A Review on Stable Election Protocol for Clustered Heterogeneous WSN

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Abstract—**Wireless communication technologies continue to grow in diverse areas to provide new and better opportunities for general business systems; Wireless sensor networks (WSN) are highly distributed network of small, lightweight wireless nodes, deployed in large numbers to monitor the environment or system. WSNs technology's growth in the computation capacity requires these sensor nodes to be increasingly equipped to handle more complex functions. Wireless Sensor Networks (WSNs) is fastest growing technology which extensively adopting for various application services including; weather monitoring, traffic prediction, surveillance, research and academic fields etc.**
We study the impact of heterogeneity of nodes, in terms of their energy, in wireless sensor networks that arehierarchically clustered. In these networks some of the nodesbecome cluster heads, aggregate the data of their cluster membersand transmit it to the sink.The behavior of such sensor networks becomes very unstableonce the first node dies, especially in the presence of nodeheterogeneity. We propose SEP, a heterogeneous aware protocolto prolong the time interval before the death of the first nodewhich is crucial for many applications, where the feedback from the sensor network must be reliable.SEP is based on weighted election probabilities of each nodeto become cluster head according to the remaining energy ineach node.The stable election protocol (SEP) is an improved algorithm of the Low Energy Adaptive Clustering Hierarchy (LEACH) in heterogeneous wireless sensor networks (WSN) to improve the life cycle. However, the unbalanced energy consumption of cluster heads and the nodes would decrease the lifetime.

Index Terms—Stable Election Protocol, election probability, heterogeneous wireless sensor networks, LEACH

I. Introduction

Wireless sensor networks (WSNs) have been receiving surpassing attention as an emerging application area for ad hoc networks. WSNs composed of a number of sensor nodes, which is low-power, low-cost, and multifunctional, with wireless computation and communications capabilities. These sensors communicate via a wireless medium within a short distance and cooperate to perform a common task, such as environment monitoring, target tracking, and industrial process control [1]. The thought is to use a collection of tiny, cheap, stationary sensors to sense physical characteristics about the surrounding environment and then transmit it to an associated sink node [2]. However, the variety in the applications of the WSNs, the main duty of the WSNs is to sense data, process the data, and transmit these data back to specific node (base station or sink).
WSNs technology's growth in the computation capacity requires these sensor nodes to be increasingly equipped to handle more complex functions. Energy conservation, coverage of sensor nodes and reliability issues are taken care of during deployment of base station in sensor network. Generally base stations are assumed static in nature but in some scenarios they are assumed to be mobile to collect the data from sensor nodes.
The LEACH [3] protocol is a Low-Energy Adaptive Clustering Hierarchy protocol as a classical algorithm in clustered routing protocols. It is clustered by the signal strength received by the node, and the cluster head node is selected in a random loop to balance the energy consumption of nodes within the network. Stable Election Protocol (SEP), was proposed in [4], a heterogeneous aware protocol, based on weighted election probabilities of each node to become cluster head according to their respective energy. This approach ensures that the cluster head election is randomly selected and distributed based on the fraction of energy of each node assuring a uniform use of the nodes energy.
The SEP [4] algorithm is a kind of classical heterogeneous network clustering routing algorithm, which is based on the LEACH protocol. The SEP algorithm uses the energy heterogeneous approach, according to the initial energy of different sets of different cluster election probability, increase the high-level nodes become the probability of cluster head, so that the high-level nodes and ordinary nodes close to the same time death. However, the SEP algorithm still has the cluster head distribution uneven, the number of nodes in the cluster is large, and the residual energy of the node is not considered. Clustering is a viable method to improve the WSN life cycle. Right now, propose to survey another and increasingly powerful technique based on the first protocol Improved-SEP and another related improvement strategies.
The rest of the paper is organized as follows. Starting with the literature review in Section II, we briefly introduce LEACH in detail in Section III. In Section IV SEP, Section V Efficient SEP Concept has been discussed. Finally, Section VI concludes the paper.

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II. Literature Review

Literature survey interprets old information and generates a combination of new information with old information. So, in this section there is a brief description of various research papers and occurrence of summary and synthesis of research papers.

Smaragdakis et al. [5] are known for a Stable Election Protocol (SEP) which is a variation of LEACH. It is designed mainly for dual level heterogeneous networks composed of doublet types of sensors (particularly Advance and normal nodes).In general, advance sensors retain extra energy and this has to be turned CH's more frequently compared to normal nodes. Here CH's chosen pertain to sensors initial energy. The main disadvantage is that this decision of CH's is not dynamic. As a consequence, advanced nodes that are far flung with reference to the sink drain their energy faster and depart from their existence soon. SEP is not suitable for multilevel heterogeneous network.

Malluh et al. [6] have suggested an improved form of SEP. Here also, advanced nodes are selected as CH's more often than the normal sensors. In addition, the number of nodes connected with each CH is considered. Thus enables equitable distribution for the sensor nodes between the CH's. Also, in the event of an excess of one sensor accessible to be a CH at certain round, EM-SEP chooses the higher energy sensor as a CH. Those two factors protract the stable period of the sensor network. The main drawback in this method is that inter-cluster communication cost is not considered.

Georgious et al. [7], propose Stable Election Protocol (SEP), a heterogeneous-aware protocol to prolong the stability period and average throughput. SEP is based on weighted election probabilities of nodes to become CH according to the residual energy. Nodes are divided into two categories; based on their energy one are advanced nodes and other are normal nodes advanced node have more energy than normal nodes. The probability to become cluster head of advanced node is more than normal nodes.

Stable Election Protocol (SEP), was proposed in [7], a heterogeneous aware protocol, based on weighted election probabilities of each node to become cluster head according to their respective energy. This approach ensures that the cluster head election is randomly selected and distributed based on the fraction of energy of each node assuring a uniform use of the nodes energy. In the SEP, two types of nodes (two tier in-clustering) and two level hierarchies were considered. Maintaining the Integrity of the Specifications as a classic clustering protocol, LEACH [8] protocol performs poorly in the heterogeneous WSN.

The SEP protocol [9] is based on the LEACH protocol, which gives different electoral cluster head probability for nodes with different energy, and performs better than LEACH in the heterogeneous WSN. However, on the one hand, SEP doesn't adjust cluster head election probability timely according to the residual energy of the node, which leads some nodes are too many to become cluster heads and dies early to reduce the lifetime; on the other hand, the nodes in the cluster transfer information directly to the cluster head which stores a problem that the energy consumption of the edge nodes far away from the cluster head is too large, here we called "edge node effect". The transmission route from cluster head to base station also needs to be optimized.

In [10] shows the effectiveness of SEP protocol in heterogeneous WSN and the shortcomings that the unbalance of energy consumption in the cluster nodes and the inflexibility of the cluster head election mechanism. In [12] uses greedy routing to solve the energy-efficient routing path of transmission information from cluster head to base station and can reduce the energy consumption eventually.

III. LEACH Schemes

Low-Energy Adaptive Clustering Hierarchy [11] is one of the most popular clustering approaches for WSN. It is an application specific architecture. In LEACH, the nodes organize themselves into local clusters, with one node acting as the cluster head and others as member nodes. All member nodes transmit their data to their respective CH, and on receiving data from all member nodes the cluster head performs signal processing functions on the data (e.g., data aggregation),and transmits data to the remote BS. Therefore, being a CH node is much more energy intensive than being a member node.

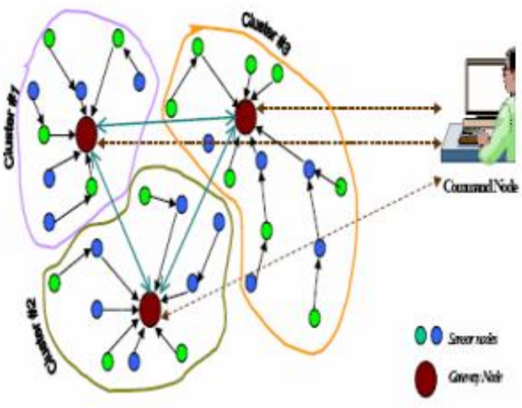

Figure 1: LEACH System

The main objective of LEACH is to select sensor nodes as cluster heads by rotation. In this way, the energy load of being a cluster head is evenly distributed among the nodes. The operation of LEACH is divided into rounds. Each round begins with a set-up phase followed by steady state phase. In the set-up phase the clusters are organized, while in the steady-state phase data is delivered to the BS. Initially CH is selected, based on the signal energy of nodes.

The nodes with higher energy are selectedas CH. Each sensor node n generates a random number between 0 and 1 and compares it to a pre-defined threshold T (n). If random<T (n), the sensor node becomes CH in that round, otherwise it is member node. Where P is the desired percentage of CHs, *r* is the current round, and *G* is the set of nodes that have not been elected as CHs in the last 1/ *P* rounds. LEACH is a completely distributed approach and requires no global information of network. LEACH can guarantee not only the equal probability of each node as CH, but also relatively balanced energy consumption of the network nodes. The LEACH show process has been showed up in Figure 2.

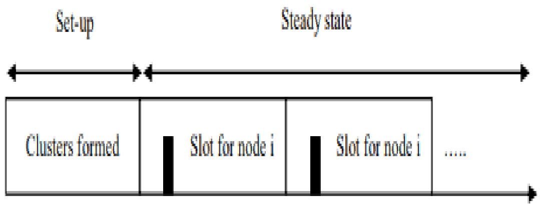

Figure 2: LEACH Protocol Process

IV. Analysis of SEP Algorithm

The SEP [12] algorithm is proposed by G. Maragdakis as a classical heterogeneous network clustering routing algorithm. This agreement is developed on the basis of the LEACH protocol, adding the initial energy isomorphism of this element, using the second energy heterogeneous network. According to the heterogeneous characteristics of the network is divided into ordinary nodes and high-level nodes, and set a different cluster election probability, so that the cluster election probability of high-level nodes is bigger more than the ordinary node. So that the high-level nodes and ordinary nodes close to the same time to death, and extend the stability of the network cycle.

SEP routing protocol is a typical two level initial energy heterogeneous WSN cluster protocol which contains 2 different energy nodes including common nodes and advanced nodes. The core idea of the SEP protocol is that computing the cluster head election probabilities of nodes according to the different initial energy and takes a random round mode to change the cluster head nodes. So, all sensor nodes can share the network load and can reduce network power loss to prolong the lifetime network.

A. Cluster Establishment Stage

It is assumed that the initial number of nodes is n, and the nodes are divided into common nodes and advanced nodes. Among nodes, the optimized cluster head ratio is P_{otp}. The initial energy of the common node is E_0. The energy of the advanced node is 1+α times of common node that is (1+α) E_0.

The total node proportion of the advanced node is m, so the total energy of the whole heterogeneous WSN is as follows [9]:

$$n(1-m)\,E_0 + nm\,(1+\alpha)\,E_0 = n(1+m\alpha)\,E_0 \qquad (1)$$

The energy demand of cluster head is bigger compared with others because cluster heads are responsible for coordinating activities between clusters and transmitting data to base stations. Therefore, the responsible cluster head is constantly rotated which makes the energy even consumed in the SEP protocol. Each node determines whether or not it can be a cluster head in the present wheel according to the respective computing probability. Each sensor node randomly selects a value between the [0 1], and compares it with the threshold $T(i)$. If the value is less than $T(i)$, the node can be elected as a cluster head; otherwise, it isn't be a cluster head.

The SEP algorithm is still a random selection cluster head mechanism using LEACH algorithm. The clustering process is to select whether to join the cluster according to the received cluster head node signal strength through the non-cluster head node. In this way, the cluster head is not evenly distributed, and its clustering method makes the number of nodes in the cluster random.

In the SEP algorithm, the election probability is only related to the initial energy of the node, but not with the residual energy; After the network is running for some time, the residual energy of the high-level node may not have the residual energy of the ordinary node, and the probability of becoming the cluster head is still higher than that of the ordinary node. This speeds up the death of some advanced nodes and reduces the overall survival time of the network. SEP algorithm is used in single-hop transmission mode, such a transmission so far away from the cluster head nodes need to spend a lot of energy to carry out long-distance information transmission, making the nodes in the network premature death, reducing the network life cycle.

B. Transmission Stage

After the cluster is built, the members of the cluster communicate with the cluster head nodes in the allocated time slot to complete the transmission of the data collected in the corresponding area. The cluster head determines the allocation time slot by sending Time Division Multiple Address (TDMA) scheduling table, and the cluster nodes are in the dormancy state of the non-transmission slot which is one way of SEP protocol to save energy. After receiving the data, the cluster head converges and compresses with its own data and sends it to the sink node.

V. IMPROVED EFFICIENT-SEP PROTOCOL

Regarding the inadequacies of SEP referenced above,we present the nodes residual energy to partake in the edge computation to alter probability of turning out to be cluster headsof nodes within time. The interlude nodesin clusterare additionally presented, so cluster nodescan transmitthe apparent data.

A. Energy Consumption Model

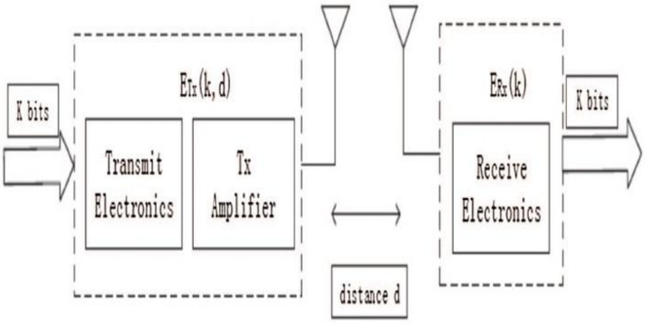

Figure 3: Energy Consumption Model

In record, energy utilization of accepting or sending k bit data whendistance d is presented.
Supplicant time

$$E_T(k,d) = \begin{cases} E_{elec}\,k + E_{fs}\,kd^2 & d < d_0 \\ E_{elec}\,k + E_{mp}\,kd^4 & d > d_0 \end{cases} \qquad (2)$$

Accepting time

$$E_R(k) = E_{R-elec}(k) = E_{elec}\,k \quad (3)$$

$E_{elec}$is energy dissipated of the transmission a unit of data; $E_{fs}$and $E_{mp}$is energy dissipated for gain magnifying; d_0 is threshold distance.

B. Cluster Head Election Method

By just presuming the initialenergy can't settle unbalanced energy utilization wonder by SEP.So nodes residual energy join the estimation of cluster headelection perspective to build WSN life cycle. On a basic level, the node with very less residualenergy hassmaller chance to be clusterhead, in order to adjust the energy utilization among nodes and life cycle enhancement.
The node residual energy is E_r; and total residual energy is Es; andenergy referencefactor is E_c.

$$E_c = e^{-(E_r - \frac{E_S}{n})} \qquad (4)$$

Mentioning to original SEP cluster head election procedure, node residual energy is integrated as energy reference factor E_c. As in SEP, the initial energy for normal nodes is Eo, and for advanced nodes, $Eadv$= 1+αEo.
Assume for intermediate nodes, E_{int}= 1+μ Eo.
We have: μ= α/2
Our probability setting $popt$ remains the same. However, the total initial energy of the system is increased by the introduction of both advanced and intermediate nodes:

$$n\cdot Eo\ 1-m-b + n\cdot m\cdot Eo\ 1+\alpha + n\cdot b\cdot(1+\mu) = n\cdot Eo(1+m\cdot\alpha+b\cdot\mu) \qquad (5)$$

Where n is the number of nodes, m is the proportion of advanced nodes to the total number of nodes n with energy more than the rest of the nodes and b is the proportion of intermediate nodes. The overall energy of the network is increased by a fraction of (1+$m\cdot\alpha$+$b\cdot\mu$) and the new epoch of the system must be equal to $Popt\cdot$ (1+$m\cdot\alpha$+$b\cdot\mu$).
E_c is the energy reference factor taken from, equation no.4, if we choose P_{nrm}, P_{int} and $P_{adv}$for probabilities of becoming normal, intermediate and advanced nodes respectively. Hence we have:

$$Pnrm = Popt/(1+m\cdot\alpha+b\cdot\mu)*Ec \quad (6)$$
$$Pint = (Popt)\times(1+\mu)/(1+m\cdot\alpha+b\cdot\mu)*Ec \quad (7)$$
$$Padv = (Popt)\times(1+\alpha)/(1+m\cdot\alpha+b\cdot\mu)*Ec \quad (8)$$

To guarantee that the sensor nodes must become cluster heads as we have assumed above, we must define a new threshold for the election processes, referring back to Eq. (5). The threshold (n_{nrm}),(n_{int}), $T(n_{adv})$ for normal, intermediate and advanced respectively becomes:

$$T(n_{nrm}) = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}[r \times mod(1/P_{nrm})]} & if\ n_{nrm} \in G' \\ 0 & otherwise \end{cases} \qquad (9)$$

From above we have n × 1−m−b normal node, which ensures that our assumption (1) is exact.

Where G' is the set of normal nodes that has not become cluster head in the past $1/P_{nrm}$ round r, the same analogy follows for the intermediate and advanced nodes,

$$T(n_{int}) = \begin{cases} \frac{P_{int}}{1-P_{int}[r \times mod(1/P_{int})]} & if\ n_{int} \in G'' \\ 0 & otherwise \end{cases} \quad (10)$$

We have $n \times b$ intermediate nodes; with G'' as the set of intermediate nodes that has not become cluster head in the past $1/P_{int}$ round r.

$$T(n_{adv}) = \begin{cases} \frac{P_{adv}}{1-P_{adv}[r \times mod(1/P_{adv})]} & if\ n_{adv} \in G''' \\ 0 & otherwise \end{cases} \quad (11)$$

We have $n \times m$ advanced nodes; with G''' as the set of advanced nodes that has not become cluster head in the past $1/P_{adv}$ round r.

From Eq. (9), (10), and (11), the average total number of cluster heads per round will be:

$$n\cdot\ 1-m-b\ \times P_{nrm}+n\cdot b\times P_{int}+\ n\cdot m\times P_{adv}=n\times P_{opt} \quad (12)$$

This gives us the same number of cluster heads compared with the original LEACH setting. However, because of the heterogeneity energy setting, energy dissipation is better controlled.

C. Intermediate Node Mechanism

SEP protocol does not optimize the data transfer between the members of the cluster, and the member nodes in the cluster transfer the information to the cluster heads directly. So, it will spend higher energy transfer information and shorten the lifetime of the network greatly for the edge nodes that are far away from the cluster head. Therefore, in this case, joining the intermediate nodes will obviously improve the adverse effects of the edge nodes and balance the energy consumption of each node.

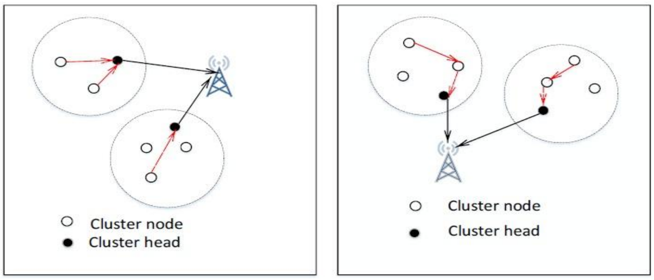

Figure 4: Direct compares indirect transmission

The principle of the intermediate node mechanism is that the nodes in the cluster use the intermediate nodes to transmit the information indirectly so as to reduce their energy consumption and prolong their life. After cluster structure is formed, the cluster node i computes the energy consumed E_1 that transmits information indirectly through other nodes in this cluster. We select the node with the smallest E_1 as the Intermediate node of node i. Compare E_1 with E_i which the energy consumption of direct transmission. If $E_1<E_i$, the node i transmits indirectly through the intermediate nodes; otherwise, the node transmits directly.Figure 4 is the comparison between direct transmission and indirect transmission in a cluster. Part (a) shows the direct transmission in a cluster and part (b) shows the indirect transmission in a cluster.

VI. CONCLUSION

In this paper we review the Stable Election Protocol (SEP), SEP sensor node in a heterogeneous two-level hierarchical network independently elects itself as a cluster head based on its initial energy relative to that of other nodes. SEP is dynamic in that we do not assume any prior distribution of the different levels of energy in the sensor nodes. Furthermore, our analysis of Efficient SEP is not only asymptotic, *i.e.* the analysis applies equally well to small sized networks. Finally SEP is scalable as it does not require any knowledge of the exact position of each node in the field.

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