Advanced Threshold Sensitive Stagnant Election Protocol For Heterogeneous Wireless Sensor Network: A Survey

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***Abstract*—Wireless sensor networks (WSNs) are presently equipped to handle more complex functions. The main challenges in wireless sensor network include enhancement of stability, conservation of energy, the lifetime of the node and the throughput of the network and its node. To improve the stability of the network as well as to reduce the energy consumption clustering is used. In a cluster, efficient routing protocol plays a vital role in maintaining the stability and also helps in saving energy. In heterogeneous networks the nodes with the higher energy have more chances to become cluster head than the nodes have low energy. It simply means that selection of cluster head and giving tasks to them will increase energy efficiency.**

In this paper we proposed Enhance Threshold Sensitive Stable Election Protocol (ETSSEP) for heterogeneous wireless sensor network. It is based on dynamically changing cluster head election probability. Various energy efficient protocols for Heterogeneous WSN have been developed in recent years and are discussed in this paper. For the past decade, active suspension systems had made up most of research area concerning vehicle dynamics. For this review, recent studies on automobile active suspensions systems were examined.

***Index Terms*—Energy Efficiency, Clustering, Heterogeneity, ETSSEP**

I. INTRODUCTION

Technological developments in the field of Micro Electro-Mechanical Sensors (MEMS) have enabled the development to tiny, low power, low cost sensors having limited processing, wireless communication and energy resource capabilities, with the passage of time researchers have found new applications of WSN. In many critical applications WSNs are very useful such as military surveillance, environmental, traffic, temperature, pressure, vibration monitoring and disaster areas. To achieve fault tolerance, WSN consists of hundreds or even thousands of sensors randomly deployed inside the area of interest [1]. All the nodes have to send their data towards BS often called as sink. Usually nodes in WSN are power constrained due to limited battery, it is also not possible to recharge or replace battery of already deployed nodes and nodes might be placed where they cannot be accessed. Nodes may be present far away from BS so direct communication is not feasible due to limited battery as direct communication requires high energy. Clustering is the key technique for decreasing battery consumption in which members of the cluster select a Cluster Head (CH). Many clustering protocols are designed in this regard [2]. All the nodes belonging to cluster send their data to CH, where, CH aggregates data and sends the aggregated data to BS [3]. Under aggregation, fewer messages are sent to BS and only few nodes have to transmit over large distance, so high energy is saved and over all lifetime of the network is prolonged.

Recent advances in wireless communication technologies have enabled the development of large-scale wireless sensor network that consist of many low-powers, low-cost and small-size sensor nodes. Sensor network hold the promise of facilitating large-scale and real-time data processing in complex environments. Key management is crucial to the secure operation of wireless sensor network.

Energy consumption for aggregation of data is much less as compared to energy used in data transmission. Clustering can be done in two types of networks i.e. homogenous and heterogeneous networks. Nodes having same energy level are called homogenous network and nodes having different energy levels called heterogeneous network.

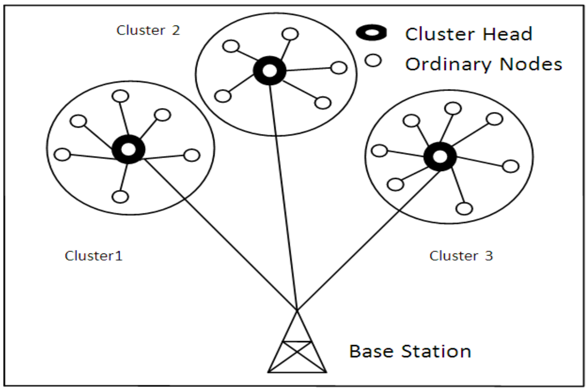

Figure 1: Clustering Based WSN

In this paper, we study performance of heterogeneous WSN protocols multi-level heterogeneous networks. We compare performance of different scenarios of multilevel heterogeneous WSNs. Heterogeneous networks contain normal, advanced and super nodes whereas super nodes have highest energy level as compared to normal and advanced nodes.

II. LITERATURE REVIEW

G. Smaragdakis et. al. [4] proposed a heterogeneity based protocol SEP. In SEP there are two levels oh heterogeneity. Weighted election probability of node is used to elect the CH. The two parameter of heterogeneous protocol are the quotient of advanced nodes *m* and the supplemental energy factor between advanced and normal nodes α. $P_{nrm} = \frac{P_{opt}}{1+m.\alpha}$ is

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used to calculate probability of node for CH election and $Padv = \frac{Popt.(1+a)}{1+m.a}$ is used for Normal nodes. . The different threshold equations are used to for the advance node and normal node.

Li. Qing et. al. [5] has implemented distributed energy efficient clustering scheme for heterogeneous WSN. In DEEC protocol cluster heads election is based on possibility of ratio of remaining energy of every node and the network's average energy. The process of CH selection is performed on the behalf of starting and remaining energy of the node. The node with more remaining and starting energy has the more possibility to become a CH. Each nodes of the network have the dissimilar initial energy. Initially, every node should be familiar with the absolute energy and lifespan of the network. In DEEC, all the nodes get the information regarding absolute energy and lifespan of network from the BS.

Femi A. Aderhunmu et. al. [6] presented a new approach SEP-E. It is extension of SEP (Stable Election Protocol). In this paper new nodes are proposed called intermediate nodes. The intermediate nodes have the energy between the advanced and normal nodes. Each node has become CH on behalf of possibility of that node and each node become CH once in every round. Energy consumption in this approach is managed at some extent because of three level heterogeneity.

Brahim Elbhiri et. al. [7] presented the DDEEC protocol for heterogeneous WSN. It is extension of DEEC protocol, where CH selection is performed on the basis of starting energy and leftover energy of nodes. Like DEEC also in this scheme all the nodes should be familiar with the total energy and lifespan of the network. In this possibility of advanced nodes is more to being CH than the normal nodes. To avoid this problem of DEEC protocol, the DDEEC introduced some changes in Threshold Residual Energy Value Th_{REV}. In Th_{REV} all the nodes must have the same probability to being a CH. The advanced nodes are mainly elected as CH for the first round then after that their energy decreases in first round then these nodes have the same probability as normal nodes, to be selected as CH. So in that case election of CH will be more balanced and equitable.

Parul Saini et. al. [8] suggested E-DEEC protocol used the technology of DEEC protocol. It uses the three level heterogeneous networks. In this paper author introduced new nodes called the super nodes. That super nodes have additional energy than advanced nodes and normal node. Probability of the nodes is the base if CH election. The probabilities are calculated by the average energy of the network at each round.

Parul Saini et. al.[9] implements TDEEC protocol with different levels of heterogeneity. Three level heterogeneous networks have super nodes with higher energy, advanced nodes with middle level energy and normal nodes with lower energy. By this protocol lifespan and durability of the network is increased. In this paper author uses the same strategy as DEEC, but arrange the Threshold for election of the CH on the basis of ratio of remaining energy and average energy of that particular round. The nodes choose the random number between the 0 to 1, if the number is lower than the threshold T(s), the node is elected as the CH and otherwise it will be an ordinary node.

A.A. Khan et. al. [10] has proposed a new protocol HSEP that decreases communication rate from CH to BS. Starting energy of the node as compare to the other nodes is relied on the weighted election probabilities. This enhances the Stability Period. It utilizes two categories of CHs i.e. primary CH and secondary CH. HSEP contains two categories of Sensor nodes i.e. Advanced and Normal nodes. Node's possibility to be a CH is calculated by starting energy of nodes. So the Secondary CHs may be from predefined primary CHs, and selection based on the probability, from these sensor nodes that previously be primary CH and just primary CHs may get part in a procedure of selecting secondary CHs.

M. M. Islam et. al. [11] has suggested an ESEP algorithm for CH election in hierarchically heterogeneous WSN to rearrange the network structure in more efficient way. The presented algorithm regard as the sensor nodes are stationary and arbitrarily scattered in the heterogeneous WSN, the location dimensions of the BT and the measurement of the sensor area are recognized. A three-tier clustered heterogeneous network is defined where the intermediate and advanced nodes choose as CHs for the growing quantity of rounds relied on their advanced starting energy comparative to other sensor nodes. A CH election procedure is regarded relied on the battery power and remaining energy of sensor node. During this procedure, advanced and moderate nodes contain advanced possibilities to be a CH in a given particular round rather than the normal nodes.

Shekhar Kumar et. al.[12] proposed the ETSSEP. It is a reactive protocol means nodes react immediately to the changes in the sensed value. It uses the three level of heterogeneity. That means ETSSEP has the three types of the nodes with different energy levels. The process of CH formation is performed on the basis of probability of the node. The probability of node is calculated on the behalf of average energy of network and node's remaining energy particular round. In ETSSEP the value of threshold value has adjusted to elect the cluster head. The threshold value is calculated by residual energy of node, average energy of the overall network and optimal number of cluster per round. In simulation, results are compared with SEP and TSEP. ETSSEP Performs better in terms of stability period, instability period, life time of the network and throughput.

III. The M Gear Protocol

In this section, we present detail of our proposed protocol. Sensor nodes have too much sensed data for BS to process. Therefore, an automatic method of combining or aggregating the data into a small set of momentous information is required. The process of data aggregation also termed as data fusion. In order to improve network lifetime and throughput, we deploy a gateway node at the center of the network field. Function of gateway node is to collect data from CHs and from nodes near gateway, aggregation and sending to BS. Our results ensure that network lifetime and energy consumption improved with the expense of adding gateway node. We add rechargeable gateway node because it is on ground fact that the recharging of gateway node is much cheaper than the price of sensor node.

A. Initial Phase

In M-GEAR, we use homogenous sensor nodes that are dispersed randomly in network area. The BS broadcast a HELLO packet. In response, the sensor nodes forward their location to BS. The BS calculates the distance of each node and save all information of the sensor nodes into the node data table. The node data table consists of distinctive node ID, residual energy of node, location of node and its distance to the BS and gateway node.

B. Setup Phase

In this section, we divide the network field into logical regions based on the location of the node in the network. BS divides the nodes into four different logical regions. Nodes in region-one use direct communication and transmit their data directly to BS as the distance of these nodes from BS is very short. Similarly nodes near gateway form region-two and send their data directly to gateway which aggregates data and forward to BS. These two regions are referred to as non-clustered regions. All the nodes away from the gateway node and BS are divided into two equal half regions. We call them clustered regions. Sensor nodes in each clustered region organize themselves into small groups known as clusters.

C. CH Selection

Initially BS divides the network into regions. CHs are elected in each region separately. Let ri represent the number of rounds to be a CH for the node S i. Each node elect itself as a CH once every r i = 1/p rounds. At the start of first round all nodes in both regions has equal energy level and has equal chance to become CH. After that CH is selected on the basis of the remaining energy of sensor node and with a probability p alike LEACH. in each round, it is required to have n x p CHs. A node can become CH only once in an epoch and the nodes not elected as CH in the current round feel right to the set C. The probability of a node to (belongs to set C) elect as CH increases in each round. It is required to uphold balanced number of CHs. At the start of each round, a node Si belongs to set C autonomously choose a random number between 0 to 1. If the generated random number for node Si is less than a predefined threshold T(s) value then the node becomes CH in the current round.

The threshold value can be found as:

$$T(S) = \begin{cases} \frac{p}{1-p\times(r \bmod (1/p))} & \text{if } s \in C \\ 0 & otherwise \end{cases}$$

Where P = the desired percentage of CHs and r = the current round, C = set of nodes not elected as CH in current round. After electing CHs in each region, CHs inform their role to neighbor nodes. CHs broadcast a control packet using a CSMA MAC protocol. Upon received control packet from CH, each node transmits acknowledge packet. Node who find nearest CH, becomes member of that CH.

D. Scheduling

When all the sensor nodes are structured into clusters, each CH creates TDMA based time slots for its member nodes. All the associated nodes transmit their sensed data to CH in its own scheduled time slot. Otherwise nodes switch to idle mode. Nodes turn on their transmitters at time of transmission. Hence, energy dissipation of individual sensor node decreases.

E. Steady-State Phase

In steady state phase, all sensor nodes transmit their sensed data to CH. The CH collects data from member nodes aggregates and forwards to gateway node.

IV. HETEROGENEOUS WSN MODEL

In this section, we assume N number of nodes placed in a square region of dimension $M \times M$. Heterogeneous WSNs contain two, three or multi types of nodes with respect to their energy levels and are termed as two, three and multi-level heterogeneous WSNs respectively.

A. Two Level Heterogeneous WSNs Model

Two level heterogeneous WSNs contain two energy level of nodes, normal and advanced nodes, where, E_o is the energy level of normal node and $E_o(1 + a)$ is the energy level of advanced nodes containing a times more energy as compared to normal nodes. If N is the total number of nodes then Nm is the number of advanced nodes where m refers to the fraction of advanced nodes and $N(1 - m)$ is the number of normal nodes. The total initial energy of the network is the sum of energies of normal and advanced nodes.

$$\begin{aligned} E_{total} &= N(1 - m)E_o + Nm(1 + a)E_o \\ &= NE_o(1 - m + m + am) \\ &= NE_o(1 + am) \end{aligned} \quad (1)$$

The two level heterogeneous WSNs contain am times more energy as compared to homogeneous WSNs.

B. Three Level Heterogeneous WSN Model

Three level heterogeneous WSNs contain three different energy levels of nodes i.e normal, advanced and super nodes. Normal nodes contain energy of E_o, the advanced nodes of fraction m are having a times extra energy than normal nodes equal to $E_o(1 + a)$ whereas, super nodes of fraction mo are having a factor of b times more energy than normal nodes so their energy is equal to $E_o(1 + b)$. As N is the total number of nodes in the network, then Nmm_o is total number of super nodes and $Nm(1 - m_o)$ is total number of advanced nodes. The total initial energy of three level heterogeneous WSN is therefore given by:

$$\begin{aligned} Etotal &= N(1 - m)Eo + Nm(1 - mo)(1 + a)Eo \\ &+ NmoEo(1 + b) \\ Etotal &= NEo(1 + m(a + mob)) \end{aligned} \quad (2)$$

The three level heterogeneous WSNs contain $(a + m_o b)$ times more energy as compared to homogeneous WSNs.

C. Multilevel Heterogeneous WSN Model

Multi-level heterogeneous WSN is a network that contains nodes of multiple energy levels. The initial energy of nodes is distributed over the close set $[E_o, E_o(1 + a_{max})]$, where E_o is the lower bound and a_{max} is the value of maximal energy.

Initially, node S_i is equipped with initial energy of $E_o(1+a_i)$, which is a_i times more energy than the lower bound E_o. The total initial energy of multi-level heterogeneous networks is given by:

$$E_{total} = \Sigma\ E_o(1 + a_i) = E_o(N + \Sigma\ a_i) \quad (4)$$

CH nodes consume more energy as compared to member nodes so after some rounds energy level of all the nodes becomes different as compared to each other. Therefore, heterogeneity is introduced in homogeneous WSNs and the networks that contain heterogeneity are more important than homogeneous networks.

V. ETSSEP

We present details about proposed protocol Enhanced Threshold Sensitive Stable Election Protocol (ETSSEP). It is based on TSEP [9]. ETSSEP is a cluster based reactive routing protocol with three level of heterogeneity. For three levels of heterogeneity, nodes with different energy levels are: advance nodes, intermediate nodes and normal nodes.
The energy of advance nodes are greater than all other nodes and a fraction of nodes which have more energy than normal node and less energy than advance nodes are called intermediate nodes, while rest of the nodes are called normal nodes

The main objective of these algorithms is to design mechanisms that prolong network lifetime by employing mobile sinks to gather information from the sensors. Assume that $\beta = \alpha/2$. In ETSSEP the total energy distributed over different types of nodes is computed.

VI. Comparison of Energy Efficient Heterogeneous Algorithm

These Energy Efficient algorithms of Heterogeneous WSN have various similarities and dissimilarities. They are suitable in different environment with different parameters. So comparison of these energy efficient heterogeneous clustering based algorithms is given in table 1. Comparison is performed based on some parameters like energy efficiency, cluster stability, network life time, heterogeneity level and objectives of algorithm.

Table 1: Comparison table for Heterogeneous Protocols

Protocol	Energy Efficie-ncy	Cluster Stability	Network Lifetime	Heteroge-neity Level
SEP [4]	Low	Moderate	low	Two level
DEEC [5]	Medium	Good	low	Two/Multi
SEP-E[6]	Medium	Moderate	Average	Three level
DDEEC[7]	High	Good	Middle	Two/Multi
EDEEC[8]	High	Good	High	Three
TDEEC[9]	High	Good	High	Three/multi
HSEP[10]	High	Good	High	Three
ESEP[11]	Medium	Moderate	Middle	Three
ETSSEP [12]	High	Excellent	High	Three

VII. Conclusion

In this paper we discuss the heterogeneous wireless sensor networks protocols. All these protocols are developed to increase energy efficiency, network lifetime, stability and instability of network. Some of the protocols have certain deficiencies while others are best suited in order to save the energy. In this paper different protocols used in heterogeneous WSN have been compared and the results of ETSSEP are found suitable for energy conservation and network stability.

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