Wireless Sensor Networks: A Game Theory Approach To Increasing Their Energy-Lasting Capacity

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ABSTRACT

In recent years, researchers have focused on ways to reduce the energy consumption of wireless sensor networks by developing more effective routing algorithms for environmental communication. In this paper, we provide a game-theoretic approach to designing a low-power routing algorithm for WSNs, and we evaluate its performance metrics. Routing protocol design, power/energy management, topology management, quality of service management, data/information gathering, data/information forwarding, packet forwarding, spectrum/bandwidth allocation, coverage optimization, WSN security, and other sensor management tasks are the main concepts of Game theory. The cluster leaders with the most trust and the most remaining energy are chosen using a game-theoretic approach. In this article, we offer a methodology for selecting nodes in wireless sensor networks that minimises energy use, and we address energy harvesting technology and other methods for conserving power.

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

Introduction

When it comes to high-resolution environmental sensing, wireless sensor networks are an "exciting developing realm of highly networked systems of low-power wireless nodes with minimal amounts of memory and CPU." Many different types of sensors for many different purposes are used in wireless sensor networks. A sensor network is made up of numerous sensor nodes that are placed in different environments and situations, such as in the open, on a battlefield beyond or in front of enemy lines, inside an industrial machine, at the bottom of a body of water, in a biologically and/or chemically contaminated field, or in a commercial building. The sensor nodes that make up a sensor network can be located anywhere: in the wild, on a battlefield behind enemy lines, inside an industrial machine, at the bottom of a body of water, in a biologically and/or chemically contaminated field, inside an office building, in or on a human body, or in a private residence. One or more sensors in the seismic, acoustic, radio
(radar), magnetic, infrared, optical, biological, or chemical domains can be housed in a single sensor node, which also generally has embedded computing capabilities and onboard storage. The sensor node is connected to other networks through wireless connectivity and communication interfaces. Location and positioning information for these sensor nodes is often gathered using a local positioning algorithm or a sink global positioning system. Spread over a unique region known as a sensor field are these sensor nodes. Each of the dispersed sensor nodes may normally gather data, do some kind of analysis on it, and then forward the results to a (predetermined) sink location.

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.

The sensing computation nodes are included in the sensor network for this purpose. In the WSN, power consumption is considered an essential factor. The lifespan of the network may be extended by implementing power control and energy conservation measures at sensor nodes and across the network. Due to the attainable nature of the network, game theory is seen as an appropriate and appealing means of achieving the desired outcome (a workable WSN).

It is possible to examine system operations and self-organizing networks by employing game theory, a subfield of mathematics. That’s how player conduct in a game is characterized. When trying to maximize their gains from the game, players can choose to be cooperative with one another or competitive with one another. The field of research known as "cooperative game theory" focuses on how rational players behave when they collaborate and take the interests of all players into account. The scope of WSN applications for non-cooperative game theory is rather large. Each node in non-cooperative game theory primarily optimizes its own utility rather than the networks as a whole by selling and buying consumer items in response to market pricing. However, in cooperative game theory, they maximize the overall network's return without sacrificing fairness and reach global pareto-optimum performance.

GAME THEORY

To put it simply, game theory is a set of mathematical tools developed to analyses competitive and cooperative settings. The goal of game theory is to determine the optimal course of action for each player and to identify stable outcomes. Games, the primary focus of game theory, are characterized as occurring whenever:

- At the very least, there are two participants (i.e.) Any entity, from an individual to a nation to a corporation to a biological species to a wireless node, can be a "player."
- There are many different tactics, or paths to take, that a player can take.
The winner of the game should be determined by the strategies employed by each participant.

The game has a set of number payoffs, one for each potential outcome. These payouts are indicative of the significance of the various participants' actions.

For all finite games, John Nash showed in 1950 that there exists a unique state of the game termed the Nash equilibrium. Nash equilibrium is a set of playable options for all players involved. No single participant may unilaterally alter her/his approach and expect to reap improved rewards. This idea has been extensively studied, as it is essential to the field of non-cooperative game theory. In 1994, John Nash, Reinhardt Selton, and John Harsanyi were awarded the Nobel Prize in economics, drawing more attention to game theory.

The following are common phrases that are linked to game theory.

Players: When there are two participants in a game, each is considered a "player," an agent that makes decisions within the context of the game.

Strategy: It's the move that a player makes in a game. A strategy game is one in which the player chooses an action from a set of options. A player's strategy in an extended form game is their exhaustive set of steps to take at each and every decision point.

There are two broad categories for strategies: pure and mixed. In this research, we use game theory to model the process of adjusting the transmission power of individual nodes in a homogeneous WSN while also taking their remaining energy into account. The connection between Game theory and WSNs is depicted in the following diagram.

There are N total participants, each of which may be a single node or a collection of them in a wireless sensor network. To put it simply, they are the game's primary decision-makers. A group of options (P) from which player I can choose. The strategy profile led to the next payoffs u1, u2, ui. Each player's approach affects the game's payoff function, which describes the maximum amount of money or utility that may be gained from the game. The results of adopting various approaches might vary. The players are the nodes or entities (decision-makers) that participate in the game. In order to participate, participants must carry out certain actions or manoeuvres. The action space represents the set of all feasible moves for player i.

Pi of player i. Suppose that p∈P is a strategy profile and i∈N is a player; then p∈Pi denotes player i’s action in p and p-i denote actions of other players except i. Different players have different tastes when it comes to action profiles. The acts of the other players have an effect on the player, and not only the player's own. Each play style in the game is given a concrete monetary value thanks to the ui utility function. It is assumed at the start of the game that all of the nodes are transmitting at full strength in order to discover their neighbors (Dohare et al., 2012). The most popular approach to foreseeing the results of a strategic interaction in the social sciences is based on the notion of Nash Equilibrium (NE), which is central to the theory of games. The NE action profile has the virtue that no single player may increase their pay off by diverging unilaterally from the power profile. Sometimes it's helpful to have access to yet another formulation for Nash equilibrium.
Utility refers to the degree of satisfaction that the decision-taker (node) obtains as a result of its activities. It is the ratio of the amount of energy expended in transmission to the expected number of successfully received bits. The preferences of each node are revealed by their utility function, which takes into account factors like connection, energy usage, and dependability. Since each sensor node knows only its own power level, neighbor count, perceived SINR from the environment, and channel condition, the problem can be viewed as an incomplete information non cooperative power and topology game, where the goal is to maximize the sensor nodes' individual payoffs while minimizing their collective costs. Once the network reaches the Northeast, nodes can no longer contribute to its growth in value on their own.

**ROUTING PROTOCOLS AND DATA DISSEMINATION IN WSN**

In WSNs, routing protocols are used to establish up a path or paths from sensor nodes to the sink. Due to their resource constraints, sensor nodes necessitate routing protocols with minimal overhead, which might arise from the passing and receiving of control messages. Dissemination strategies for large-scale wireless networks, data-centric routing, directed diffusion, adaptive routing, and other specialized routing mechanisms all fall under the umbrella of "routing and data dissemination."

All wireless sensor network routing techniques may be broken down into one of three categories: data-centric, location-based, or hierarchical. The idea of data aggregation is to merge information obtained from many sources. Most WSN routing methods use some kind of mechanism to reduce energy usage. The following diagram illustrates how routing protocols in WSN are implemented in practice.
CLUSTERING IN WSN

There is a common need for the nodes in a sensor network to form into groups. With the help of clustering, precious resources like frequency, bandwidth, power, and spectrum may be used more effectively, and hierarchical structures can be formed on the nodes. Some nodes in a cluster can serve watchdog responsibilities over other nodes in the cluster, allowing the network's health to be monitored and misbehaving nodes to be found. Only the nodes in a given cluster can choose a new routing and cluster-head node, while all other nodes must always use that node as a gateway before sending or receiving any data. The maximum distance between cluster leaders can be set to be less than the maximum range of communication between individual nodes.

CONCLUSION

In this research, we explore a game-theoretic model for power regulation in a homogeneous sensor network, factoring in the remaining energy of individual nodes. For the game model, we analyze connection and investigate the presence and uniqueness of routing and clustering.
All of the deployment options are evaluated based on how useful nodes are with and without leftover energy. The lowest possible transmission power is used to provide maximum utility. The addition of prevents the nodes from interfering with one another as a result of a single node's optimizing behavior. As a result of using less energy for transmission, the lifespan of the sensor nodes is effectively increased.

REFERENCES


