# Game Theory Based Survey on Energy-Efficient Routing Protocols in Wireless Sensor Networks

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#### Abstract

Remote Sensor Networks (WSNs) are comprised of little lowpower hubs that are utilized in various regions like condition observing and a few military and regular citizen applications. Yet, because of its little size and restricted vitality source, vitality effectiveness is its fundamental zone of concern, and numerous strategies have been created to improve its organization lifetime. Game Theory is being utilized in WSNs to improve the vitality productivity of an organization and its lifetime. Game Theory is appropriate for such issues as it tends to be utilized in hub or organization level to energize the dynamic abilities of WSNs. This review paper centers around various kinds of grouping conventions planned in WSNs utilizing Game Theory to battle the issue of vitality effectiveness. Specifically, we address the methodologies by which Game Theory has been utilized in WSNs to improve its organization lifetime including the games utilized in every convention.

**Keywords** Wireless sensor networks Game Theory Energy Efficiency Clustering.

## I.INTRODUCTION

Remote Sensor Networks (WSNs) join countless correspondence hubs with confined detecting, handling, and computational capacities [1]. WSNs are being utilized in different applications, in actuality. WSNs have utilizes running from basic social issues, for example, observing of condition and territory, traffic worldwide position framework (GPS), health related crisis, and wellbeing administrations to financial issues like creation control and structure checking [2]. Be that as it may, there is consistently an asset limitation because of the nature and property of WSNs. There is

consistently instability because of its remote nature, and there are numerous vitality related inadequacies because of its capacity constraint. There are numerous difficulties to make the organization proficient to drag out organization lifetime alongside its own applications because of its requirements. Directing includes finding the ideal method to communicate information from source to objective hubs in the organization. Because of its little hubs, network lifetime is one of its most significant variables. Subsequently, directing consistently includes power the executives in its cutting edge while planning conventions. Many steering conventions use bunching or various leveled way to deal with limit the utilization of vitality during information transmission. Bunching includes making a bunch or gathering of groups to communicate information from source to objective hubs in the organization. Game Theory is utilized in different backgrounds in various applications in various sciences. It has additionally been utilized in WSNs. It is utilized for various angles in WSNs like relieving egotistical hubs, giving games to expand proficiency, planning steering conventions, security conventions. We can discover numerous works have been conveyed out utilizing Game Theory to improve various viewpoints in WSNs. Game Theory came into reality as a part of financial matters. It is a numerical model used to inspect just as anticipate the activities of judicious and egotistical people. This paper contemplates existing proposed game models utilized for planning grouping calculation with vitality productivity as the fundamental concern which further prompts vitality productive steering in WSN.

#### **II. GAME THEORY**

Game Theory was initially utilized in financial aspects to settle on choices in questionable conditions. It gives numerical strategies to dissecting the circumstances and foreseeing the future dependent on the choice taken by singular player. A game is a tuple <N, S, U>, where N: set of players,

S: a lot of activities/methodologies for every player and U: utility or result work.

Every player has certain methodology with which he plays the game, and it is characterized in set S. Every methodology will comprise of some activity plan which covers conceivable circumstances that can come up in a game. An utility in a game is the players' motivating force for playing that system. It depicts the players' inclination and allocates a few result for every system, and the result with a bigger worth is the one that is supported. A Nash Equilibrium is an answer in a game with the end goal that the activities of the players do not change regardless of whether it knows the system of different players as it doesn't improve its utility.

## (i)Types of Games

There are various types of games, and its grouping is appeared in Fig. 1. A brief depiction of every one of the sorts is given underneath:



## Fig. 1 Types of Games List

Helpful and Non-agreeable Games: The game wherein every player knows the procedures of different players and

chooses the system that favors all the players is known as helpful games, though non-agreeable games will be games in which nobody helps out one another and each player is attempting to augment their own benefit.

Typical Form and Extensive Form Game: Normal structure games will be games in which the adjustments just as techniques utilized in a game are appeared in an even arrangement. It tends to be utilized to discover techniques that are ruled just as in Nash Equilibrium. The broad structure game is where the depiction of game is done in a choice tree structure. It helps in occasions chose by some coincidence. Synchronous Move and Sequential-Move Games: Simultaneous-move games are games in which the players embrace the system at the same time. Every player is unconscious about the methodology of another player, while in consecutive move games comprise of games where players come to know procedure of prior players. Lose-lose and Nonzero-Sum Games: Zero-aggregate games will be games in which one player's benefit adds up to another player's misfortune, and consequently, the entirety of results is continuously zero, though in nonzero-total games, the aggregate of results isn't zero.

Symmetric and Asymmetric Games: Symmetric games will be games in which the procedure received by all players is same. Here, the settlements rely upon the procedure of the game. Hilter kilter games will be games where players receive various methodologies. Here, the adjustments rely upon the player. Most games, all things considered, are non-helpful ones where every hub just thinks about itself and its organization lifetime. There are additionally agreeable ones where hubs concur with one another to build adjustments. Numerous writing has demonstrated the utilization of nonagreeable games in WSNs where vitality effectiveness becomes most extreme significance. Consequently, in such circumstance, hubs will not squander additional vitality and moderate its vitality by not taking an interest all the while. So the narrow minded hubs are boosted by offering greater adjustments. Additionally, now and again, egotistical hubs are likewise rebuffed as surrendered hubs are doubly rebuffed to demoralize egotistical hubs from surrendering.

## (ii) Games Used for Energy Efficiency in WSN

WSNs are comprised of sensors with restricted vitality gracefully so the sensors should be ready to oversee vitality proficiently while additionally limiting its utility and finishing its appointed work by imparting in the organization. There are various games and approaches taken by the papers in this overview to improve its vitality effectiveness contrasted with past conventions. There are various games additionally utilized in these papers to accomplish required outcomes. From [3], it is seen that the accompanying Game Theory strategies have been utilized to figure games in WSN:

- (I) Cooperative and non-helpful game
- (ii) Repeated game
- (iii) Coalitional game
- (iv) Evolutionary game
- (v) Gur game
- (vi) Bargaining game
- (vii) Bayesian game
- (viii) Transferable and non-adaptable utility game
- (ix) Zero and nonzero games
- (x) Ping-Pong game
- (xi) Jamming game

There have been many exploration papers in WSN identified with Game Theory. Non-helpful game is the game which intently looks like the genuine circumstance as every hub is narrow minded. Non-agreeable Game Theory reviews the connection among contending players, where every player separately chooses its technique and each player will likely expand its utility or decrease of its expense. In the study, Nonhelpful games have been utilized to discover Nash Equilibrium under inadequate data and in one where each hub speaks with one another. In another non-agreeable game, a Subgame Perfect Nash Equilibrium is utilized to choose Bunch Heads. Helpful game is one in which alliances are shaped by gathering of players, and these players attempt to fortify their game situation by finding an alliance and go about as a solitary substance by righteousness of an understanding. In one, agreeable game is utilized to discover Nash Equilibrium. Coalitional Game Theory is utilized in another to shape alliances to communicate information. Transformative Game Theory (EGT) is another methodology. Here, a few methodologies in the game program the players. From enormous populace, irregular players are attracted consistently and made to play the same unadulterated or blended techniques. The result incorporates the individual wellness or anticipated number of enduring posterity. Bayesian game is additionally utilized in another approach. In it, we pick the Cluster-Head among rich hubs and helpless hubs through a Bayesian game. In it, Bayesian Nash Equilibrium is reached through Bayesian games.

#### **III. Related Works**

In this segment, we present methodologies and conventions utilized by scientists to improve the vitality productivity in WSNs utilizing Game Theory. Koltsidas and Pavlidou [4] figured a grouping component called Clustered Directing for Selfish Sensors (CROSSs) which has the basic perspective as the irregular pivot of Cluster-Head's function for the objectives of vitality adjusting, in view of the soundness and narrow-mindedness of the sensor hubs in the organization. In this paper, bunching game (CG) is utilized with an utility capacity that includes a result of 0 to a hub in the event that everything hubs don't take an interest and an utility of v-c in the event that it turns into a Cluster-Head and v for a hub in the event that it doesn't turn into a Cluster-Head vet some other hub is one (where c is the cost of turning into a CH and v is the addition sum for fruitful information transmission to Base Station). It is an instance of blended procedures Nash Equilibrium. In this, the players select their procedure succeeding a likelihood dissemination. haphazardly Consequently, the hubs register the likelihood of turning into a CH. Furthermore, haphazardly a few hubs pronounce themselves as CHs and ready others with the goal that different hubs can send information to the closest CH. CHs along these lines total and send the information to the sink. It is at that point rehashed. Zero Probability Rule (ZPR) is likewise used to set the likelihood of hubs that have been CHs to zero until each neighbor has been a CH, and afterward, it switches back it to typical. Notwithstanding, the paper accept that each sensor speaks with every single other sensor.

Xie et al. [5] detailed another calculation and named it as Localized Game Hypothetical Clustering Algorithm (LGCA). In this methodology, vitality effectiveness is improved by utilizing Game Theory (blended procedure Nash Equilibrium) and a rehashed grouping game. The game and utility capacity is like the [4], i.e., Clustering game. It varies however because of the way that in it, each hub plays a grouping game all alone and furthermore joins the rounds of their neighbors' to get its harmony likelihood. This assists hubs with pronouncing themselves as CHs. It likewise utilizes Carrier Sense Various Access with Collision Avoidance (CSMA/CA) system as shirking of closeness between two CHs. Its downside is that it expected that each hub's boundary is the equivalent. Additionally, different significant boundaries like hub degree, leftover vitality, and separation to Base Station (BS) are not of worry in this paper. Likewise, last CHs ought to have more inclination toward incredible hubs rather than any hubs.

Yang et al. [6] proposed a half and half appropriated grouping convention dependent on Game Hypothesis called HGTD (Hybrid, Game Theory based and Distributed grouping). This proposed calculation contains two stages: (I) introduction and (ii) arrangement stage. Introduction stage lets hubs figure the good ways from the hub to the Base Station and furthermore its neighbors. The arrangement stage comprises of speculative CHs determination, last CHs political decision, and bunches development. Provisional CHs choice lets every hub play different bunching games with itself and its neighbors. It at that point plays a grouping game on its own and figures the balance likelihood to choose without anyone else whether to be a CH. It at that point communicates and gets messages to know its neighbor conditional CHs. The last CHs are chosen to guarantee an even dissemination of CHs. Any speculative CHs with no neighbor conditional CHs consequently turns into a last CH. For other people, it begins an iterative cycle in which conditional hubs are chosen when every hub select a CH in view of the least expense. The hubs become the conditional hubs for next round. At that point in the event that the hub is in nmax (I) emphasis and furthermore is the speculative CH in addition to has the most minimal expense inside a sweep R or it doesn't have any neighboring CHs, it turns into a last CH and it at that point communicates the message inside range R. In group development, the ordinary hub with neighboring last CHs chooses the hub with the littlest hub degree to join the bunch. It additionally enhances LGCA by doling out more weight toward potential CHs with less neighbor CHs and more lingering vitality to improve it.

Zheng et al. [7] utilized the Game Theory's hypothesis to break down steering in WSNs. It additionally proposes a bunching directing calculation dependent on the Bayesian game called Bayesian Game Clustering Routing Algorithm (BGCRA). BGCRA utilizes partition of hubs into poor and rich hubs. It is not the same as others as it utilizes Bayesian game yet in addition it expect that the organization comprises of functional heterogeneous WSNs, while most conventions expect the homogeneous organization which isn't accurate in a genuine circumstance. In a functional heterogeneous WSN, there might be unique kinds of sensor with various inclinations and attributes and diverse force levels. In this calculation, the hubs are isolated into rich and helpless hubs as to remained vitality class, and the inclinations for the two hubs are diverse for both. However it additionally should be more comprehensive in division of hubs other than just rich and poor.

Mishra et al. [8] proposed a Cluster-Heads (CH) choice calculation named as Game Theory-Based Energy-Efficient Cluster-Head Selection Approach (GECSA) utilizing Subgame Perfect Nash Equilibrium (SPNE) choice of Game Theory. In this paper, a Game G that is non-helpful is thought of. It is accepted that the number of players is n and each bunch is viewed as a major part in the game, and thereare k hubs in each bunch. Each player has q number of systems meant as S. The lingering vitality Eresidual is fixed as a system for every player pi. At that point the activity of one player is checked with another player to see the more noteworthy one. After getting SPNE, the one is chosen as a CH. There are various quantities of methodologies for every major part in the game, and every player as indicated by his adjustments picks his best technique. Each player chooses its best technique in the midst of all SPNEs indicated as smax what's more, picks it as a CH in case of various SPNEs.For CH conveyance in each district, there is a factual assignment of sensor hubs in a limited space. In the wake of choosing the CHs, each CH communicates declaration bundles inside a sweep guess b ri, where b is the framework boundary. Each non-CH ought to get the bundle. From these bundles, the non-CH picks a CH as their own and sends the data. The CH first totals the information previously sending it to the sink hub through another CH.

Raja and Dananjayan [9] have proposed a Game Theory based steering convention which upgrades the lifetime of WSN. It utilizes Cooperative Multiple Input Multiple Yield (CMIMO) conspire alongside Efficient Energy Consumption Protocol (EECP) proposed by them. In this paper, EECP is utilized toward the starting to choose CHs. It contains (1) CH political race stage (2) intracommunication stage, and (3) intercommunication stage. In each round, the above stages are rehashed. The first stage comprises of appointment of CH, and the technique utilized is randomized greatest weight determination technique. The subsequent stage (intracommunication stage) comprises of information assortment and collection by CH from its bunch individuals. The third stage (intercommunication stage) comprises of sending the totaled information to the sink hub through CHs and CNs. At that point, CMIMO is utilized as a directing plan. It comprises of three stages: group development, intra-and intercluster communication. In CMIMO utilizing greatest weight determination technique, the CHs are chosen. At that point, the chose CH hubs pick helpful sending hubs and agreeable accepting hubs for CMIMO correspondence dependent on the loads in agreement to each hubs vitality accessibility. Hubs with higher loads closer to the chosen CH will be the sending and accepting helpful gathering hubs for the bunch. Here, coalitional Game Theory is utilized for the choice of CNs and determination is finished utilizing the premise as the separation and remaining vitality of the hubs. The coalitional game is demonstrated as (N, m, V) where N is the arrangement of players (hubs), {1, 2..., n}, m is the trademark work dependent on the organization lifetime, V is the parcel of N,  $V \subseteq N$ . It is, be that as it may, not reasonable for short separations but rather viable in longer separations. There is likewise a defer issue.

Tyagi et al. [10] proposed a Bayesian Coalition Game-based improved grouping in WSNs utilizing the ideas of Learning Automata (LA) and Bayesian Alliance Game (BCG) where Sensor Nodes (SNs) are considered as the major parts in the game with dynamic edge based alliance development among themselves, i.e., the hubs structure alliance dependent on separation based edges making a parcel of the organization field. Simultaneously, a prize or punishment is appointed to each major part in understanding to the limited number of activities performed. One of the SNs is chosen as CH dependent on the subfield. So in this methodology, information can be sent to BS straightforwardly or through CHs. A LA-helped alliance game-based bunching plan is being utilized. Hub densities are determined as G1; G2 of the determined subregions. In the event that G1 = G2, LA's activity is compensated with updates to activity likelihood vector. Punishment is additionally performed by the abovementioned. The calculation of proportion of rewards and a punishment is done, and another alliance is joined if and just if the worth is lower than predefined limit else it proceeds in the current alliance. CH is picked as the hub having greatest estimation of PF. It communicates the message to CMs utilizing TDMA plan.

Tan et al. [11] proposed a calculation for Cluster-Head determination dependent on cost sharing game known as Cost Sharing Game-based Clustering (CSGC). It is utilized to select CHs and reasonable portion of cost. It utilizes a cost sharing game comprised of a set N with m operators and a cost work C. It additionally utilizes Shapley worth and cost shares (n) to disperse the absolute expense fairly. In this paper in a group, a cost sharing game is utilized with three specialists as  $PCH_0$ ;  $PCH_1$ ;  $PCH_2$  where one is in focus, different has extra vitality, and the other is in the limit of a group. So a potential CHs is chosen ( $PCH_0$ ) and other potential CHs are enrolled by above conditions. Presently, CMS are enrolled. It is finished by same conditions as CHs. Just non-CHs are permitted. It is utilized to transfer information in their schedule openings and rests in other time. CHs alliance is utilized to share cost.

## **IV CONCLUSION**

This report begins by a short presentation of WSN, its application, and extraordinary parts of WSN. The constraints of sensor hubs in WSNs are additionally quickly talked about. Game Theory and its parts are presented, and Nash Equilibrium is additionally noted. Game Theory is talked about as a way to deal with battle vitality proficiency issues looked by WSNs. The various games utilized by paper overviewed are talked about in brief. We have examined the participation or non-collaboration of hubs in an organization. We have examined the different ways the papers attempted to improve vitality proficiency, be it by utilizing groups and Cluster-Head or moderating egotistical hubs by rebuffing hubs or remunerating others abundantly for taking an interest. Most papers expect the homogeneity of organizations and furthermore that correspondence between hubs are consistently there. It additionally shows the improvement of various conventions utilized for vitality productivity in ensuing papers.

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