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Modified Enhanced Stable Election Based Routing Protocol for Wireless Sensor Networks

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ABSTRACT: Wireless Sensor Networks (WSNs) are expected to find wide applicability and increasing deployment in near future. There are a few protocols using sensor clusters to coordinate the energy consumption in a WSN. In this paper, we propose a Modified Enhanced Stable Election Based Routing Protocol for WSNs. The proposed protocol which is an extension of the Enhanced Stable Election Protocol (ESEP), considers the residual energy and ensures the maximum network life time.

I. INTRODUCTION

Clustering is widely adopted in WSNs, where the entire network is divided into multiple clusters. Clusters have cluster heads be responsible for data aggregation. It has the advantages of low energy consumption, simple routing scheme and good scalability, and it reduce the energy hole problem to some extent. Most traditional clustering routing protocols for WSN are based on homogeneous networks where all sensor nodes are identical in terms of battery energy and hardware configuration. However, due to the variation of nodes' resources and possible topology change of the network, heterogeneous sensor networks are more practical in reality. The presence of heterogeneous nodes with enhanced capacity is known to increase network reliability and lifetime [1].Election of cluster heads plays a significant role. In many researches, nodes' position and connectivity have been focused. Cluster heads elected in [2] are determined to have minimum composite distance of sensors to cluster head and cluster head to base station. In [3], the cluster head selection depends on remaining energy level of sensor nodes for transmission. [4] Provides the first trajectory based clustering technique for selecting cluster heads and meanwhile extenuate the energy hole problem. Density-based clustering protocol for WSNs [5] improves LEACH based on a metric of nodes' relative density.

Heterogeneous algorithms are also introduced. SEP [6] is a heterogeneous-aware protocol that sets two types of nodes according to the initial energy. In [7], the cluster heads are elected by a probability based on the ratio between the residual energy of each node and the average energy of the network. In [8], cluster heads respectively perform data fusion and data communication. Nodes with higher residual energy, lower communication cost and more strong data processing capacitywill be prior to become the cluster head.In [9], weighted election probabilities of each node to become a cluster head are set according to the residual energy in each node. Cluster head Reelection Protocol for heterogeneous WSNs [10] is dynamic and depends on local (inter-cluster) information of about energy remaining in sensor nodes without requirement of global knowledge of residual energy of the network.An inefficient use of the available energy leads to poor performance and short life cycle of the network. To this end, energy in these sensors is a scarce resource and must be managed in an efficient manner. The proposed protocol which is an extension of the Enhanced Stable Election Protocol (ESEP) [11], considers the residual energy and ensures the maximum network life time. The simulation result shows an improvement in effective network life time and increased robustness of performance in the presence of energy heterogeneity.

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II. RELATED WORK

2.1 STABLE ELECTION PROTOCOL (SEP)

The authors in SEP [6] were one of the first to address the impact of energy heterogeneity of nodes in WSNs that are hierarchically clustered. Their approach was to assign weighted probability to each node based on its' energy level as the network evolves. One major characteristic of this approach is that it rotates the cluster head to adapt the election probability to suit the heterogeneous settings. The authors exploited the capabilities of LEACH to develop an adaptive and well distributed model to cater for extra energy introduced into the network, which is a source of heterogeneity. Under the model development of SEP, two kinds of nodes with different energy levels were used, constituting a two-level hierarchical WSN in a single-hop setting. The assumption is that the nodes are not mobile and are uniformly distributed over the sensing region.

The first improvement to LEACH was to extend the epoch of the sensor network according to the energy increment. A round is the time interval for all nodes to send data to their respective cluster heads; the cluster heads gather the data and report to the base station; this set of rounds constitutes an epoch. If the nodes are homogeneous, with an optimal percentage 'p_{opt}' of nodes 'n' that can become cluster head in each round, LEACH guarantees that every node will become cluster head exactly once every '$1/p_{opt}$' rounds (epoch). But the theory ceases to hold when LEACH is used in the presence of heterogeneity. Once the first node dies out, the instability in the system turns out to be high and the clustering process becomes unreliable. This is because 'p_{opt}' is only optimal when the population of the network is constant and equal to the initial value 'n'. To solve the problem of instability, the authors in SEP redefined a new epoch for the sensor network. They used two kinds of nodes: normal nodes (α) and advanced nodes (*m*). The advanced nodes have more energy factor α than the normal nodes. The advanced nodes take up cluster head position more than the normal nodes during the same epoch according to SEP model estimation. The new proposed epoch is equal to $1/p_{opt}(1 + m\alpha)$. SEP used an election probability based on the initial energy of each node to elect the cluster heads by assigning a weight equal to the initial energy of each node divided by initial energy of the normal nodes. The weighted probabilities for normal and advanced nodes in SEP were chosen to reflect the extra energy introduced into the network system. The probabilities and the total initial energy are given below respectively:

$$P_{nrm} = P_{opt}/(1 + m\alpha), \qquad \text{------- (i)}$$

$$P_{adv} = (P_{opt})(1 + \alpha)/(1 + m\alpha), \qquad \text{------- (ii)}$$

$$E_{total} = nE_o(1 + m\alpha) \qquad \text{------- (iii)}$$

whereP_{nrm} is the weighted probability for the normal nodes, P_{adv} is the weighted probability for the advanced nodes, *m* is the proportion of the advanced nodes with α times more energy than the normal nodes and E_{Total} is the total initial energy of the network.

2.2 ENHANCED STABLE ELECTION PROTOCOL (ESEP)

An extension of SEP considers three types of nodes; normal nodes, intermediate nodes and advance nodes. Where, advance nodes are in a fraction of total nodes with an additional energy as in SEP and a fraction of nodes with some extra energy greater than normal nodes and less than advance nodes, called intermediate nodes, while rest of the nodes are normal nodes. Intermediate nodes can be chosen by using b, a fraction of nodes which are intermediate nodes and using the relation that energy of intermediate nodes is μ times more than that of normal nodes. In SEP energy for normal nodes is E_0, for advance nodes it is $E_{adv} = E_0 (1+\alpha)$ and energy for intermediate nodes can be computed as $E_{int} = E_0(1 + \mu)$, where $\mu = \alpha /2$. So total energy of normal nodes, advance nodes and for intermediate nodes will be, $n.b(1 + \alpha)$, $n\, E_0.(1 - m - bn)$, and $n.m.\, E_0.(1 + \alpha)$ respectively. So, the total Energy of all the nodes will be, $n\, E_0.(1-m-bn) + n.m.\, E_0.(1 + \alpha) + n.b.(1 + \mu) = n.\, E_0\, (1 + m\alpha + b\mu)$ where n is number of nodes, m is proportion of advanced nodes to total number of nodes n with energy more than rest of nodes and b is proportion of intermediate nodes.

The probabilities of P_{nrm}, P_{int} and P_{adv} are given by

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$$P_{nrm} = \frac{P_{opt}}{1+\propto m+\mu\, b} \qquad \text{------- (iv)}$$

$$P_{int} = \frac{P_{opt}(1+\mu)}{1+\propto m+\mu b} \qquad \text{------- (v)}$$

$$P_{adv} = \frac{P_{opt}\,(1+\propto)}{1+\propto m+\mu\, b} \qquad \text{------- (vi)}$$

Therefore, new threshold T_{nrm} for normal nodes becomes:

$$T_{nrm} = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}[r \bmod (\frac{1}{P_{nrm}})]} & if\ n_{nrm} \in G' \\ 0 & otherwise \end{cases} \qquad \text{---------- (vii)}$$

where r is the current round, G' is the set of nodes which has not become cluster heads within the last $1/P_{nrm}$ rounds.

Similarly, threshold for intermediate nodes is given by

$$T_{int} = \begin{cases} \frac{P_{int}}{1-P_{int}[r \bmod (\frac{1}{P_{int}})]} & if\ n_{int} \in G'' \\ 0 & otherwise \end{cases} \qquad \text{------- (viii)}$$

where r is the current round, G'' is the set of nodes which has not become cluster heads within the last $1/P_{int}$ rounds.

Similarly, threshold for advanced nodes is given by

$$T_{adv} = \begin{cases} \frac{P_{adv}}{1-P_{adv}[r \bmod (\frac{1}{P_{adv}})]} & if\ n_{adv} \in G''' \\ 0 & otherwise \end{cases} \qquad \text{---------- (ix)}$$

where r is the current round, G''' is the set of nodes which has not become cluster heads within the last $1/P_{adv}$ rounds.

III. PROPOSED MODIFIED ENHANCED STABLE ELECTION BASED ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS

Based on equations of probabilities for advanced, intermediate and normal nodes, discussed in ESEP, the cluster head selection method has been improved by considering the residual energy of sensor nodes. As is shown in Equation (x), the weighed probability for normal nodes is

$$P_{nrm} = \frac{P_{opt}}{1+\propto m+\mu\, b} \cdot \frac{E_{residual}}{E_0} \qquad \text{---------- (x)}$$

where P_{opt} is the optimum percentage of cluster head, α is the factor of additional energy in the advanced nodes, μ is the factor of additional energy in the intermediate nodes, m is the fraction of nodes chosen as advanced nodes, b is the fraction of nodes chosen as intermediate nodes, $E_{residual}$ is the energy left in sensor nodes after certain rounds, and E_0 is the initial energy of any nodes.

Similarly, the weighed probability for intermediate nodes is given by

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$$P_{int} = \frac{P_{opt}(1+\mu)}{1+\propto m+\mu b} \cdot \frac{E_{residual}}{E_0} \quad \text{----------} \quad (xi)$$

and the weighed probability for the advanced nodes is given by

$$P_{adv} = \frac{P_{opt}(1+\propto)}{1+\propto m+\mu b} \cdot \frac{E_{residual}}{E_0} \quad \text{----------} \quad (xii)$$

For all three types of nodes, normal, intermediate and advanced, the calculation of threshold depends on their probabilities which are given below.

$$T_{nrm} = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}[r \bmod (\frac{1}{P_{nrm}})]} & if\ n_{nrm} \in G' \\ 0 & otherwise \end{cases} \quad \text{----------} \quad (xiii)$$

where r is the current round, G' is the set of nodes which has not become cluster heads within the last $1/P_{nrm}$ rounds.

Similarly, threshold for intermediate nodes is given by

$$T_{int} = \begin{cases} \frac{P_{int}}{1-P_{int}[r \bmod (\frac{1}{P_{int}})]} & if\ n_{int} \in G'' \\ 0 & otherwise \end{cases} \quad \text{---------} \quad (xiv)$$

where r is the current round, G'' is the set of nodes which has not become cluster heads within the last $1/P_{int}$ rounds.

Similarly, threshold for advanced nodes is given by

$$T_{adv} = \begin{cases} \frac{P_{adv}}{1-P_{adv}[r \bmod (\frac{1}{P_{adv}})]} & if\ n_{adv} \in G''' \\ 0 & otherwise \end{cases} \quad \text{----------} \quad (xv)$$

where r is the current round, G''' is the set of nodes which has not become cluster heads within the last $1/P_{adv}$ rounds.

3.1 SIMULATION AND RESULTS

Simulations are carried out using MATLAB. Simulation parameters are listed in Table 1,where 100 sensor nodes are distributed randomly in a rectangular region of 100m x 100m. There are 20% advanced nodes which are equipped with 200% more energy than the normal nodes (which means m = 0.2 and α = 2) and there are 10% intermediate nodes with 150% more energy than the normal nodes (which means b=0.1 and µ = 1.5). Simulation results show that proposed modified ESEP routing protocol performs better considering metrics of network life time and throughput.

Table 1: Simulation parameters

Network Parameters	Value
Network Size	100m x 100 m
Initial Energy of Sensor Nodes	0.5 J
Packet Size	4000 bits
Transceiver idle state energy consumption	50 nJ/bit
Data Aggregation/ Fusion Energy consumption	5 nJ/bit/report

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d_0	Sqrt(Efs / Emp) =87.7058m
Amplification Energy (Cluster to BS) $d \geq d_o$	Efs = 10pJ/bit/m^2
Amplification Energy (Cluster to BS) $d \leq d_o$	Emp = 0.0013pJ/bit/ m^2

Figure 1 and 2 show comparison of protocols SEP, ESEP and proposed modified ESEP regarding dead nodes and alive nodes relative to number of rounds. From figure 1 and 2, it can be seen that of these three protocols, in terms of stability period, proposed modified ESEP performs better.

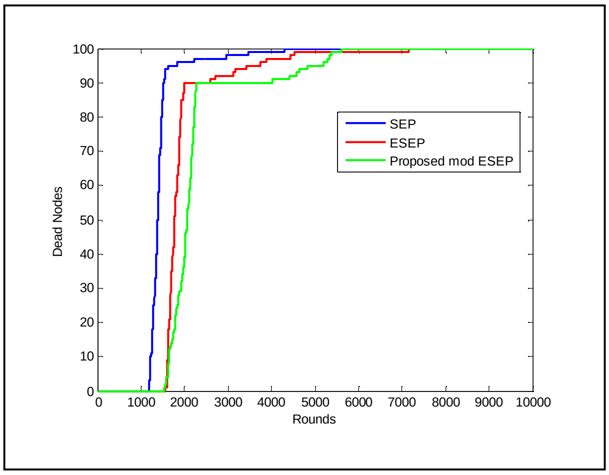

Fig 1: Comparison, dead nodes of a network

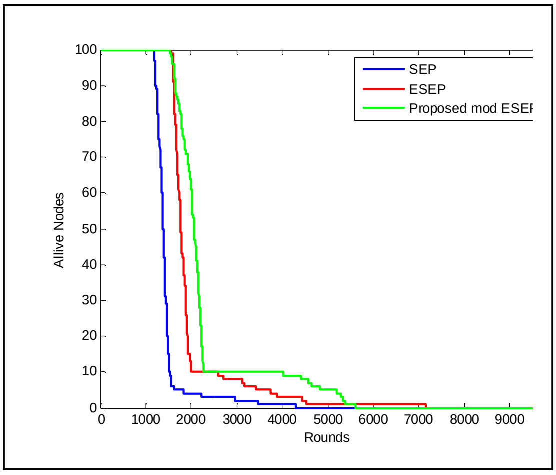

Fig 2: Comparison, alive nodes of a network

In Figure 3, number of data packets to base station is calculated for all routing protocols i.e., for SEP, ESEP and proposed modified ESEP. It shows that proposed modified ESEP is efficient in successful data delivery. In other words throughput increases quiet remarkably.

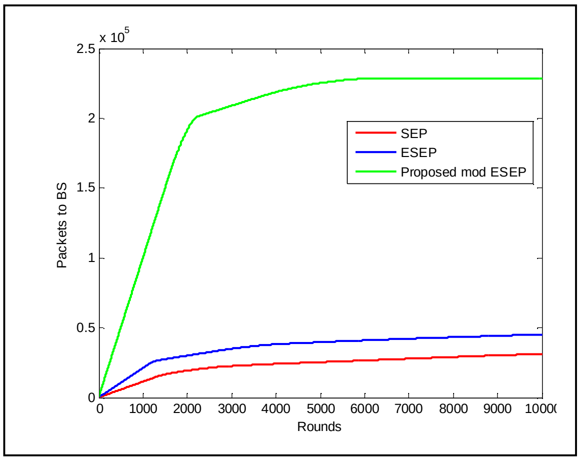

Fig3:Comparison, Packets transmitted to base station

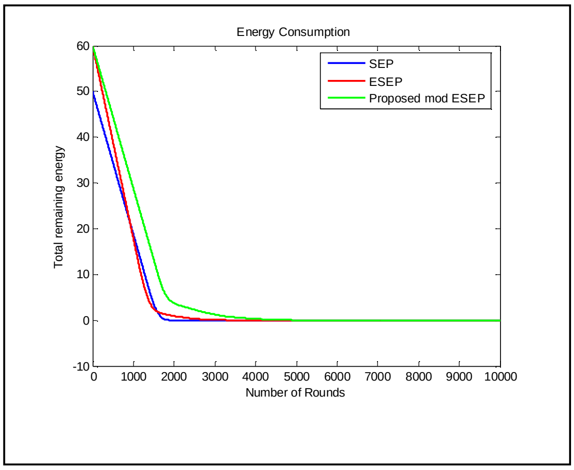

Fig 4: Total remaining energy over rounds

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Figure 4 shows that total initial energy of the network is 60 J which decreases linearly up to 1500 rounds and after that there is a difference from the round where first node dies in respect to them. Energy remaining per round for proposed modified ESEP is more as compared to SEP and ESEP.

IV. CONCLUSION

The Modified Enhanced Stable Election based routing Protocol for WSNs has been proposed, examined and compared with existing SEP and ESEP routing protocols. Simulation results show that the proposed Modified Enhanced Stable Election based routing Protocol shows better performance in terms of energy saving, alive nodes and packet transmission.

REFERENCES

[1] ZhanyangXu, Yue Yin, Jin Wang, “An Energy-efficient Clustering Routing Algorithm for Heterogeneous Wireless Sensor Networks” , NGCIT 2013, ASTL Vol. 27, pp. 85-93, 2013
[2] X.X.Zhang, M.Zhang, Z.C.Zhang, “An improved WSNs clustering routing algorithm and its performance”, Science paper Online, 2010, 5(2), pp.92-96.
[3] M.C.M.Thein, T.Thein, “An energy efficient cluster-head selection for wireless sensor networks”, International Conference on Intelligent Systems, Modelling and Simulation (ISMS), 2010, pp. 287-291.
[4] H.Munaga, J.V.R.Murthy, N.B.Venkateswarlu, “A novel trajectory clustering technique for selecting cluster heads in Wireless Sensor Networks”, International Journal of Recent Trends in Engineering, 2009.1(1).
[5] J.F.Qiao, S.Y.Liu, X.Y.Cao, “Density-based clustering protocol for wireless sensor networks”, Computer Science, 2009,36(12), pp.46-49
[6] GeorgiosSmaragdakis, Ibrahim Matta, and AzerBestavros, “SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks”, In Proceeding of the International Workshop on SANPA, 2004.
[7] L. Qing, Q. Zhu, M. Wang, “Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks”, In ELSEVIER, Computer Communications 29 (2006), pp 2230-2237.
[8] Femi A. Aderohunmu, Jeremiah D. Deng, “An Enhanced Stable Election Protocol (SEP) for Clustered Heterogeneous WSN”, Department of Information Science, University of Otago, New Zealand. The Information Science Discussion Paper Series, Number 2009/07, October 2009, ISSN 1177-455X
[9] X.L.Xu, J.N.Qiu, “Energy efficient cluster-head selection for heterogeneous wireless sensor networks”, Chinese Journal of Sensors and Actuators, 2009, 22(3).
[10] D.Kumar, T.C.Aseri, R.B.Patel, “EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks”, Computer Communications, 2009, 32, pp.662–667
[11] R.Tandon, S.Nandi, “CRP: Cluster head Re-election Protocol for heterogeneous wireless sensor networks”, Proceedings of Fifth International Conference on Communication Systems and Networks (COMSNETS), 2013, pp.1-10.