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AN INVESTIGATION OF ENHANCED THRESHOLD SENSITIVE STAGNATION ELECTION PROTOCOL FOR HETEROGENEOUS WSN

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Abstract—It is now possible for wireless sensor networks, often known as WSNs, to carry out tasks that are becoming more difficult. When it comes to wireless sensor networks, the most significant challenges include enhancing dependability, conserving resources, extending the lifetime of each node, and increasing the throughput of both the network and the nodes. In order to improve the network's dependability while also reducing its energy consumption, clustering is being utilized. It is essential to have an efficient routing protocol in a cluster in order to maintain reliability and cut down on energy consumption. When it comes to cluster heads in heterogeneous networks, nodes that have a higher energy level have a better probability of being cluster heads than nodes that have a lower energy level. It is crystal clear that the selection of a cluster leader and the delegation of work to that individual would result in an increase in energy efficiency.

In this article, the Enhance Threshold Sensitive Stable Election Protocol (ETSSEP) is proposed as a solution for heterogeneous wireless sensor networks. It can be defined as the probability that the election of a cluster head will change over the course of time. For heterogeneous wireless sensor networks (WSNs), a number of energy-efficient protocols have been developed in recent years, and the article provides a description of these protocols.

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

I. INTRODUCTION

New solutions of wireless sensor networks (WSN) have been discovered by scientists as a result of technological advancements in the field of micro electro-mechanical sensors (MEMS), which have enabled the manufacturing of low-cost, low-power sensors that are small in size and have limited processing energy resource capabilities. Wireless communication has also been made possible. In a wide variety of important systems, such as security monitoring, environmental monitoring, traffic monitoring, temperature monitoring, noise monitoring, vibration monitoring, and disaster response, wireless sensor networks (WSNs) are particularly successful. In order to achieve fault tolerance, wireless sensor networks (WSNs) are constructed from hundreds or even thousands of sensors that are geographically dispersed throughout the region of interest [1]. Only particular nodes are required to send their data to the base station, which is sometimes referred to as the sink. In most cases, the power capacity of the nodes in a wireless sensor network (WSN) is insufficient, which results in power restrictions. Furthermore, it is not possible to recharge or replace the batteries of nodes that have already been deployed, as well as nodes that are placed in regions that are otherwise inaccessible. Direct connection is not possible due to the constraints of the battery because nodes can be located a significant distance away from the base station. A great deal of energy is required for direct connection. In the process of clustering, members of the cluster select a Cluster Head (CH), which is the major strategy for lowering the amount of battery utilization. A number of different clustering protocols are planned to be implemented throughout this regard [2]. Every node in the cluster sends its data to CH, which then combines the information into a single message and sends the consolidated data to BS.

As a result of consolidation, fewer messages are being transmitted to BS, but only a few nodes are required to communicate over extensive distances. This results in the conservation of resources and the extension of the network's overall lifespan.

Rapid improvements in wireless communication technologies have made it possible to improve large-scale wireless sensor networks in a sustainable manner. This progress has been made possible by the availability of a large number of sensor nodes that are modest in size, low in cost, and low in power consumption. In harsh environments, sensor networks have the potential to simplify the processing of large amounts of data in real time. Maintenance that is of essential importance is necessary for the reliable operation of a wireless sensor network [3].

When it comes to the storage of data, the energy need for the aggregation of data is significantly lower. There are two types of networks that are capable of clustering: homogeneous networks and heterogeneous networks. Heterogeneous networks are characterized by the presence of nodes that have varying energy values, whereas homogeneous networks include nodes that have the same energy status.

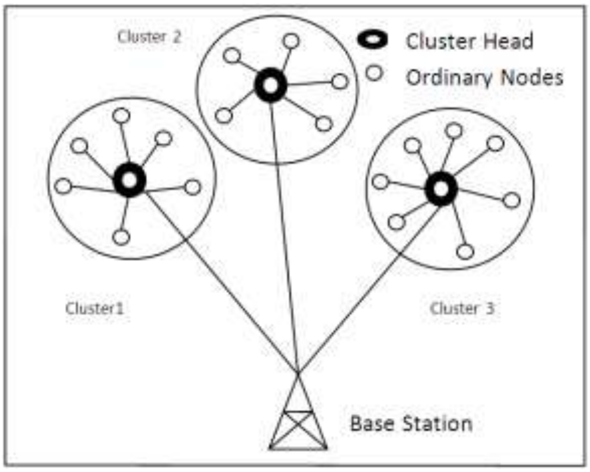

Fig 1: Clustering Based WSN [3]

Throughout the entirety of this research, we explore the effectiveness of heterogeneous wireless sensor network protocols in multi-level heterogeneous networks. The outcomes of a number of different multi-level heterogeneous WSN scenarios are compared and contrasted. There are three types of nodes that operate in heterogeneous networks: standard, modern, and extreme. Extreme nodes have the highest energy value when compared to conventional and sophisticated nodes.

II. LITERATURE REVIEW

G. Smaragdakis et. al. [4] proposed the use of a heterogeneity-based protocol known as SEP. There are two different levels of heterogeneity at the SEP level. In order to choose the CH, the weighted election probability of each node is utilized. The two parameters that make up the heterogeneous protocol are the supplemental energy factor among conventional and advanced nodes, as well as the quotient of advanced nodes, which is denoted by m. α. P$nrm = \frac{Popt}{1+m.\alpha}$ is used to calculate probability of node for CH election and $Padv = \frac{Popt.(1+\alpha)}{1+m.\alpha}$ is used for Normal nodes. . The different threshold equations are used to for the advance node and normal node.

For heterogeneous WSN, Li. Qing et al. [5] have applied a distributed energy-efficient clustering technique. The selection of cluster heads in the DEEC protocol is based on the potential ratio of each node's remaining energy to the average energy of the network. The CH selection process is carried out on behalf of the node's initial and residual energy. A node has a greater chance of becoming a CH if it has more initial and residual energy. Every network node has a different starting energy. Every node should first be aware of the network's total energy and lifespan. In DEEC, the BS provides all nodes with information about the network's lifespan and absolute energy.

SEP-E is a novel method that Femi A. Aderhunmu et al. [6] introduced. SEP (Stable Election Protocol) is being extended. This study proposes new nodes that are referred to as intermediate nodes. The energy between the advanced and normal nodes is found in the intermediate nodes. Every node has evolved CH once every round, and each node has become CH on behalf of its potential. The three levels of heterogeneity in this technique help to manage energy use to some degree.

The DDEEC protocol for heterogeneous WSN was introduced by Brahim Elbhiri et al. [7]. It is an extension of the DEEC protocol, in which the starting energy and remaining energy of nodes are used to elect the CH. Similar to DEEC, every node in this scheme should be aware of the network's overall energy and longevity. In this case, advanced nodes have a far higher chance of being CH than regular nodes. The Threshold Residual Energy Value 〖Th〗_REV was modified by the DDEEC in order to circumvent this issue with the DEEC protocol. Every node in 〖Th〗_REV must have an equal chance of being a CH. Advanced nodes are mostly chosen as CH in the first round. Once their energy levels in the first round drop, they have the same chance as regular nodes to be chosen as CH. Therefore, the CH election will be more equitable and balanced in that scenario.

The E-DEEC protocol was proposed by Parul Saini et al. [8] and utilized the DEEC protocol's technology. It makes use of heterogeneous networks with three levels. The super nodes are novel nodes that the author introduced in this paper. Compared to standard and advanced nodes, super nodes possess more energy. The foundation of CH election is the nodes' probability. The average network energy at each round is used to compute the probabilities.

The TDEEC protocol is implemented by Parul Saini et al. [9] with varying degrees of heterogeneity. Higher-energy super nodes, middle-level advanced nodes, and lower-energy normal nodes are all present in three-level heterogeneous networks. The network's longevity and resilience are improved by this protocol. The author of this article employs the same approach as the DEEC, but sets the threshold for choosing the CH based on the average energy of that round and the ratio of energy left. A random number between 0 and 1 is selected by the nodes; if the number is less than the threshold T(s), the node is elected as the CH; if not, it is an ordinary node.

A new protocol called HSEP has been devised by A.A. Khan et al. [10] that lowers the transmission rate from CH to BS. The weighted election probabilities are used to determine the node's initial energy in relation to the other nodes. The Stability Period is improved as a result. It makes use of main and secondary CHs, two types of CHs. The two types of sensor nodes found in HSEP are Advanced and Normal nodes. The beginning energy of nodes is used to determine a node's likelihood of being a CH. Thus, the secondary CHs may be selected from preset primary CHs based on likelihood. Only primary CHs may participate in the secondary CH selection process from these sensor nodes that were previously primary CHs.

In order to more effectively reorganize the network topology, M. M. Islam et al. [11] proposed an ESEP method for CH election in hierarchically diverse WSN. The proposed technique recognizes the location dimensions of the BT and the measurement of sensor area, taking into account that sensor nodes are stationary and randomly distributed in heterogeneous WSN. Based on their advanced initial energy compared to other sensor nodes, intermediate and advanced nodes are selected as CHs for an increasing number of rounds in a three-tier clustered heterogeneous network. A CH election process is thought to be dependent on the sensor node's remaining energy and battery power. In contrast to normal nodes, advanced and moderate nodes have advanced chances of becoming a CH in a specific round during this process.

ETSSEP was proposed by Shekhar Kumar et al. [12]. Since the protocol is reactive, nodes respond quickly to variations in sensed value. Three levels of heterogeneity are used. Accordingly, there are three different kinds of nodes with different energy levels in ETSSEP. The CH creation procedure is carried out based on the node's probability. The average network energy and the node's remaining energy in a given round are used to calculate the node's probability. The threshold value in ETSSEP has been modified to elect the cluster head. Node residual energy, network average energy, and the ideal number of clusters every round are used to determine the threshold value. SEP and TSEP are used in simulation results. ETSSEP performs better in terms of throughput, network lifetime, stability period, and instability period.

III. THE M GEAR PROTOCOL

One of these sections explores the specifics of our recommended method. With BS to handle, sensor nodes receive an overwhelming amount of detected data. Therefore, it is necessary to automate the process of integrating or consolidating the data into a small collection of essential data. The process of consolidating data is referred to as data fusion. To improve throughput and network longevity, we distribute a gateway node across the middle of the network field. The job of the gateway node is to collect information from CHs and neighboring nodes, compile it, and transmit it to the BS [13]. According to our research, the presence of a gateway node extended the network's lifespan and reduced its energy consumption. Since fast charging a gateway node is significantly less expensive than recharging a sensor node, we provide a rechargeable gateway node.

A. *Beginning Phase*

In M-GEAR, we make use of homogenous sensor nodes that are dispersed at random throughout the network area. The BS transmitted a HELLO packet. In response, the sensor nodes notify the BS of their position. The BS stores all sensor node details in the node data sheet and calculates the range between each node. The node's position, distance from the BS and gateway node, remaining energy, and unique ID are all included in the node data sheet.

B. Setup Phase

Throughout this section, we distinguish the network area into logical areas based on its position within the network, including its node. After that, BS divides the nodes into four logical sections. Nodes in region-one use direct communication to send data directly to BS because of the short distance between BS and other nodes. Nodes close the gateway from regional two in accordance with this, send their data to the gateway that combines it, and then forward it to the BS. These two categories of territories are also known as non-clustered zones. The majority of nodes are divided into two distinct halves, far from the gateway node by BS. They are called clustered areas. Sensor nodes in each grouped province organize into smaller groups known as clusters.

C. Selection of CH

BS initially divides the network into pieces. The appointment of CHs varies per zone. Let ri be the number of rounds that must have passed for the node Si to be a CH. The through node elects itself with a CH after each ri = 1/p round. Whole nodes in both regions have the same energy and CH probability just at the start of the very first round. The CHs that were selected then concentrated on the sensor node's residual energy, but they did so with a predetermined probability that was comparable to LEACH. There must be n x p CHs in each round. Nodes that aren't selected as CH in the current round are assigned to both sets C. A node can only be CH for one epoch. As CH gets better, there is a chance that a node (from set C) will elect in each round. Keeping the quantity of CHs balanced is crucial. A node Si from set C randomly selects a number between 0 and 1 at the start of each round. Node Si appears CH even in the current round unless the given random quantity is smaller than a preset threshold T(s) value.
The threshold damage is calculated as follows:

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

In this case, P stands for the anticipated percentage of CHs, r for the current round, and C for the number of nodes that were rejected as CHs in the prior round. CHs inform their neighbors of their position after each area's CHs are elected. A control packet is transmitted by CHs using the CSMA MAC protocol. Following receipt of a control packet from CH, each other node sends an acknowledged packet. The node that locates the nearest CH joins the same CH.

D. Scheduling

Every other CH generates TDMA-focused time slots for some of its member nodes until all of sensor nodes have been organized into clusters. With its usual planned time slot, each of the affiliated nodes transmits its sensed data to CH. That any such, nodes go into standby mode. Only at transmitting end, nodes switch on their transmitters. As a result, energy dispersion of each sensor node reduces.

E. The Steady-State Stage

Only certain sensor nodes transfer their sensed data to CH during the steady state process. The CH consolidates data across member nodes and sends it to the gateway node.

IV. HETEROGENEOUS WSN MODEL

In this section, we'll assume that a square section with M × M dimensions contains N nodes. These WSNs are known as two, three, or multiple-level heterogeneous WSNs because they have two, three, or more types of nodes according to specific energy stages.

A. Two Level Heterogeneous WSNs Model

Two-stage heterogeneous WSNs contain both standard and enhanced nodes. The energy value of a standard node is represented by Eo, while the energy value of an advanced node, which has a times more energy than a typical node, appears to be represented by $Eo(1 + a)$. If N is the total number of nodes, then $N(1 - m)$ is the count of normal nodes, and m is the proportion of advanced nodes [14]. The cumulative starting energy of the network is the sum of the energies of its regular and advanced nodes.

$$\begin{aligned} Etotal &= N(1-m)Eo + Nm(1+a)Eo \\ &= NEo(1-m+m+am) \\ &= NEo(1+am) \end{aligned} \tag{1}$$

As comparing to homogeneous WSNs, two-level heterogeneous WSNs have a million times additional energy.

B. Three Level Heterogeneous WSN Model

Three-level heterogeneous WSNs have three different node energy stages: standard, advanced, and super nodes. The energy of regular nodes is equal to Eo, that of advanced nodes of fraction m is a times that of normal nodes, which is equal to $Eo(1 + a)$, and that of super nodes of proportion mo is b times that of normal nodes, which is equal to $Eo(1 + b)$. Where N is the number of devices in the network, $Nm(1 - mo)$ is the total number of advanced nodes, and $Nmmo$ appears to be the total number of very nodes.

Consequently, a three-level heterogeneous WSN's gross starting energy is given by:

$$Etotal = N(1-m)Eo + Nm(1-mo)(1+a)Eo + NmoEo(1+b)$$

$$Etotal = NEo(1 + m(a + mob)) \tag{2}$$

When compared to homogeneous WSNs, three-level heterogeneous WSNs have $(a + mob)$ turns additional energy.
After a few rounds, the energy levels of every other node differ from one another since CH nodes absorb more energy than member nodes. Because of this, heterogeneous WSNs incorporate heterogeneity, therefore heterogeneous WSNs are far more important than homogeneous ones.

V. ETSSEP

The Enhanced Threshold Sensitive Stable Election Protocol (ETSSEP), the proposed protocol, is explained in depth. The TSEP [15,16] model is, in fact, its main focus. In reality, ETSSEP is a reactive routing protocol based on a three-level heterogeneous cluster. Nodes of different energies with three levels of heterogeneity are called advance nodes, intermediate nodes, and regular nodes.

While the majority of nodes are regarded as normal nodes, advance nodes receive significantly more energy than all other nodes, while intermediate nodes are a subset of nodes that have more energy than regular nodes and less energy than advance nodes.

The algorithms' main goal is to create frameworks that gather sensor data using mobile sinks in order to increase network lifetime. Suppose that $\beta = \alpha/2$ is accurate. ETSSEP computes the total energy dispersed across different types of nodes.

VI. Comparison of Energy Efficient Heterogeneous Algorithm

There are a number of similarities and differences among these energy-efficient heterogeneous WSN algorithms. They work well in a range of settings with varying conditions. Therefore, table 1 presents a comparison of the energy-efficient heterogeneous clustering-focused techniques. Energy efficiency, cluster stability, network lifetime, degree of heterogeneity, and algorithm goals are among the criteria that are the focus of the comparison.

Table 1: Comparison table for Heterogeneous Protocols

Protocol	Energy Efficie-ncy	Cluster Stability	Network Lifetime	Hetero ge-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

VII. CONCLUSION

These protocols for heterogeneous wireless sensor networks are the topic of discussion in this article. All of these protocols are being developed in order to bring about improvements in energy efficiency, network longevity, network stability, and network instability. There are a few methods that have specific shortcomings, while others are the most beneficial in terms of energy conservation. In this article, a comparison is made between a number of different protocols that are utilized in heterogeneous wireless sensor networks (WSN), and the findings of ETSSEP are shown to be suitable for energy conservation and network stability.

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