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The Study of Wireless Sensor Networks Using Cooperative Bargaining Game Theory Approach

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ABSTRACT

Game theory is a framework of mathematical tools to research on the complex interactions among interdependent rational players. In game theory the Nash equilibrium concept is the most important one. It theoretic approaches are cooperative and non-cooperative games. Game theory produces revolutionary changes in economics and important applications in sociology. Games can be a single round or repetitive and that the players enjoys in making his or her moves constitutes the player's "strategy". Rules govern the outcome for the set of moves taken by the players and outcomes produce payoffs for the various players which can be expressed by means of a payoff matrix. Cooperative Bargaining game concepts, theory and applications are mainly focusing on wireless sensor networks. It consists of a number of sensor nodes each with limited power energy, bandwidth, storage and processing capabilities. Clustering is the most important one of the basic approaches that offers a practical way of providing scalability and it's designing a large and dense sensor networks. Here one of the best approaches to enhance the survivability of WSN is to allow only some sensor nodes to be a cluster node, called cluster head, that to communicate all the information to the base station. In this paper we have proposed a Bargaining game theoretic approach for selecting a cluster head for every cluster in a group.

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INTRODUCTION

Wireless sensor networks is a fast growing and exciting research area that has attracted considerable research attention in the last few years. This is recent tremendous technological advances in the development of low-cost sensor devices equipped with wireless network interfaces interconnecting several hundred to a few thousand sensor nodes opens up several technical challenges and immense applications. Its applications of spanning several domains like military, medical, industrial, and home networks. Wireless sensor networks always moved from the research domain into the real world with the commercial availability of sensors with networking capabilities. Sensor networks require sensing systems that are long-lived and environmentally compatible. Unthread, unattended, self powered low-duty-cycle systems are typical.

Power consumption is often an issue that needs to be taken into accounts as a design constraint. The sensor node lifetime strongly depends on battery power. In practical cases, the wireless sensor node has a limited power source (<500mAh, 1.2v), and replenishment of power may be limited or impossible altogether. Battery operation for sensors used in commercial applications is typically based on two AA alkaline cells or one Li-AA all. It follows that power management and power conservation are critical functions for wireless sensor networks and one need to design power-aware protocols and algorithms.

To conserve energy, most routing protocols for wireless sensor networks employ certain technique to minimize the energy consumption. Routing protocols in WSNs are for setting up one or more paths from sensor nodes to the sink. These nodes in a sensor network often need to organize themselves into clusters. Each cluster elects a cluster head node, and routing is done along among the cluster heads (the remaining nodes always route packets through their cluster heads).

Game theory is a set of mathematical tools that to study the complex interactions among independent astute players. From the past decades, game theory has made a revolutionary impact on a wide number

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of disciplines ranging from economics, politics, philosophy (or) even psychology. The emergence of large-scale distributed wireless networks, as well as the recent interest in mobile flexible network where the nodes are autonomous decision makers has brought to surface many interesting game theoretic problems that arise from the competitive and cooperative interplay of the different wireless entities.

In a game theoretic framework, one can distinguish between two main categories:
(i) *Non Cooperative*: A node forwards information on behalf of another node
(ii) *Cooperative*: A node handles only its own communication

In this paper, we study coordination among the users, over the Bargaining game theory and we proposed a coordination method for target tracking in WSN based on cluster and Bargaining game theory. When a target moves to the sensing field, a cluster head volunteers invite its neighboring sensors to form a cluster. After detection, then the process of classification is carried in order to initiate target tracking. Last, all information in the process are gathered to perform tracking. The cluster heads receive the information from other nodes and transmit information to the base station these help them to maximize the overall network lifetime and provide a scalable network.

II. Related Work:

The approach of resource bargaining was also explored in the past for solving problems in different network domains. For instance, Liang *et al.* developed network dynamic resource allocation schemes with incomplete information, based on online test-optimization strategy. Mazumder *et al.* used the concept of bargaining in the context of packet-switched networks.

Kelly (1997) and Kelly *et al.* (1998) studied the authors considered the problem of charging and rate-allocation based on valuation of utility function.

Felegyhazi *et al.* addressed the problem of cooperation among different wireless sensor networks. The strategies of the owners of the networks are set if their nodes forward messages coming from other networks and if they ask other networks to forward their messages. It is assumed that sensors send messages periodically and synchronously to their respective sinks and these, in turn, send to their nodes a bit telling if the data collection was satisfactory. From this, nodes control their strategies to minimize their energy consumption and maximize the data collection rate.

III. Mathematical Model:

3.1 Cooperative Game Theory And Bargaining:

Game theory is a set of mathematical tools that are useful in analyzing the decision problems with interactions among self-interested decision makers, called players. The normal form of game theory is a 3-tuple Γ= { N , X, P}. Here Γ is a particular game, where N={ $n_1, n_2,.....n_n$ } is a finite set of the players (sensor nodes), X = { $x_1, x_2,....... x_n$ } is the set of actions available to players (set of strategy space of the sensor node), X_i (i =1,2,3,….n) is the set of actions available to player i , $X = X_1 \times X_2 \times ...... \times X_n$, and P= { $p_1, p_2,.... p_n$ } is the corresponding payoff function of player(node), p_i is a utility value of each player i (node) at the end of an action.

In a non –cooperative game theory, we focus on the individual player's strategies and their influence on payoffs, and try to predict what strategies players will choose (Equilibrium concept). In a cooperative game theory, we abstract from individual player's strategies and instead focus on the coalition may attain some payoffs, and then we try to predict which coalitions will form (and hence the payoffs agent obtain). So a cooperative game is a game in which the players have complete freedom of prepay communication to make joint binding agreements. These agreements may be of two kinds to coordinate strategies or to share payoffs.

In 1950's John Nash recognized that in non-cooperative games there exist sets of optimal strategies (so called Nash equilibrium) used by the players in a game such that no player can benefit by unilaterally changing his or her strategy if the strategies of the other players remain unchanged. John Nash wrote in his seminal paper on cooperative games that to understand the outcome of a bargaining game, we should not focus on trying to model the bargaining process itself, but instead, we should list the properties, or axioms, that we expect the outcome of the bargaining process to exhibit.

In a bargaining problem, there is a set of possible allocations, the *feasible set* F , and one of them has to be chosen by the players. Importantly, all the players have to agree on the chosen allocation; otherwise, the realized allocation is $\overline{d}$, the *disagreement point.*

Definition 1:

An *n*-player bargaining problem with set of players N a pair (F , d) whose elements are the following:

Feasible set: F is the comprehensive hull of a compact and convex subset of $\Re^N$.

Disagreement point: d is an allocation in F . It is assumed that there is $x \in F$ such that $x > d$.

We denote the set of n-player bargaining problems by B^N . Moreover, given a bargaining problem $(F, d) \in B^N$, we define the compact set $F_d = \{x \in F : x \geq d\}$.

Given two allocations x, $y \in F$, we say that x is *Pareto dominated* by y or that y Pareto dominates x if $x \leq y$ and $x \neq y$ (i.e.) for each $i \in N$, $x_i \leq y_i$, with strict inequality for at least one player. An allocation $x \in F$ is *Pareto efficient* in F, or just efficient, if no allocation in F Pareto dominates x.

Definition 2:

An *allocation rule* for n-players bargaining problems is a map $\phi : B^N \rightarrow \Re^N$ such that, for each $(F, d) \in B^N$, $\phi(F, d) \in F_d$.

To determine the bargaining solutions, the following allocation rules are important to calculate the utility space:

Let ϕ be an allocation rule and consider the following properties we may impose on it.

(1) ***Pareto Efficiency (EFF)***: The allocation rule ϕ satisfies EFF if, for each $(F, d) \in B^N$, $\phi(F, d)$ is a Pareto efficient allocation.

(2) ***Symmetry (SYM)***: Let π denote a permutation of the elements of N and $x \in \Re^N$, let x^π be defined, for each $i \in N$, by $x_i^\pi = x_{\pi(i)}$. We say that a bargaining problem $(F, d) \in B^N$, is symmetric if, for each permutation π of the elements of we have that (i) $d^\pi = d$ and (ii) for each $x \in F$, $x^\pi \in F$

Now ϕ satisfies SYM if, for each symmetric bargaining problem $(F, d) \in B^N$, we have that, for each pair $i, j \in N$, $\phi_i(F, d) = \phi_j(F, d)$.

(3) ***Covariance with positive affine transformations (CAT)***: $f^A : \Re^N \rightarrow \Re^N$ is a positive affine transformation if, for each $i \in N$, there are $a_i, b_i \in \Re$, with $a_i > 0$, such that, for each $x \in \Re^N$, $f_i^A(x) = a_i x_i + b_i$. Now ϕ satisfies CAT if, for each $(F, d) \in B^N$ and each positive affine transformation f^A, $\phi(f^A(F), f^A(d)) = f^A(\phi(F, d))$.

(4) ***Independence of irrelevant alternatives (IIA)*** : ϕ satisfies IIA if, for each pair of problems $(F, d), (\hat{F}, d) \in B^N$, with $\hat{F} \subset F$, $\phi(F, d) \in \hat{F}$ implies that $\phi(\hat{F}, d) = \phi(F, d)$.

The four properties above are certainly appealing. EFF and SYM are very natural and CAT states that the choice of the utility representations should not affect the allocation rule. If the feasible set is reduced and the proposal of the allocation rule for the original problem is still feasible in the new one, then the allocation rule has to make the same proposal in the new problem.

Definition 4:

If $(F, d) \subset B^N$ and let $g^d : \Re^N \rightarrow \Re$ be defined, for each $x \in \Re^N$, by $g^d(x) = \Pi_{i \in N}(x_i - d_i)$, i.e., if $x > d$, $g^d(x)$ represents the product of the gains of the players at x with respect to their utilities at d.

Theorem 1:

Let $(F, d) \in B^N$. Then, there is a unique $x \in F_d$ that maximizes the function g^d over the set F_d.

Proof:

Since g^d is continuous and F_d is compact, g^d has a maximum in F_d. Suppose that there are, $z, \hat{z} \in F_d$, with $z \neq \hat{z}$, such that $\max_{x \in F_d} g^d(x) = g^d(z) = g^d(\hat{z})$.

Far, each $i \in N$, $z_i > d_i$ and $\hat{z}_i > d_i$. By the convexity of F_d, $\bar{z} = \frac{z}{2} + \frac{\hat{z}}{2} \in F_d$.

We now show that $g^d(\bar{z}) > g^d(z)$, which is a contradiction with the fact that z is a maximum.

We have that $In(g^d(\bar{z})) = \sum_{i \in N} In(\bar{z}_i - d_i) = \sum_{i \in N} In\left(\frac{z_i - d_i}{2} + \frac{\hat{z}_i - d_i}{2}\right)$, which , by the strict concavity of the logarithmic functions, is strictly larger than

$$\sum_{i \in N}\left(\frac{1}{2} In(z_i - d_i) + \frac{1}{2} In(\hat{z}_i - d_i)\right)$$

$$= \frac{1}{2} In(g^d(z)) + \frac{1}{2} In(g^d(\hat{z})) = In(g^d(z))$$

and hence $g^d(\bar{z}) > g^d(z)$.

Definition 5:

The Nash solution is defined for each bargaining problem $(F, d) \in B^N$ by $NA(F, d) = z$, where $g^d(z) = \max_{x \in F_d} g^d(x) = \max_{x \in F_d} \pi_{i \in N}(x_i - d_i)$.

Theorem 1 ensures that the Nash solution is a well defined allocation rule. Given a bargaining problem $(F, d) \in B^N$, the Nash solution selects unique allocation in F_d that maximizes the product of the gains of the players with respect to the disagreement point.

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3.2 Cooperative Cluster Head Scheme:

The cluster head nodes cooperate and joined among themselves to transmit data cooperatively rather than selecting the cooperative sending and receiving groups in each cluster and are shown in the Figure 1.

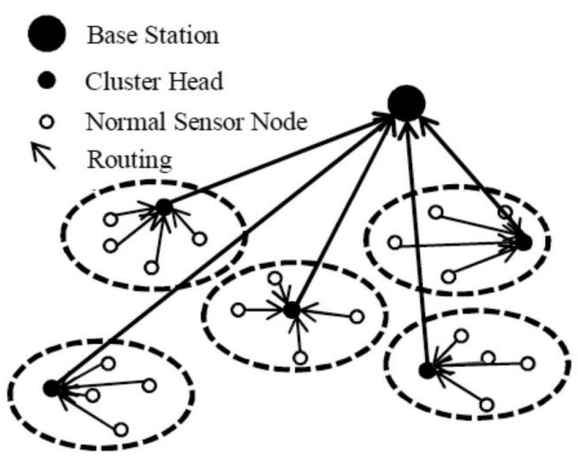

Fig. 1: Cluster Head structure in WSN.

Network lifetime and node's trust is another main issue in WSN. The nodes captured the opponents and behave as malicious nodes, and directly attack the network by misreporting, modifying useful data packets. The trust based work reduces the packet loss and routing overhead by eliminating the compromised nodes and is considered in the design of the game.

Each cluster elects a cluster-head node, and routing is done only along the cluster-heads and the remaining nodes always route packets through their cluster-heads. This is most advantageous for calculating the possibilities of simpler communication protocols within a cluster and recycling of resources such as frequency assignments among not joining the clusters, and saving power.

3.3 Cluster Head Game:

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 π value, this will encourage node having maximum π value within neighbors to win the game. Each node's π value is calculated by the equation as follows:

$$\pi_i = \alpha \frac{E_i}{E_{init}} + \beta R_i - \gamma n \quad (1)$$

Where

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

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

γ 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.

After the cluster formation, each cluster head selects one cooperative sending and receiving nodes for cooperative MIMO communication. The selection of cooperative nodes take part in MIMO communication is modeled as a bargaining game and bargaining is done based on the residual energy of the nodes. These sensor nodes are the players and the game is choosing the set of nodes for cooperative transmission and reception. The purpose of this grouping is to reduce the total power consumption and increase the energy efficiency.

RESULTS AND DISCUSSION

In this phase each cluster head gets paired with other cluster head sensors and transmits data cooperatively together with the node which senses information transmits the data to the cluster head within its cluster. Then the cluster head broadcasts the data to 'J' cluster head nodes which compose the distributed array. Each node in the transmitting cooperative group has data and encodes the transmission sequence according to Space Time Block Coding as if each node were a distinct transmit antenna element. The cluster sensor node sends its data to the selected cooperative node, and they encode the data using Space Time Block Coding and transmit the encoded data to the sink

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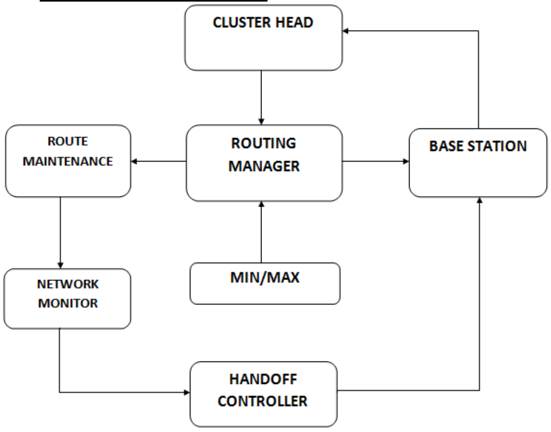
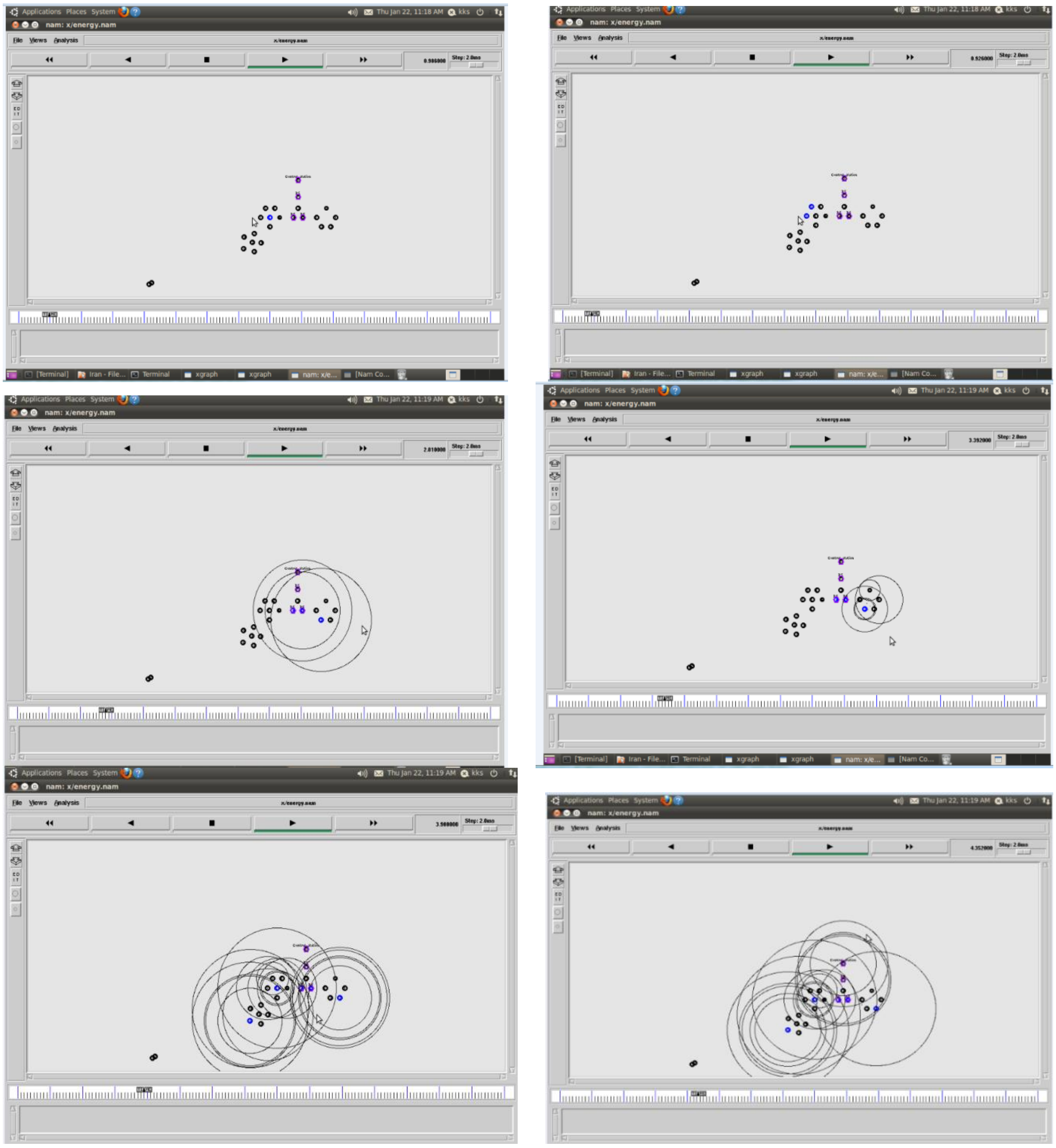
cooperatively bargaining. The following figure shows that the number of nodes alive for each and every round of data transmission. The performance of cluster head scheme is analyzed in terms of energy consumption.

CLUSTER HEAD SELECTION:





V. Conclusion:

This paper shows that an energy efficient cooperative technique termed as cluster head cooperative bargaining Trustworthy Energy Efficient routing algorithm based on game theory is proposed for wireless sensor networks were selected and numbers of cluster heads are used to form a structure. Game theory is used to elect cluster heads and select the cooperative nodes for cooperative communication. This result shows that the proposed cooperative bargaining performs better and extends the data transmission and saves more energy.

REFERENCES

Agnihotri, S., P. Nuggrhalli and H.S. Jamadagani, 2005. On maximizing lifetime of a sensor cluster", in Proc.6th IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks, pp: 312-317.

Akyildiz, I.F., W. Su, Y. Sankarasubramaniam and E. Cayirci, 2002. "A survey on sensor networks", IEEE Commun. Mag., 40(8): 102-114.

Al-Karaki, J.N. and A.E. Kamal, 2004. "Routing techniques in WSNs: Asurvey", IEEE Wireless Communication, pp: 6-28.

Binmore, K.G., A. Rubinstein and A. Wolinsky, 1986. "The Nash bargaining solution in economic modeling",Rand J. Econ., 17(2): 176-188.

Chang, J.H. and L. Tassiulates, 2004. Maximum lifetime routing in WSNs IEEE/ACM Trans. Networking, 12(4): 609-619.

Gengzhong Zheng, 2010. Study on the power control of wireless sensor networks based on Game theory"- Journal of Information and computational science, 7(4): 957-964.

John, J., F. Nash, 1950. "The bargaining problem", Econometrica, 18(2): 155-162.

Kelly, F., 1997. "Charging and rate control for elastic traffic", Eur. Trans. Telecommunication, 8: 33-37.

Kelly, F., A. Maulloo and D. Tan, 1998. " Rate controlin communication networks: Shadow prices, proportional fairness and stability", Journal of operation Research Society, 49: 37-252.

Metha, S. and K.S. Kwak, "Application of game theory to wireless sensor networks"- Inha university, korea.

Nash, J.F., 1950. "Equilibrium points in n-person game" Proc. Natl. Acad. Sci. U.S.A., 36(1): 48-49.

Osborne, M.J. and A. Rubibstein, 1994. "Acourse in Game Theory", Cambridge, MA: MIT Press.

Von Neumann and Morgenstern, 1953. "Theory of Games and Economic Behaviour.

Zhou, Z., S. Zhou, S. Cui and J.H. Cui, 2006. "Energy-efficient cooperative communication in clustered WSNs", in. Proc. IEEE Military Communication Conference, pp: 1-7.

Zwick, R. and C.C. Lee, 1999. " Bargaining and search: An experimental study", Group Decision Negotiation, 8(6): 463-487.