Performance Analysis of Energy Efficiency in WSN System

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Abstract— Wireless Sensor Networks (WSNs) are ad-hoc networks, consisting of distributed devices (motes) using sensor nodes to monitor physical or environmental conditions at different locations. Devices in a WSN are resource constrained; they have low processing speed, storage capacity, and communication bandwidth. In most settings,the network must operate for long periods of time, but the nodes are battery powered, so the available energy resources limit their overall operation. It is a great challenging aim to design an energy efficient routing protocol, which can minimize the delay while offering highenergy efficiency and long span of network lifetime. In this paper, we study the impact of heterogeneity and survey different clustering algorithms for heterogeneous WSNs; highlighting their objectives, features, complexity, etc. Then proposed the TSEP routing protocol for prolong the lifetime of a WSN and compared the result with basic distributed clustering routing protocol LEACH (Low Energy Adaptive Clustering Hierarchy). Simulation results using MATLAB are showed that the TSEP hetrogeneous system significantly reduces energy consumption and increase the total life time of the wireless sensor network compared with LEACH.

***Key words* — Clustering, Energy efficiency, Heterogeneity, Stability, Throughput, WSN**

I. INTRODUCTION

WSN is widely used to collect reliable and accurate information in the distance and hazardous environments, and can be used in National Defense, Military Affairs, Industrial Control, Environmental Monitor, Traffic Management, Medical Care, Smart Home [1] etc. The sensor whose resources are limited is cheap, and depends on battery to supply electricity, so it's important for Routing to efficiently utilize its power in both military and civilian applications such as target tracking, surveillance, and security management. It has been well recognized that clustering provides an efficient and scalable way to design and organize large-scale WSNs for energy efficiency of data communication. But sensor networks deployed in harsh or unstructured environments, sensor nodes are typically powered by irreplaceable batteries with a limited amount of energy supply. We would like the sensor network to perform its functionality as long as possible. A variety of protocols have been proposed to enhance the life of WSN and for routing the correct data to the base station. Communication protocols highly affect the performance of wireless sensor networks by an evenly distribution of energy load and decreasing their energy consumption and thereupon prolonging their lifetime. Thus, designing energy efficient protocols is crucial for prolonging the lifetime of wireless sensor networks. So, we described a novel energy efficient and lifetime increased proposed protocol as enhanced from LEACH protocol [2-3].

II. PAST EVALUATION IN WIRELESS SENSOR NETWORKS

Sensor network growth was set off by the United States in the Cold War. A network of acoustic sensors was located on planned areas on the underneath of the sea for detection and tracking of Soviet submarines [4]. The system of acoustic sensors was known as the Sound Surveillance System (SOSUS). Human operators had a vital job in these systems. The sensor network was wired network that did not contain the energy bandwidth restrictions of wireless system. Contemporary study on sensor networks started in 1980 through the Distributed Sensor Networks (DSN) agenda at the Defence Advanced Research Projects Agency (DARPA). Current enhances during computing and communication has origin a considerable move in sensor network study and got it nearer to achieving the unique vision. Tiny and low-cost sensors based upon micro-electro-mechanical system (MEMS) technology, wireless networking, and economical low-power processors authorize the operation of wireless ad hoc networks designed for different applications. Therefore, the agenda developed by latest networking method is appropriate for extremely dynamic ad hoc environments.

Wireless networks based on IEEE 802.11 standards [5] now are able to provide bandwidth forthcoming those of wired networks. At the similar time, the IEEE has observed the low cost and high abilities that sensor networks advise. The association has defined the IEEE 802.15 standard designed for personal area networks (PANs), having a radius of 5 to 10 m [6]. Beside this, enhances in chip capability and processor manufacture abilities have decreased the energy per bit necessity for both computing and communication. Sensing, processing and communications now achieved on a particular chip.

III. HETEROGENEOUS MODEL FOR WSN

From the last few years, the researchers attract towards wireless sensor networks due to its broad applications and unique challenges. Early study on wireless sensor networks mostly focused on the homogeneous wireless sensor network in which every node contain similar system resource. But, now a day's heterogeneous wireless sensor network is becoming more and more well-liked. Furthermore the results of researches demonstrate that heterogeneous nodes be able to improve network reliability and prolong network lifetime without considerably increasing the cost. The heterogeneous node provides data filtering, fusion and transport and is more costly and more capable. It might posses one or more type of heterogeneous resource, e.g., improved energy capability or communication ability. They can be line powered, or their batteries can be replaced easily. Compared with the normal nodes, they might be configured with additional powerful microprocessor and additional memory. Moreover, they can communicate among the sink node through high-bandwidth, long-distance network, for example Ethernet. The existence of heterogeneous nodes in a wireless sensor network is able to enlarge network reliability and network lifetime. In heterogeneous wireless sensor network, one essential and vital deployment difficulty is to make a decision that how many and wherever heterogeneous nodes be supposed to be deployed in the network [7].

3.1 Impact of heterogeneity on WSN

a) **Prolonging network lifetime**. In the heterogeneous wireless sensor network, all normal nodes know how to send data report to the base station (sink) through the adjacent heterogeneous node. Moreover the normal nodes, particularly around the base station, don't require forward enormous packets from other nodes [8]. The average energy utilization for forwarding a packet from the normal nodes to the sink in heterogeneous sensor networks will be much less than the energy consumed in homogeneous sensor networks. As the size of network increases, the gap of energy utilization between these two types of networks will be larger and larger.

b) **Improving reliability of data transmission**. As the sensor network links tend to have low reliability as well as every hop considerably lowers the continuous delivery rate. With heterogeneous nodes, there will be fewer hops between normal sensor nodes and the base station (sink). Thus the heterogeneous sensor network is able to obtain much superior end-to-end delivery rate than the homogeneous sensor network.

c) **Decreasing latency of data transportation.** Computational heterogeneity can reduce the processing latency in instant nodes. Also link heterogeneity is capable of reduce the waiting time in the transmitting queue. Fewer hops between sensor nodes and sink node too signify fewer forwarding latency[9].

IV. Clustering Hierarchy

It has been well recognized that clustering provides an efficient and scalable way to design and organize large-scale WSNs for energy efficiency of data communication. In a typical hierarchical WSN that deploys a large number of homogeneous or heterogeneous sensors, clusters are formed around a set of strategically selected or randomly designated Cluster Heads (CHs). The sensors within each cluster, often referred to as Leaf Nodes (LNs), collect and send environmental measurements to their corresponding CH, which performs an appropriate form of data processing (i.e., aggregation and compression) and sends the result to a BS for integration with data from other clusters. The BS, which is located either inside or outside the sensor network region, could be wire connected or rechargeable, and hence is often considered to have unlimited energy supply. Apparently, the number and location of CHs in hierarchical WSNs have a significant effect on the energy consumption for data communication from LNs to the BS [8-10].

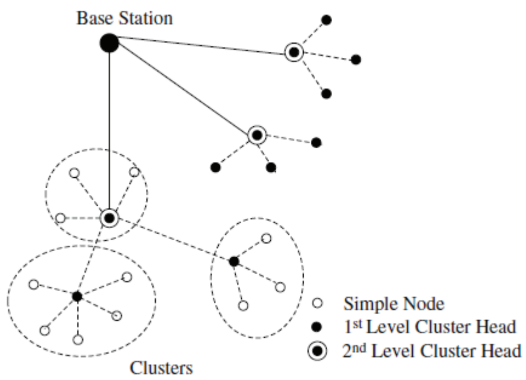

Figure 2. Nodes communicate to Base Station through Cluster Heads

4.1 Low-Energy Adaptive Clustering Hierarchy

Low-Energy Adaptive Clustering Hierarchy (LEACH) minimizes energy dissipation since cluster heads are formed based on the received signal strength and the energy consumption is less since the transmission is only done by cluster heads. To balance the energy dissipation of nodes, cluster heads change randomly over time. The node chooses a random number between 0 and 1 and becomes the cluster head for the current round if the number is less than the following threshold:

$$T(n) = p/(1-p*(r*mod(1/p))) \qquad \text{if } n€G= \; 0$$

$$\text{otherwise} \qquad (1)$$

Where, p is the desired percentage of cluster heads, r is the current round and G is the set of nodes that have not been cluster heads in the last $1/p$ rounds [11].

4.2 Threshold Sensitive Stable Election Protocol (TSEP)

Threshold sensitive Stable Election Protocol is based on three levels of heterogeneity and has a reactive routing protocol [12]. Advance nodes having energy greater than all other nodes; intermediate nodes have energy in between normal and advance nodes whereas the remaining nodes are normal nodes. Intermediate nodes can be elected with *'x'*, a part of nodes which are intermediate nodes and by using the relation that energy of normal nodes is *'μ'* times additional than that used for the normal nodes. In the case of SEP energy considered for normal nodes is E_o, for advance nodes it is

$$Eadv = Eo(1+A) \qquad (2)$$

and energy for intermediate nodes can be calculated as

$$Ein = Eo\ (1 + \mu) \qquad (3)$$

where $\mu = A/2$. As a result, the tota Energy of all the nodes will become

$$E_t = n*Eo(1+m*A + x*n) \ (4)$$

where, *'n'* is number of nodes, 'm' is fraction of advanced nodes to entire number of nodes *'n'* having energy greater than remaining of nodes and *'x'* is fraction of intermediate nodes. The best possible probability of nodes, which are separated on the basis of energy, to be selected as a cluster head can be computed by using following formulas:

$$Pnrm = p*/\ (1+m*A + x*n) \qquad (5)$$

$$Pint = p*(1+\mu)/\ (1+m*A + x*n) \qquad (6)$$

$$Padv = p*(1+A)/\ (1+m*A + x*n) \qquad (7)$$

Thus, to ensure that cluster head selection is made in the similar method as we have assumed, we have taken an additional factor into consideration, which is threshold level. Every node produces randomly a number inclusive of '0' and '1', when produced value is less than threshold then this node turns into cluster head [6]. For every this types of node, there are different formulas for the computation of threshold depending upon their probabilities, which are shown below:

$$Tnrm = pnrm / [\ 1– pnrm(\ r*mod\ 1/pnrm)\ ]\ , \quad if\ nnrm \in G' \qquad (8)$$

$$Tint = pint / [\ 1 – pint\ (\ r*mod\ 1/\ pint)\ ], \quad if\ nint \in G'' \qquad (9)$$

$$Tadv = padv / [\ 1– padv\ (\ r*mod\ 1/\ padv)\ ], \quad if\ nadv \in G''' \qquad (10)$$

Here G', G'' and G''' are the set of normal nodes, intermediate nodes and advanced nodes that has not turn out to be cluster heads in the past respectively

V. Performance measurement parameters with simulation

The performance measures that are used to evaluate clustering protocols are;

a) Stability period : It is defined as the time period until death of the first node dead.

b) Network lifetime. It is defined as the start of operation of the sensor network to the death of the first alive node.

c) Number of cluster heads per round. This measures the number of elected cluster heads or preassigned cluster heads with their energy levels.

d) Throughput. Rate of data sent over the network. (Data sent from cluster head to sink + the rate of data sent by nodes to their heads)

VI Simulation Result of Hierarchical Routing Protocol

The performance analysis of the routing protocols for wireless sensor networks has been performed in MATLAB. The 2-level hierarchy includes two types of nodes such as normal nodes & advanced nodes and varies the energy from 0 to 1. While in 3-level hierarchy, three types of nodes such as normal nodes, intermediate nodes and advanced nodes are present and have the value of energy 0, 0.5 & 1 respectively. This type of hierarchy is used for TSEP. The clustered wireless sensor network in a field is designed with dimensions of 100x100. The position of the sink or base station is located at the center.

6.1 Simulation Parameters for Comparison LEACH & TSEP

The 100m x100m region has been created for the comparative analysis of LEACH & TSEP protocols on the basis of network lifetime, stability period and throughput. The 100 sensor nodes spread randomly and the sink or base station is located at the center point (50×50). The packet size of 4000 bits has been sent by the nodes to their cluster heads as well as the combined packet size that a cluster head sends to the sink. The parameters used in the simulation are mentioned below in Table 1.

Table 1 Simulation Parameters

Parameters	Value
Network Field	(100,100)
Number of Nodes	100
Initial Energy of Nodes	0.5 J
Message Size	4000 bits
Eelec	50 nJ/bit
Eamp	0.0013 pJ/bit/m4
Efs	10 nJ/bit/m2
EDA	5 nJ/bit/signal
Threshold Distance	70

6.1.1 Performance Comparison Results of LEACH & TSEP

Case 1: ***m =0.4, A=1, μ= 0.5, x= 0.2***

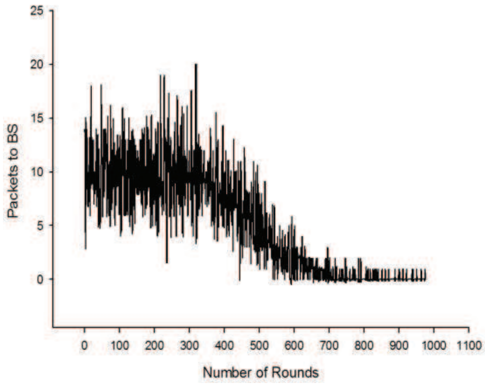

Fig1 Number of packets to Base Station in LEACH

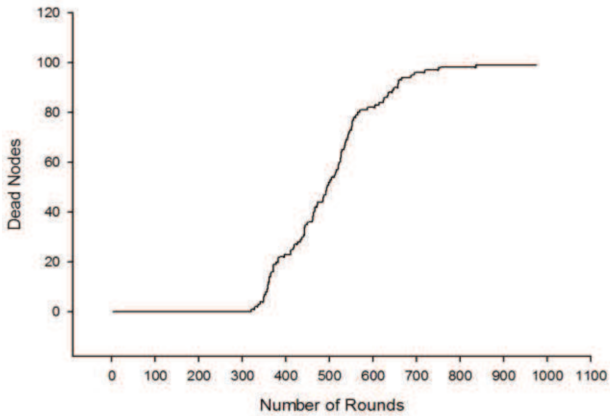

Fig 2 Stability of LEACH

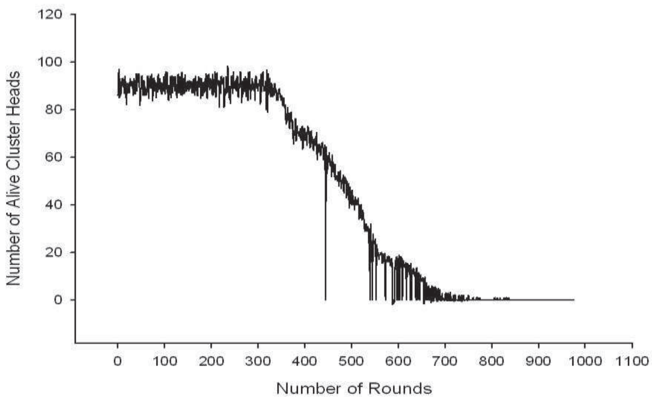

Fig 3 Throughput of LEACH

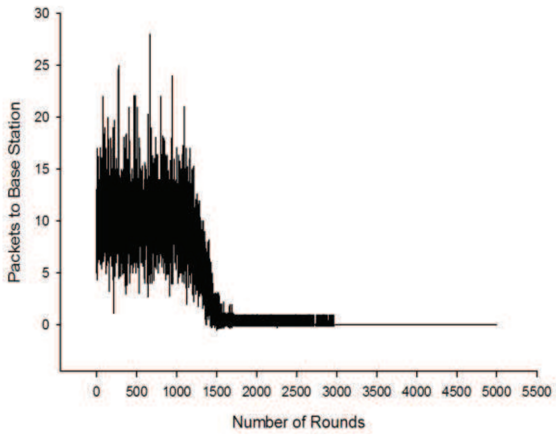

Fig 4 Number of packets to Base Station in TSEP

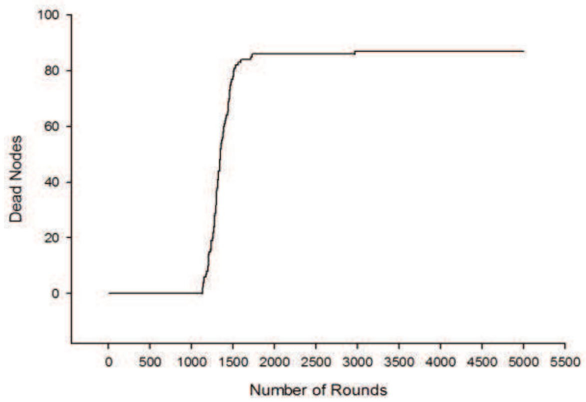

Fig 5 Stability of TSEP

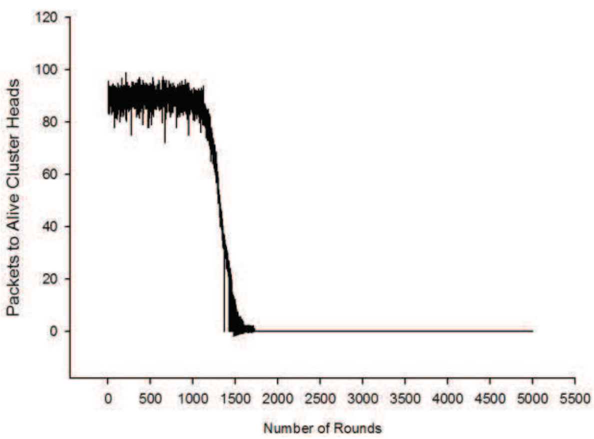

Fig 6 Throughput of TSEP

It is observed from the simulation results in Fig 1 to Fig 6 that number of packets sent to the base station in case of LEACH lies in range of 0-20 nodes in the 0-300 rounds and at least 3-4 packets still sent to the base station around the 1000^{th} round. For TSEP routing protocol, the packet sent to the base station are in the range of 0-30 for 0-1300 rounds and last 2-3 packets sent up to 2950 rounds. The stability of the LEACH lies in the range 310-700 rounds, since the first sensor node dies at 310 and last node goes up to 700^{th} round. For TSEP, the first dies at 1100 round and the algorithm is stable up to 1500 rounds. The cluster heads affect the stability and life time of the routing protocols since larger the cluster heads more will be the packets sent to the base station. For LEACH, the life time of the sensor nodes is up to 680, since the last CH node dies at 680^{th} round. For the TSEP, the last node dies at 1100^{th} and 1500^{th} round. The throughput of the TSEP algorithm is high since it can sustain the life time up to more number of rounds.

VII. CONCLUSION AND FUTURE WORK

The present paper deals with the energy efficient saving TSEP clustering routing protocol for WSN. Simulative Results showed that the TSEP Heterogeneous System provides better performance in energy efficiency and increasing level in lifetime of the wireless sensor networks our the LEACH system in the individual clustering of the whole network.

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