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STUDY ON CO OPERATIVE AND NON – COOPERATIVE GAME THEORY TECHNIQUES IN WIRELESS SENSOR NETWORKS

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ABSTRACT

This paper focuses on the occurrence of Cooperative and Non-cooperative Game Theory techniques and their applications in Wireless Sensor Networks. The CANGT is one of the classical combinatorial optimization problems and is known for its diverse applications. This paper aims at describing the state of the art of Cooperative and Non - Cooperative Game Theory Techniques in wirelesssensor networks. In recent years, wireless communication has experienced exponential growth caused by the need for connectivity. Wireless sensor networking is a broad research area, and many researchers have done research in the area of power efficiency to extend network lifetime. A node can easily transmit data to a distance node, if it has sufficient battery power. For maximizing the lifetime of network, the data should be forwarded such that energy consumption is balanced among the nodes in proportion to their energy reserved, instead of routing to minimize consumed power. And this can be achieved using CANGT.

Keywords: *Cooperative GameTheory, Non cooperative Game Theory, Formulation, Power management and Wireless Sensor Networks.*

1. INTROUCTION

Game theory is divided into two branches, called the non-cooperative and cooperativebranches. The payoff matrices we have been looking at so far belong to the non-cooperative branch. Now, we are going to look at the cooperative branch. The two branches of game theory differ in how they formalize interdependence among the players. In the non-cooperative theory, a game is a detailed model of all the moves available to the players. By contrast, the cooperative theory abstracts away from this level of detail, and describes only the outcomes that result when the players come together in different combinations. Though standard, the terms non-cooperative and cooperative game theory are perhaps unfortunate. They might suggest that there is no place for cooperation in the former and no place for conflict, competition etc. in the latter. In fact, neither is the case. One part of the non-cooperative theory (the theory of repeated games) studies the possibility of cooperation in ongoing relationships.And the cooperative theory embodies not just cooperation among players, butalso competition in a particularly strong, unfettered form Wireless sensor network (WSN) consists of low-power, low-cost, and energy – constrained sensor responsible for monitoring a physical phenomenon and reporting to access points where the end – user can access the data. In manyapplications, it is undesirable or infeasible to replace or recharge sensors. Hence, the network lifetime becomes a critical concern in the design of WSNs. While various energy-efficient protocols have been proposed to prolong network lifetime, lifetime analysis is notoriously difficult since the network lifetime depends on many factors including network architecture and protocols, data collection initiation, lifetime definition, channel characteristics, and energy consumption modal. Upper bounds on lifetimes are thus derived for various WSNs. In the recent advances in Min – Electro – Mechanical System (MEMS) technology, wireless communications, and digital electronics, WSNs have become increasingly one of the most promising and interesting areas in the past years. WSNs may be very large systems, which are comprised of small sized, low power, low- cost sensor nodes that collect information about the physical environment in detail.Due to the self-organization and fault- tolerance characteristics, WSNs can be expected to many applications. Theauthors in have classified the applications of WSNs as military applications, environmental applications, health applications, home applications, and other commercial applications. In the future, this widespread range of application areas will make WSNs an integral part of our lives. (Aumann, R., "Game Theory," in Eatwell, J., Milgate, M., and P. Newman, The New Palgrave, New York, Norton, 1989.

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II. GAME THEORY FORMULATION

Game theory is a branch of applied mathematics that deals with multi-person decision-making situations. It is devised for the purpose of accounting for interactions among strategies of rational decision makers, and it is essential for determining a preferred strategy where such interactions are in play. A game generally consists of a set of players, a set of strategies for each player, and a set of corresponding utility functions. A strategy for a player is a complete plan of actions in all possible situations throughout the game. In any games, the players try to act selfishly to maximize their consequences according to their preferences. These preferences are expressed by a utility function, which maps every consequence to a real number. Nash equilibrium is a solution concept that describes a steady state condition of the game; no player would like to change his strategy unless there is a better strategy that can result in more utility that is favorable for the player current.

The normal form of a game is given by a tuple

$$G= (I, S, U), \tag{1}$$

Where G is a particular game, I is a finite set of players,

$$S = \{S_i\}, \tag{2}$$

Where Si is the set of strategies for each player $i \in I$, and

$$U=\{u_i\} \tag{3}$$

is the set of utility functions that the players wish to maximize. For each player i, the utility function u_i, is a function of the particular strategy chosen by player i, s_i, and the particular strategies chosen by all of the other players in the game, s_{-i}. From this model, Nash equilibrium is identified wherein no player will rationallychoose to deviate from his chosen strategy otherwise he will diminish his payoff, i.e.,

$$u_i(s_i, s_{-i}) \geq u_i(s_i', s_{-i}), \tag{4}$$

for all $s_i' \in S_i$

WSNs consist of thousands of sensor nodes and may be dispersed over a large area. Typical sensor nodes are of limited communication and computing capabilities, and are powered by batteries. WSNs and provide a secure routing, the authors in formulate the cooperative and non-cooperative game theory problem as a two-player, nonzero-sum, and non-cooperative game between the attacker and the WSNs. The game is formulated as follows. With respect to one fixed low-power sensor node k, the low-power sensor node has three strategies: (AS_1) low power sensor node k, (AS_2) does not low power, or (AS_3) low power sensor node a different sensor node. Correspondingly, the WSNs have two strategies: (SS_1)defend sensor node k, or (SS_2) defend a different sensor node. The payoffs of these two players are expressed inthe form of 2×3 matrices A and B, which denote theWSNs' and the low power's payoffs respectively. The authors define $U(t)$ to be the utility of WSNs' ongoing sessions, AL_k to be the average loss of power sensor node k, $C_k$to be the average cost of defending sensor node k, and $N_k$to be the number of sensor nodes communicating with low power sensor node k. Then the WSNs' payoff matrix $A= [a_{ij}]$ is defined as

$$\begin{bmatrix} \mathbf{U(t)-C_k} & \mathbf{U(t)-C_k} & U(t)-Ck-?_{(i=1)}^{(N_k)}??\,AL\,?_k \\ U(t)-Ck-?_{(i=1)}^{(N_k)}??\,AL\,?_k & \mathbf{U(t)-C_k} & U(t)-Ck-?_{(i=1)}^{(N_k)}??\,AL\,?_k \end{bmatrix}$$

where a_{11}represents (AS_1, SS_1) when the low power and the WSNs choose the same sensor node k, to attack and to defend respectively; a_{12}represents (AS_2, SS_1) when the attacker does not attack at all, but the WSNs defend sensor node k; a_{13}represents (AS_3, SS_1) when the low power sensor node k', but the WSNs defend sensor node k; a_{21}represents (AS_1,SS_2) when the low power senornode k, but the WSNs defend low power sensor node k'; a_{22}represents (AS_2, SS_2) when the low power does not, but the WSNs defend low power sensor node k'; a_{23} represents (AS_3, SS_2) when the low powersensor node k'', but the WSNs defend a different low power sensor node k'. To calculate the attacker payoff matrix, theauthors define three parameters: CW to be the cost ofwaiting and deciding to attack in the future; CI to be thecost of intrusion for attacker; $PI(t)$ to be the average profitof each attack. Then the attacker's payoff matrix $B= [b_{ij}]$ is defined as

$$\begin{bmatrix} PI(t)-CI & CW & PI(t)-CI \\ PI(t)-CI & CW & PI(t)-CI \end{bmatrix}$$

Where b_{11} and b_{21} represent the low power sensornode k; $b_{12}$and b_{22}represent the does not low power any nodes; b_{13} and b_{23}represent the low power thedifferent sensor nodes rather than sensor node k. The authors prove that the game has Nash equilibrium at strategy pair (AS_1, SS_1)

III.WIRELESS SENSOR NETWORKS (WSN) NETWORK

In Telecommunications, a network refers to a connection of devices such as telephones, computer switches and printers. A node is where a number of connections meet at a common point within the network. Nodes in general are complex structures and in order to ensure the smooth flow of information through the node, the equipment at the node must operate to well defined rules or what is referred to as a protocol. Some of the networks in common use are:

i) Local Area Network (LAN): connects devices that are close geographically. eg. in the same building.
ii) Wide Area Network (WAN): connects devices that are well separated geographically. eg. long distances telephone lines or radio may have to be used for the connections.
iii) Metropolitan Area Network (MAN): Designed for use in a town or city.
iv) Campus Area Network (CAN): Designed for operations in a campus such as a military campus or the campus of an educational establishment.
v) Home Area Network (HAN): Designed to connect together devices in a person's home.eg. computers and printers.

Wireless Sensor Networks (WSN)

A Wireless Sensor Network (WSN) is a network of thousands of small low-cost sensor nodes whose communications with a central station are conveyed by means of wireless signals. The sensor network consists of the sensor fields, sensor nodes, sink and Task manager.

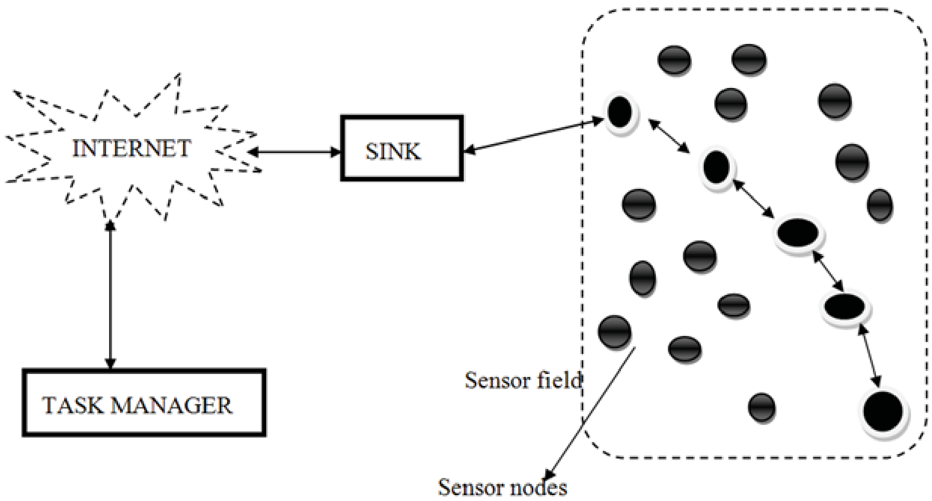

Figure-1: Components of a wireless sensor network

i. Sensor field: It is the region where the sensor nodes are scattered.
ii. Sensor Nodes: They collect data and route data back to the sink and the end users. Data are routed back to the end user by a multichip infrastructure less architecture through the sink. Therefore they are the heart of the network.
iii. Sink: It is a sensor node with the specific task of receiving, processing and storing data from the other sensor nodes. The sink may communicate with the task manager node via Internet or satellite.
iv. Task Manager : It is also known as base station which extract information from the network and disseminates control information back into the network. The base station is either a laptop or a workstation.

Sensor nodes in WSN mainly use a broadcast communication paradigm where the sensor signals are used in further analysis of the sensed environment. WSN is preferred as the sensor system architecture with regard to its inherent redundancy but is susceptible to disadvantages caused by limited operation life-time.

The first WSN was designed and used in 70s, in military held during the Vietnam war. WSN consist of nodes, from few to several one, which work together to capture data from an environment region and send this data to a base station. These sensor nodes uses to track and monitor heat, temperature, vibratory movement, etc. They are small with limited computing resources and base on arouting algorithm, they can transmit data to the user.

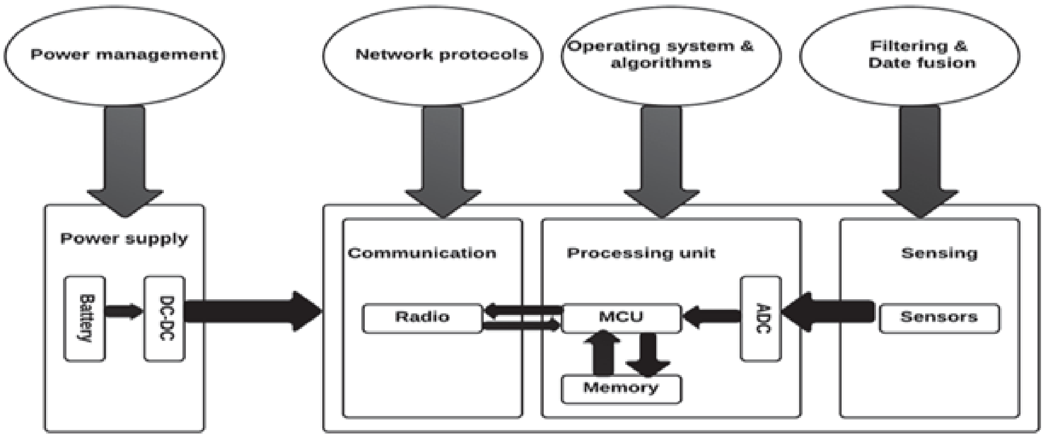

Figure-2: Wsn sensor node system architecture

MODELS OF WIRELESS SENSOR NETWORKS

Sensor nodes used in wsn can be fixed or mobile. So, accordingly to this wsn's can be classified into two types:
a) Static Wireless Sensor Networks
b) Mobile Wireless sensor networks

a) Static Wireless Sensor Networks
Static wireless sensor network, have all nodes fixed at one place. i.e there is no motion among the nodes placed in the sensor networks. This type of network model is reliable, easy to implement. To communicate between two nodes is simple as all the nodes are static.

b) Mobile Wireless Sensor Networks
In mobile wireless sensor networks nodes are mobile .i.e. nodes can move from place to place. Due to which communication between two nodes can be very complicated. Routes selected for communication also have to change with respect to movement of nodes. Node which has to transfer the data called source node and node to which the data has to be sent is called sink node. But MWSNs are more advantageous over static WSNs.

IV. MOTIVATIONS

Wireless Sensor Networks (WSN s) are large-scale, dynamic and limited in Power. This WSN s can be used for various applications such as military, environmental, health, home and other commercial applications. With the high degree of deployment flexibility, applications of WSN are vast and can be broadly classified into the monitoring and tracking categories.

Monitoring applications include environmental monitoring such as forest fire detection, bio complexity mapping of the environment, flood detection, precision agriculture, health monitoring contains role-monitoring of human physiological data, monitoring doctors and patients conditions and drug administration in hospitals.

Tracking applications include objects, animals, humans, vehicles and military enemy tracking. For example, in a battle field, a commander can be aware of the status of Friendly troops or the availability of equipment by sing the sensor networks. Another application is forest fire early detection system. Smoke or temperature sensors can be deployed into a fire-susceptible forest area to detect a forest fire on its early stage. Lastly the technology of WSN also can be used in health applications. The physiological data are collected by wireless sensors are stored fora long period and used for medical exploration. Hence in the future this wide range of applications will make sensor networks an integral part of our lives. We categorize the applications into military; environmental, health and home application.

V. APPLICATIONS

A. Military Applications: Wireless sensor networks can be an integral part of military command, control, communication, computing, intelligence, surveillance and targeting (C4ISRT) systems. The rapid deployment, fault tolerance and self-organization characteristics of sensor networks make them a very promising sensing technique for military (C4ISRT). Since sensor networks are based on dense deployment of disposable and low cost sensor nodes, destruction of some nodes by hostile actions does not affect military applications as much as the destruction of traditional sensor, which makes sensor networks concept a better approach for battlefield.

B. Environmental Applications: Some environmental applications of sensor network include tracking the movement of birds, small animals and insects; monitoring environmental conditions that affect crops and livestock, irrigation, macro instruments for large scale earth monitoring and planetary exploration; chemical/biological detection; precision agriculture; biological, Earth and environmental monitoring in marine, soil and atmospheric contexts; forest fire detection and meteorological and geophysical research; flood detection; bio complexity mapping of the Environment and pollution study.

C. Health Application: Some of the applications are providing interfaces for the disabled; integrated patient monitoring; diagnostics; drug administration in hospital; monitoring the movements and internal process of insects or others mall animals; telemonitoring of human physiological data; and tracking and monitoring doctors and patients inside a hospital.

D. Home Applications: Home automation; as technology advances, smart sensor nodes and actuators can be buried appliances, such as vacuum cleaners, micro wave ovens, refrigerators and VCRs. These sensor nodes inside the domestic devices can interact with each other and with external network via the internet or satellite. They allow end users to manage home devices locally and remotely more easily.

VI.CONCLUSION

The field of WSNs is a very important research area. Due to the limited capabilities of sensor nodes, providing security to sensor networks is a challenging task, however, there are not popular applications of WSNs without considering WSNs. Sensor Networks hold a lot of promise in applications where gathering sensing information in remote locations is required. It is an evolving field, which offers scope for a lot of research. Their energy-constrained nature necessitates us to look at more energy efficient design and operation. We have done a survey on the various issues in sensor networks like energy efficiency, routing and localization and the various schemes proposed for these issues and have given brief descriptions of these schemes. Further work is necessary in the areas of media access control, security and privacy. Traditionally, communication energy has been a major part of a node's energy consumption. But, with the necessity of implementing high-consuming sensors in WSNs, sensing unit has to also be driven carefully. Real-life implementations of these WSNs require autonomy of several years, with battery power supply. Thus, energy resources should be managed judiciously with energy consumption reduction on the sensor level, node level and network level.

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