Enhanced Threshold Sensitive Stable Election Protocol for Heterogeneous Wireless Sensor Network

Priya Gupta, Mr. Pratyush Tripathi

***Abstract*— A sensor nodes in wireless sensor network are of fixed battery power. Therefore energy utilization in an efficient way is the most important matter of concern in the design and development of wireless sensor network (WSNs).**

Energy efficiency of the proposed approach can be improved through Multiple Cluster Heads. The efficient routing protocol in a cluster plays an important role in energy saving and stability of the cluster and its nodes. 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. The ETSSEP is simulated using MATLAB and found that it performs better than Stable Election Protocol (SEP) and Threshold Sensitive Stable Election protocol (TSEP) in terms of stability and network lifetime. A Wireless Sensor Network (WSN) is composed of multiple number of nodes each of which consists of sensing devices to collect data from environment. Clustering has been proven as one of the most effective technique for reducing energy consumption of the wireless sensor networks. In this paper, we are displaying a survey on hierarchical routing protocols based on LEACH (Low Energy Adaptive Clustering Hierarchy) protocol.

***Index Terms*— Clustering, Routing, Stable Election Protocol, Heterogeneous environment, Energy, efficiency, Wireless sensor network.**

I. INTRODUCTION

A Wireless sensor network (WSN) typically consists of a large number of low cost, low power, and multifunctional wireless sensor nodes with sensing, wireless communications and computation capabilities. Wireless sensor network (WSN) consists of tiny battery powered sensor nodes to monitor physical or environmental conditions, like sound, vibration, pressure, temperature, motion or pollutants at different locations [2]. The nodes need to communicate with each other the and with base station in order to collect and transmit required data. Hence, the routing is considered as a major research challenge in WSNs. In this network, node senses the data from impossibly accessible area and sends their report to the base station also called the sink. The nodes in wireless sensor networks can be mobile or stationary and deployed in the area through a proper or random deployment mechanism.

In clustering, the entire sensor network is divided into number of clusters. Each clusters may contain multiple nodes, however, one node out of these is selected as cluster head. The cluster head is responsible for the communication with the nodes outside the cluster. The most prominent method to divide the nodes of a WSN in to clusters is LEACH (**Low Energy Adaptive Clustering Hierarchy) [1].** To reduce energy of wireless sensor network LEACH protocol has been used. It introduces concept of rounds. The aim of leach is to design the nodes into clusters and evenly distribute the energy among the sensor nodes in the network. In each cluster there is an elected node called cluster head or gateway.

Wireless sensor network is important because the sensor nodes in wireless sensor network are constrained by limited energy. The way to improve a WSN lifetime is to develop energy efficient protocols for reducing energy consumption. One of the well known energy efficient methods is the clustering based algorithm which is designed for homogeneous wireless sensor network. The clustering algorithms were also improved and applied to the heterogeneous wireless sensor network. 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. The Wireless sensor network (WSN) is a broadcast network; it consists of a large number of sensors that are effective for gathering data in a variety of environments. Since the 12 sensors operate on battery power, it is a great challenging aim to design the energy efficient routing protocols.

II. LITERATURE REVIEW

The wireless sensor network has been deployed with different wireless networking technologies. The 802.11 protocol is the first standard protocol for wireless local area networks (WLAN), which was introduced in 1997.After that it was upgraded to 802.11b with data rate increased and CSMA/CA mechanism for medium access control (MAC). In 1998 this team developed second generation sensor node by applying some innovations which was named as Wireless Integrated Network Sensors (WINS). These WINS had a processor board with an Intel strong ARM SA1100 32-bit embedded processor (1 MB SRAM and 4 MB flash memory), radio board that supports 100 kbps with adjustable power consumption from 1 to 100 m, a power supply board, and sensor board.

Node first senses its target and then sends the relevant information to its cluster-head. Then the cluster head aggregates and compresses the information received from all the nodes and sends it to the base station. The nodes chosen as the cluster head drain out more energy as compared to the other nodes as it is required to send data to the base station which may be far located. Hence LEACH uses random rotation of the nodes required to be the cluster-heads to evenly distribute energy consumption in the network. After a number

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of simulations by the author, it was found that only 5 percent of the total number of nodes needs to act as the cluster-heads. TDMA/CDMA MAC is used to reduce inter-cluster and intra-cluster collisions. This protocol is used were a constant monitoring by the sensor nodes are required as data collection is centralized (at the base station) and is performed periodically.

In WSN,Sensor nodes sense the data from impossibly accessible area, cooperatively forward the sensed data to the sink or base station via multi-hop wireless communication and sends their report to the base station also called the sink [12]. The nodes in wireless sensor networks can be mobile or stationary and deployed in the area through a proper or random deployment mechanism.

III. Clustering

WSNs is large scale networks of small embedded devices, each with sensing, computation and communication capabilities. They have been widely discussed in recent years. Micro-Electro-Mechanical System (MEMS) sensor technology has facilitated the development of smart sensors, these smart sensors nodes are small devices with limited power, processing and computation resources. Smart sensors are power constrained devices that have one or more sensors, memory unit, processor, power supply and actuator. In WSNs, sensor nodes have constrained in term of processing power, communication bandwidth, and storage space which required very efficient resource utilization. Clustered [1, 11] sensor networks can be classified into two types, homogeneous [10] and heterogeneous wireless sensor networks. In a homogeneous network, all the nodes are identical in terms of energy. On the other side, in a heterogeneous network, different types of nodes in terms of energy levels are used.

Clustering drastically reduces the energy consumption and improves the network lifetime. In this approach different protocols are used. The protocols for such types of networks must be energy efficient due to non-replacement of batteries in nodes after its deployment. Protocols are classified into two categories according to their applications, proactive protocols and reactive protocols. In former, sensor nodes sense the data from different locations and continuously transmit that data to the cluster head, then cluster head transmits to the base station either it is needed or not, while in later, the cluster head transmits the data only if there is a drastic change in the sensed value.

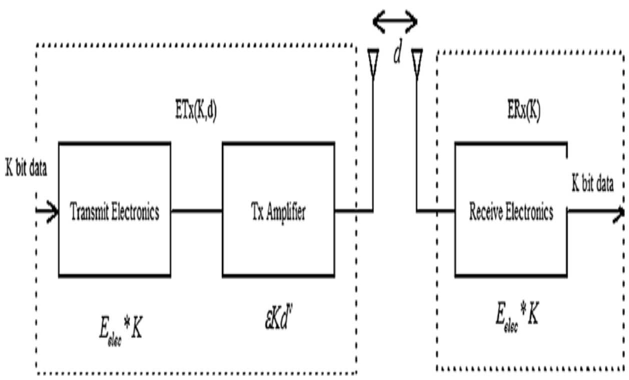

Figure 1: Radio energy dissipation model

Clustering is mainly divided into three phases: cluster head (CH) selection, cluster formation and data transmission. The first part is CH selection, in which cluster heads are elected on the basis of the probability of being a cluster head [3]. Once the cluster head is elected, it broadcasts advertisement to the nodes to form a cluster formation, the sensor nodes in the cluster send their sensed value to the cluster head during their time slots. The cluster head receives all the data from sensor nodes and aggregate it before transmitting to the sink. Clustered sensor networks can be classified into two categories in terms of energy. In a heterogeneous network, different nodes are at the different energy levels while in a homogeneous network, all the nodes are having the same energy levels

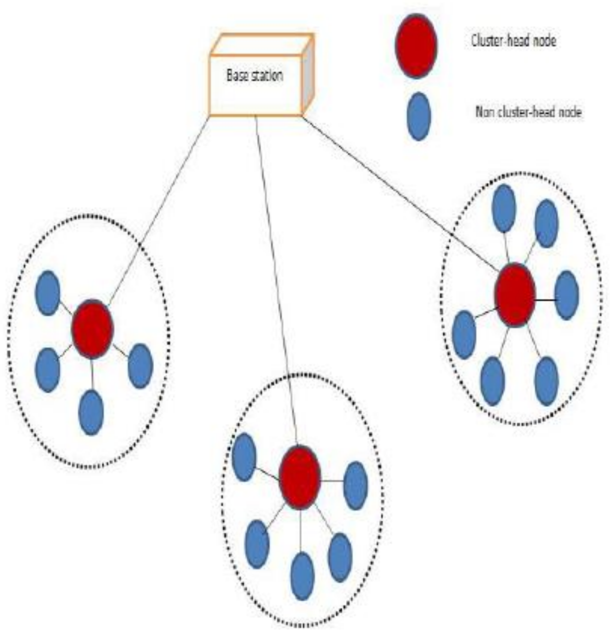

Figure 2: Cluster based wireless sensor network

In routing protocols, cluster head election reduces energy consumption and enhances the network life time. Classical approach like direct transmission (DT) and minimum energy transmission (MTE) does not guarantee well distribution of energy load of sensor nodes.

IV. LEACH Schemes

Low-Energy Adaptive Clustering Hierarchy 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.

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 selected as 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.

However, there exist a few disadvantages in LEACH as follows:

1) LEACH assumes a homogenous distribution of sensor nodes in given scenario, which is not very realistic

2) Some clusters will be assigned with more number of nodes; this could makes CH nodes run out of energy quickly.

3) CH has the extra burden of performing long range transmission to the distant BS, which results in too much energy consumption. Various modifications have been made to the LEACH protocol, which form LEACH family, such as TL-LEACH, E-LEACH, M-LEACH, LEACH-C, V-LEACH, etc

V. SYSTEM DESCRIPTION

We have considered a heterogeneous network. A heterogeneous network is one in which all the nodes does not it have equal energy. Let us assume that the total number of nodes is n & m fraction of the nodes has α time more energy than the other nodes. They are called as advanced nodes.

Therefore, Number of normal nodes = (1-m) x n Energy per normal node = e0 Number of advanced nodes = m x n Energy per advanced node = e0 x (1 + α)

Hence the total energy of the network = ((1-m) x n) x e0 + (m x n) x (e0 x (1 + α)) In this approach the same procedure as in the normal LEACH protocol is followed i.e., the formation of the clusters is same in this heterogeneous system and also the cluster head selection by comparing the residual energy of the individual in every round. The structure of the proposed Leach-Heterogeneous system for wireless sensor networks is shown in Fig. 4

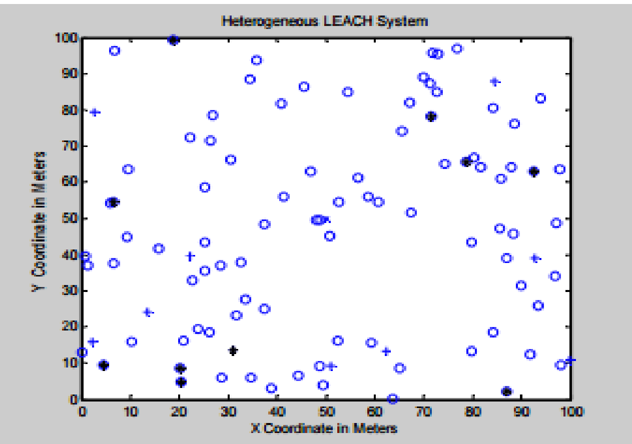

Figure 4: Proposed Heterogeneous LEACH System "+" symbol indicates advance Node

VI. PROPOSED ALGORITHM

we present details about proposed 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 β = α/2. In ETSSEP the total energy distributed over different types of nodes is computed.

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For normal Node:

$$E_{nrm} = n \cdot b \cdot (1 + \beta)$$

For Intermediate Node:

$$E_{int} = n \cdot (1 - m - bn) \cdot E_0$$

For Advance Node:

$$E_{adv} = n \cdot m(1 + \alpha) \cdot E_0$$

Total energy E total for all the nodes is calculated as

$$\begin{aligned} E_{total} &= n \cdot (1 - m - bn) \cdot E_0 + n \cdot m \cdot (1 + \alpha) \cdot E_0 + n \cdot b \cdot (1 + \beta) \\ &= n \cdot E_0 (1 + m \cdot \alpha + b \cdot \beta) \end{aligned}$$

Where, m and b denotes the advance nodes and intermediate nodes fraction of total number of nodes n.

VII. RESULTS

A set of experiments is conducted to test the performance of schemes, we consider the above network features and parameters, ETSSEP is implemented and examined using MATLAB. We considered two scenarios for simulation. Initially, the experiment is performed with diverse number of nodes ranging from 25 to 400 placed in 100 m 9 100 m area. Each sensor node is assumed to have initial energy 0.5 J. Next we compare the performance of ETSSEP with Stable Election Protocol (SEP) and Threshold Sensitive Stable Election Protocol (TSEP). In comparisons, we consider 100 sensor nodes placed in 100 m 9 100 m area. In both scenarios, the position of the base station is taken in the middle of the sensing area, and the performance of protocols is given in terms of stability period, network lifetime and throughput. Figures 3, 4 and 5 describe the first scenario, and Figs. 6, 7, 8, 9, 10, 11, 12 and 13 describe the second scenario. In this heterogeneous wireless sensor network, we use radio parameters which are shown in Fig. 1 for deployment of different protocols, and estimate the performance of three level of heterogeneity.

Figure 3: It describes the stability of ETSSEP, and it clearly shows that as we increase the number of nodes the stability of protocol changes randomly. When there are 25 nodes its

stability is highest, it falls steeply from 25 to 50 nodes, then it rises uniformly from 50 to 100 nodes, thereafter it remains almost constant from 100 to 200 nodes, and then after 200 it drastically fall down.

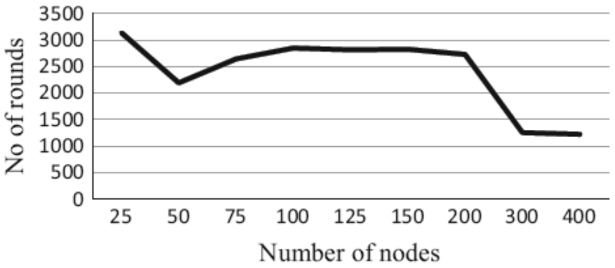

Figure 3: Stability of ETSSEP after incrementing number of nodes

Figure 4: It describes the life span of ETSSEP as we increase the number of nodes successively, and shows that at 25 nodes life time of network is highest, between 50 and 100 nodes life time increases uniformly, thereafter it remains almost unchangeable from 100 to 200 nodes but then after 200 it decreases very gradually.

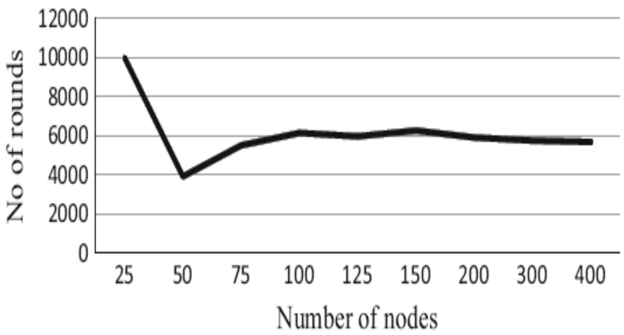

Figure 4: Life-span of ETSSEP after incrementing number of nodes

Figure 5: It displays the throughput of the ETSSEP. The throughput of protocol increases gradually from 25 to 150 nodes, and thereafter the increase in throughput are rising steeply.

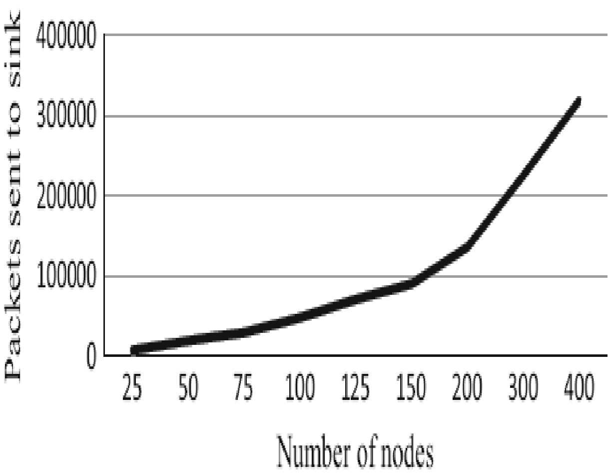

Figure 5: Number of packets sent to base station (throughput) of the ETSSEP

Figure 6 shows the number of alive nodes per round, it shows that nodes die more slowly in ETSSEP in comparison to other two protocols discussed in this paper. In SEP, TSEP and ETSSEP the first node die at the round number 974, 2068 and 2762 respectively.

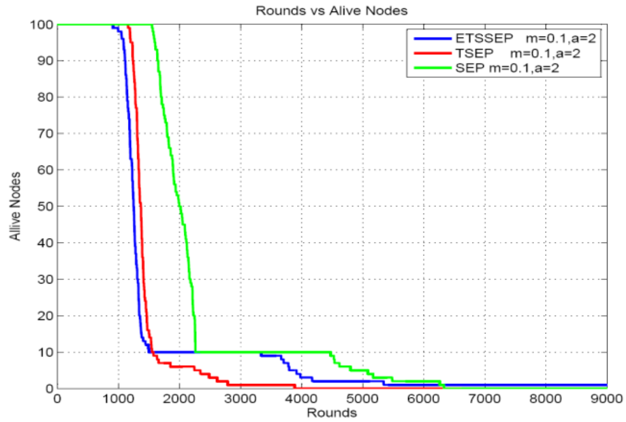

Figure 6: Number of alive nodes during rounds

Figure 7 shows the number of dead nodes over the number of rounds, it shows that in SEP, TSEP and in ETSSEP all nodes die after 1667, 4908 and 6763 number of rounds respectively.

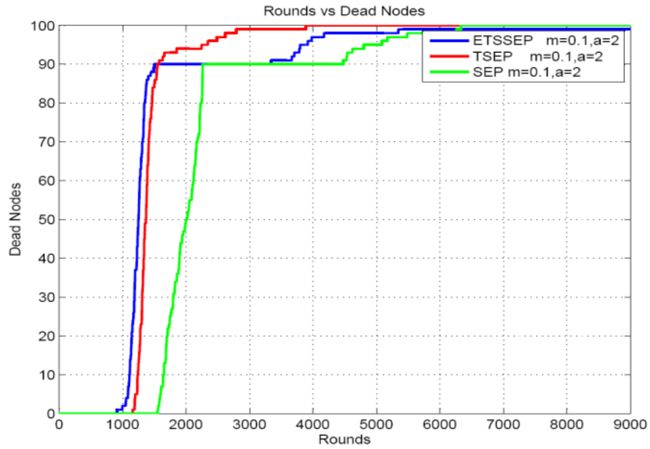

Figure 7: Number of dead nodes during rounds

Figure 8 Describes the number of packets sent to the base station, and clearly specify that throughput of ETSSEP is far better than SEP and TSEP. The number of packets sent to the base station in SEP, TSEP and ETSSEP are 23,715, 25,000 and 48,000 respectively.

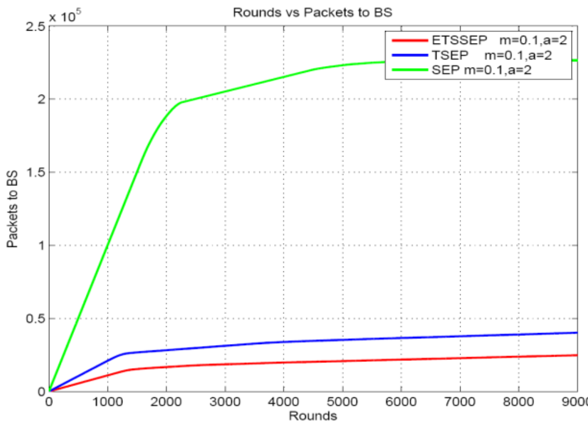

Figure 8: Throughput of the protocols

In the simulation run, we used the following parameters as described in Table 1. The initial energy (E0) of node is set to 0.5 J, the message size is 4000 bits. Eelec = 50 nJ/bit is the energy dissipated to run the transmitter and receiver circuitry, Efs and Eamp is the free space and multipath fading channel. EDA is energy consumed for data aggregation, Popt is the optimal probability to be a cluster head and m refers to the fraction of advance nodes containing extra amount of energy.

Parameter	Value
Network field	100,100
Number of nodes	25–400
Initial energy (E_0)	0.5 J
Message size	4000 bits
E_{elec}	50 nJ/bit
E_{fs}	10 nJ/bit/m^2
E_{amp}	0.0013 pJ/bit/m^2
E_{DA}	5 nJ/bit/signal
P_{opt}	0.1
a	2
m	0.1

Table 1 Parameters used in the simulation

Table 2 display the stable period, network lifetime and throughput of ETSSEP after incrementing the number of nodes in increasing order.

Number of nodes	Stable period (in rounds)	Network lifetime	Packet sent to BS
25	3135	10,000	7202
50	2193	3909	13,096
75	2643	5509	29,564
100	2847	6141	47,900
125	2814	5968	70,641
150	2826	6256	90,134
200	2728	5910	136,059
300	1256	5746	225,430
400	1224	5680	318,365

Table 2 Performance of ETSSEP with different parameters

The performance analysis of ETSSEP against SEP and TSEP is display in Table 3.

Protocol	Stability	Instability period	Lifetime	Throughput
SEP	974	693	1667	23,500
TSEP	2068	2840	4908	26,075
ETSSEP	2762	4001	6763	48,946

Table 3 Comparison table of SEP, TSEP and ETSSEP

VIII. Conclusion

Stability period and network life time is one of the key issues for designing the WSN protocols. In this paper, energy aware reactive routing protocol for heterogeneous networks (ETSSEP) presented and compared with SEP and TSEP. ETSSEP increases he stability period and network lifetime of sensor networks as 33.5 and 37.79 % in comparison to TSEP, and more than twice and about thrice in comparison to SEP. In addition to this it is also analyzed that the performance of ETSSEP in terms of stability, network lifetime and throughput with number of nodes successively in the same environment. The proposed protocol is best suited for the WSN environment.

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