or in front of enemy lines; in the interior of industrial machinery; at the bottom of a body water, in a biologically and/or chemically contaminated field; in a commercial building;

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in or on a human body; or in a home. A sensor node typically has embedded processing capabilities and onboard storage; the node can have one or more sensors operating in the seismic, acoustic, radio (radar), magnetic, infrared, optical, and biological or chemical domains. The sensor node has typically wireless links, and communication interfaces to neighboring domains. These sensor nodes also often has location and positioning knowledge that is acquired through a local positioning algorithm or sink global positioning system. These sensor nodes are scattered in a special domain called a sensor field. Each one of the distributed sensor nodes typically has the capacity to collect data, analyze them, and route them to a (designated) sink point.

The four basic components of sensor network are

1. An assembly of localized or distributed sensors.
2. A central point of information clustering.
3. An interconnecting network.
4. A large set of computing resources at the central point (or beyond) to handle data correlation event trending, status querying and data mining.

In this context, the sensing computation nodes are considered part of the sensor network. Power consumption is an important issue is taken to be in account in the WSN. Power control and Energy saving strategies should be devised at sensor nodes as well as in the network to enhance the network lifetime. In order to obtain a feasible WSN and due to accomplish nature of the network, game theory is regarded as a suitable and attractive to accomplish the goal.

Game theory is a branch of mathematical field that can be used to analyzed system operations and self-organizing networks. It describes a behavior of players in a game. Players either may be cooperate or non cooperate while striving maximize their outcomes from the game. Cooperative game theory is the study of behavior of rational players when they cooperate and consider the utility of all the players. Non cooperative game theory covers a broad range of applications in WSN. In non cooperative game theory, the nodes are sell, consumer goods, buy in response to the prices to the market and is mainly focused on each user's individual utility rather than the utility of the complete network. But in cooperative game theory they achieve general pareto-optimal performance and maximize the whole network's payoff while fairness.

GAME THEORY

Game theory is defined in the broadest sense and it is a collection of mathematical tools formulated and to study the situations of conflict and cooperation. Game theory is concerned with finding the best actions for individual players' decision makers in these situations and recognizing stable outcomes. The main object of study in game theory is the game and is defined to be in any situation in which:

- There are at least two players (i.e.) A player may be an individual, a nation, a company, a Biological species or a wireless node.
- Each and every player has a number of possible strategies, courses of action she or he may choose to follow.
- The strategies chosen by each and every player should determine the outcome of the game.

- An associated with each possible outcome of the game is a collection of numerical payoffs. These payoffs represent the value of the outcome of the different players.

In 1950, John Nash demonstrated that finite games always have Nash equilibrium, called as a strategic equilibrium. Nash equilibrium is a list of strategies for each player. It has the property that no player can unilaterally change her/his strategy and get a better payoff from the game. This is the main concept of non-cooperative game theory and has been a focal point of analysis. Game theory receives a special attention in 1994 with the awarding of the Nobel Prize in economics to John Nash, Reinhardt selton and John Harsanyi.

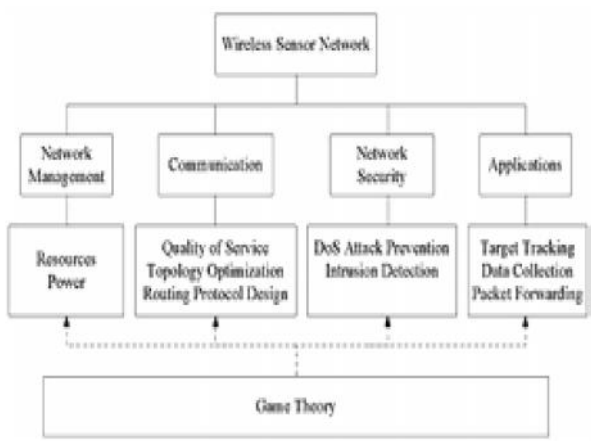
Game theory is associated with the following terminologies.

Players: A player is an agent who makes decisions in a game (i.e.) there are two players in a game.

Strategy: It is a course of action taken by a player. Game in strategic form, is a strategy (i.e.) one of the given possible actions of a player. In an extensive form game, a strategy is a complete plan of actions for each decision point of the player.

The strategy can be classified into pure strategy and mixed strategy. In this paper, game theory has been adopted and adjustment of transmission power of each node in a homogenous WSN considering the residual energy of the nodes is formulated as non cooperative game where nodes exchange information only with their neighbors. The following figure shows that the relationship between Game theory and wireless sensor networks.

Figure 1: Shows that the Relationship Between Game Theory and Wireless Sensor Networks



A set of players N, which may be a group of nodes or an individual node in wireless sensor networks. They are the main decision makers of the game. A set of actions, *P*, available for the player *i* to make a decision. The payoff $\{u_1, u_2, ..., u_i\}$ resulted from the strategy profile. Payoff function expresses the level of income or utility that can be got from the game by the players and is a function of the strategy of all the players. Different strategies may lead to different benefits. The node or the entities (decision makers) that play the game are called the players. The players take part in the game by performing particular actions or moves. The player *i*'s possible actions is called the action space P_i of player *i*. Suppose that $p \in P$ is a strategy profile and $i \in N$ is a player; then $p_i \in P_i$ denote player *i*'s action in p and *p-i* denote actions of other players except *i*. Each player has preferences for the action profiles. A player is affected not only by its own actions, but also by the actions of the other players as well. A utility function ui assigns a real value to each action profile of the game. At the beginning of the game, it is assumed that the nodes transmit with maximum power level to gather neighbor information (Dohare *et al.*, 2012). Nash Equilibrium (NE) is a fundamental concept in the theory of games and the most widely used method of predicting the outcome of a strategic interaction in the social sciences. NE is an action profile with the property that no single player can obtain a higher pay off by deviating unilaterally from power profile. Another expression for Nash equilibrium is sometimes very useful.

Utility refers to the level of satisfaction that the decision-taker (node) receives as a result of its actions. It is defined as the ratio of the expected number of bits received correctly to the energy consumed in the transmission. The utility function reveals the node preferences while considering reliability, connectivity and power consumption. In this way, the problem is viewed as an incomplete information non cooperative power and topology game, where the sensor node only has information about its own power level, neighbor number, SINR perceived from the environment and its own channel condition and if each node is assumed as a fully rational entity, NE of game theory is achieved when each node want to maximize selfish payoff and minimize the cost. When the system reaches the NE, no nodes can increase its utility any more through individual effort.

MOTIVATION

With the quick development in wireless technology, WSN will surely find more and more application when the requirement for sensing the environment appears. There are many different techniques that can be applied to WSN, game theory being one of them. Game theory has been increasingly applied in the field of WSNs (Dasgupta and Dutta, 2013), and especially routing or clustering protocols, which require as much efficiency as possible. A node tries to obtain the maximum profit for taking series of actions. Whether a node gets a profit or not is dependent on the success of the action. Thus game theory can help in protocol optimization. Often nodes decisions at a specific layer are made with the idea of optimizing performance at some other layer; hence game theory can provide an insight into viewpoints for optimization. It allows scrutinizing the existence, distinctiveness and convergence to a steady state point when nodes in the network perform adaptations irrespective of others (Asadi *et al.*, 2013).

The above discussion, clearly justifies the use of game theory as a technique to realize enhancements in a WSN in one or another way, so as to bring about an optimal result in the specific fraction of field it is applied to.

In Dasgupta and Dutta (2013), the authors present a wide perspective of applications of game theory in the broad area of WSN, discussing game theoretic optimizations in many sub-areas including routing protocol design with some clustering protocols like (Heinzelman *et al.*, 2000; Jing and Aida, 2009; and Koltsidas and Pavlidou, 2011) being included in it. This paper intends to realize a coherent and well-defined view of such optimized protocols. Thus, the scope of this paper is restricted to the exploration of the use of game theory in clustering protocols for WSNs.

OTHER APPLICATIONS OF GAME THEORY IN WSN

A variety of clustering protocols exist in WSN. Game theory has emerged as a new approach to analyze problems in WSN. With the application of game theory to clustering protocols, a more approaches have risen. Game theory, as observed in all of the above protocols mentioned in this survey, has resulted in optimization. It is of immense use, especially in the case of selfish nodes, e.g., game theoretic model for selfish node avoidance routing (Dohare *et al.*, 2012).Thus, applicable in scenario of network, whose security has been compromised by making the nodes behave selfishly which can lead to perilous consequences, e.g., the importantly needed data may not be accessible because of DoS (Denial of Service) attack. In Agah and Das (2007) authors devise the prevention of DoS attacks in WSN as a repeated game between an intrusion detector and nodes of a WSN, where some of these nodes are malicious.

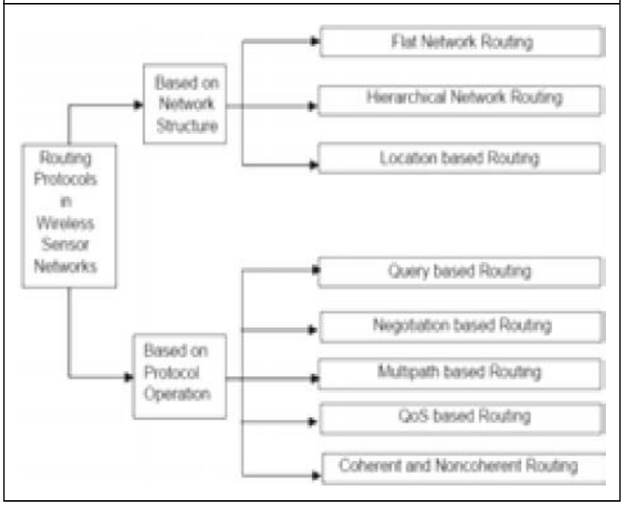
Game theory is not just applicable to domain of clustering protocols but to a variety of domains within WSN. For example, improving routing protocols using game theory (Akyildiz *et al.*, 2002; and Asadi *et al.*, 2013), energy saving and power control (Chong and Kumar, 2003), detection of malicious behavior by nodes (Chen *et al.*, 2013) (hence the application in field of WSN security).It can also be used in applications of WSN, e.g., target tracking. A technique for target tracking utilizing multi-agent and game theory has been proposed in (Sengupta *et al.*, 2010; and Shi *et al.*, 2012). When a target emerges in the sensing region, sensor nodes start the formation of coalition dynamically and then they begin to negotiate using game theory. Coalition is made to track it with the target moving (Shi *et al.*, 2012). These are a few fields mentioned for using game theory, though a whole many realms still exist within WSN, to which game theory can be appropriately applied.

ROUTING PROTOCOLS AND DATA DISSEMINATION IN WSN

Routing protocols in WSNs are for setting up one or more paths from sensor nodes to the sink. Since sensor nodes have limited resources routing protocols should have a small overhead, which may result from control message interchange and catching. Routing and data dissemination issues deal with dissemination mechanisms for large scale wireless networks, data-centric routing, directed diffusion, adaptive routing and other specialized routing mechanism.

Routing protocols for wireless sensor networks generally fall into three groups: data-

Figure 2: The Technique of Routing Protocols in WSN

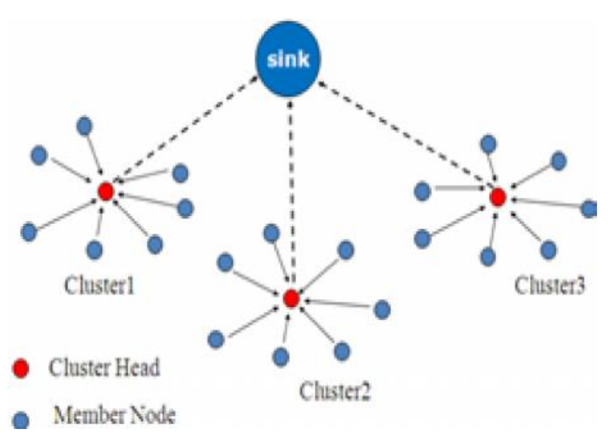


centric, location based and hierarchical based. The concept of data aggregation is to combine the data arriving from different sources along the way. To preserve energy, most routing protocols for WSN employ certain technique to minimize energy consumption. The following figure shows that the technique of routing protocols in WSN.

CLUSTERING IN WSN

The nodes in a sensor network often need to organize themselves into clusters. Clustering allows hierarchical structures to be built on the nodes and enables more efficient use of scarce resources, such as frequency, bandwidth, power and spectrum. Clustering also allows the health of the networks is monitored and misbehaving nodes to be identified as some nodes in a cluster can play watchdog roles over other nodes. Each cluster elects a routing and cluster-head node is done only among the cluster heads and the remaining nodes always route packets through their cluster heads. Cluster heads can be chosen to have a minimum separation comparable to the node communi ation range. The following figure shows that the formation

Figure 3: The Formation of Cluster in WSN



of cluster head in sensor nodes.

The sensors are intelligent agents and the game theoretic paradigm is considered for cluster head election.

The objects of the game in WSN are:

- A set of Players, *N*, in wireless sensor networks.
- A set of actions $X = \{x_1, x_2, ..., x_n\}$ be the set of nodes' strategies, (i.e.) if node *i* choose to be cluster head then $x_i = 1$ otherwise $x_i = 0$.

The payoff $P = \{p_1, p_2, ..., p_n\}$ resulted from the strategy profile. Assumed that each node's payoff is equal to its cluster head's ®-value, this will encourage node having maximum ® value within neighbors to win the game. Each node's ® value is calculated by the equation as follows:

$$\text{®}_i = \sim \frac{E_i}{E_{init}} + R_i - \text{¥}n \quad ...(1)$$

where

~- be the weight parameter of node's residual energy level.

- be the weight parameter of node's trust level.

¥- be the weight parameter corresponding to average path loss.

E_{init} be the Node's initial energy level.

E_i be the Node's current residual energy level.

R_i be the Node's trust level.

CONCLUSION

A game theoretic model with for power control taking into account the residual energy of the nodes in a homogeneous sensor network considering various deployment schemes have been analyzed in this paper. The connectivity is taken into consideration and the existence and uniqueness of the routing and clustering are studied for the game model. The utility of nodes without residual energy and with residual energy are compared for all the deployment schemes. The maximum utility is obtained at minimal transmission power scheme. With the inclusion of the interference among the nodes due to the optimizing behavior of a particular node is suppressed. Further the sensor nodes by requiring lesser transmit power and thereby extends the network lifetime efficiently.

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