Performance Analysis of Energy Efficient Clustering Algorithms for Wireless Sensor Network

Dharm Singh
Department of CSE
College of Technology and Engineering, MPUAT
Udaipur, India

Naveen Choudhary
Department of CSE
College of Technology and Engineering, MPUAT
Udaipur, India

Shilpa Pandey
Department of CSE
College of Technology and Engineering, MPUAT
Udaipur, India

ABSTRACT
Wireless sensor networks (WSN) are emerging in various fields like wildlife monitoring, mining industries, security surveillance. The efficiency of sensor networks strongly depends on the routing protocol used. Routing protocols providing an optimal data transmission route from sensor nodes to sink to save energy of nodes in the network. This paper presents simulation results of existing clustering algorithms for heterogeneous wireless sensor network. The simulation results show how the election criteria for cluster heads election such as random election and nodes with different energy level affect the number of cluster heads elected, and the network lifetime. In this paper, we analyze three different types of routing protocols: LEACH, SEP, and TEEN. Simulation results are provided to show the comparative effectiveness of different clustering algorithm on network lifetime and cluster head selection and failure nodes in the network. Sensor networks are simulated using MATLAB simulator.

Keywords
Wireless sensor network, TEEN, LEACH, SEP, energy-efficient, network- lifetime.

1. INTRODUCTION
A sensor network is a collection of communicating sensing devices. These devices communicate wirelessly to transmit their readings and widely known as wireless sensors. A sensor network is collection of such communicating devices. When large number of sensors can be spread across a geographical area and networked in applications then it is termed as Wireless sensor Network. Clustering is a technique that is used to enhance the lifetime of the sensor network by reducing energy consumption [1]. This paper provides experimental performance evaluation of existing routing algorithm for wireless sensor network. This paper consider the following protocols that organize sensor network into energy efficient algorithm for simulation studies.

2. ENERGY EFFICIENT CLUSTER BASED ROUTING PROTOCOLS

Hierarchical routing performs energy-efficient routing in WSNs, and contributes to overall system scalability and lifetime. In a hierarchical architecture, sensors organize themselves into clusters and each cluster has a cluster head, i.e. sensor nodes form clusters where the low energy nodes are used to perform the sensing in the proximity of the phenomenon. The less energy constrained nodes play the role of cluster-heads and process, aggregate and forward the information to a potential layer of clusters among themselves toward the base station. In this section, we introduce three cluster based scheduling mechanism

2.1 Leach (Low-energy adaptive clustering hierarchy)
It is mainly designed for sensor network where an end user wants to remotely monitor the environment. The data from the individual node must be sent to a central base station, which may be located far from the sensor network and through which the end user can access data. Simulation shows that LEACH is an energy-efficient protocol that extends system lifetime. In LEACH, the network is randomly divided into several clusters, where each cluster is managed by a cluster head (CH). The sensor nodes transmit data to their cluster heads, which transmit the aggregated data to the base station. There are number of rounds in this and each round begins with setup phase i.e. a group of sensor nodes select a cluster head, and this setup phase is followed by steady phase means the sensing nodes can begin sensing and transmitting data to their cluster head. During setup phase each node will calculate their probability of becoming the cluster head [3].

Probability is given by-

$$P_i(t) = \frac{k}{(N-k) * r \bmod \left(\frac{n}{k}\right)} : \quad C_i(t)=1$$

$$0: \quad C_i(t) = 0$$

Here r is number of rounds have passed and Ci (t) = 0. N is total number of nodes in the network and k is optimal number of cluster head.

2.2 SEP (Stable Election Protocol)
When there are heterogeneous nodes present in any network this protocol improves on election of cluster head. In this nodes of different energy levels are considered. In heterogeneous application the election probability of becoming the cluster head will depend on the type of existing nodes in presence of m fraction of advance node with additional energy of factor α [3]. Weighted probability for normal and advance node is given by:

For normal node: $p_{nrm} = \frac{Popt}{1+\alpha.m}$ (2)

For advance node: $p_{adv} = \frac{Popt}{1+\alpha.m} \times (1+\alpha)$ (3)

Where pnrm and padv are probability of normal node and advance node [7].

2.3 TEEN (Threshold sensitive energy efficient sensor network protocol)

It's a hierarchical protocol designed to respond to sudden changes in the sensed attributes. It uses data centric mechanism. In this hierarchical grouping is being done. Where closer nodes form clusters and this process goes on until the sink is reached. After clustering is done, the cluster head broadcasts two thresholds to the nodes- the hard and the soft threshold. [5] TEEN is important for time-critical applications, in which the network is operated in a reactive mode. TEEN uses a data-centric method with hierarchical approach. The sensor network architecture in TEEN is based on a hierarchical grouping where closer nodes form clusters and this process goes on the second level until the sink is reached.

Table 1. Comparison of Energy efficient Rounting Protocol.

Protocols	Network Type	Application	Cluster head Selection
LEACH	Proactive network	fault detection and diagnosis.	Random , Dynamic Election
SEP	Proactive	Similar	Scalable and dynamic , Presence of advance node
TEEN	Reactive network	Time critical	Based on two threshold value

3. SIMULATION ENVIRONMENT

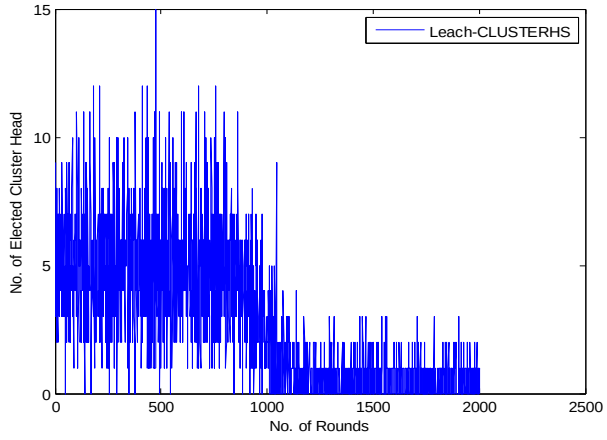

Fig 1: Elected Cluster Head LEACH

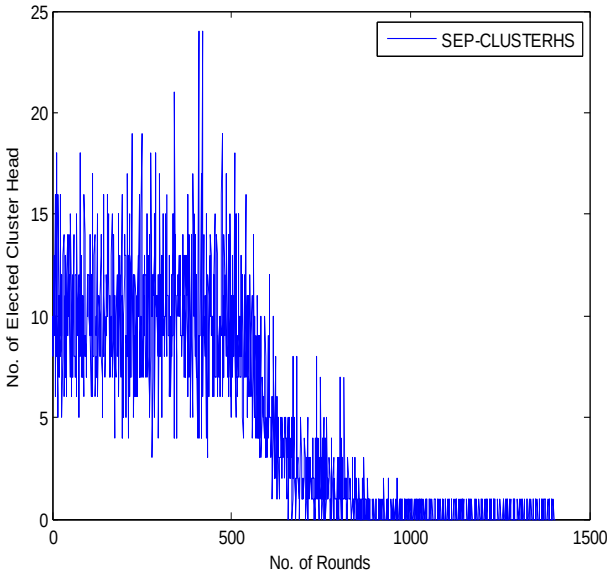

Fig 2: Elected Cluster Head in SEP

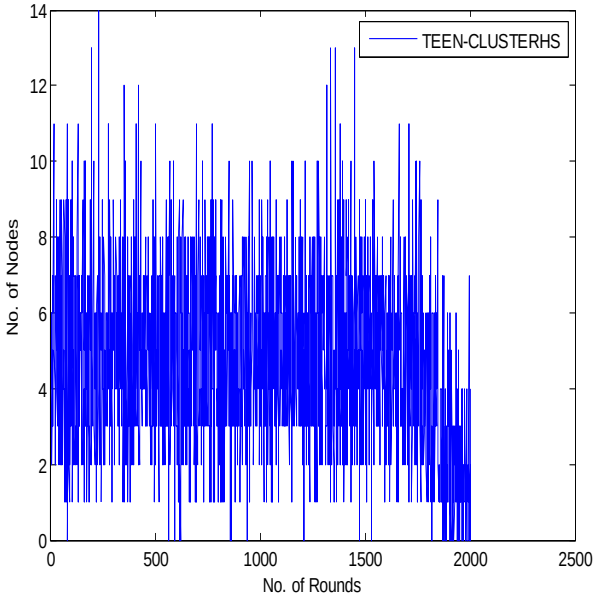

Fig 3: Elected Cluster Head in TEEN

Sensor networks are simulated using MATLAB simulator. To evaluate the performance of the clustering routing protocols in wireless sensor network the simulation consists of 100 nodes with initial energy of 0.5 Joule, scattered randomly within a 100x100 m sensor field.

The Base Station is (BS) located at (50,150) m, 4000 packet length and 50 bit control packets. The energy consumption due to communication will be calculated using the first order energy model.

We assume that each sensor node generates one data packet per time unit to be transmitted to the BS. For simplicity, we refer to each time unit as a round.

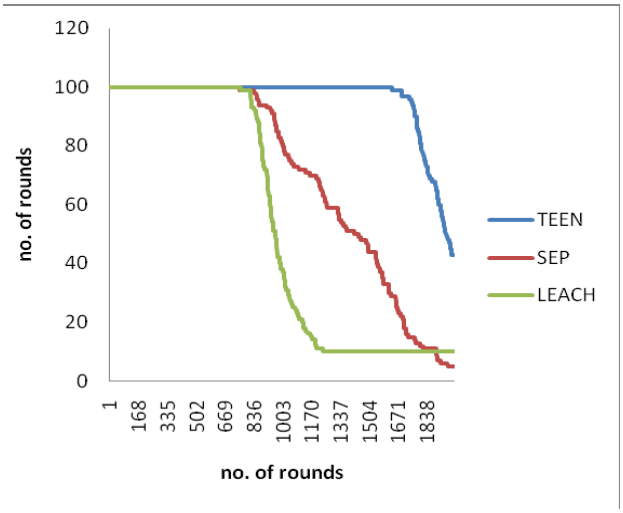

Fig 4: Network Life Time in Leach, SEP and Teen Heterogeneous environment w.r.t. total no. of rounds

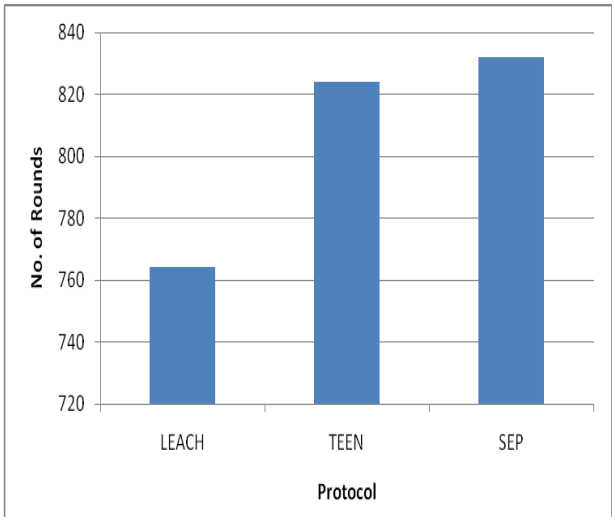

Fig 5: Network Lifetime (stability) of LEACH, TEEN and SEP wrt FND

4. PERFORMANCE MATRICES USED IN SIMULATION

4.1 Elected cluster Head per Round

The election of Cluster head is lies on various parameters like Initial energy Eo, probability p. In probabilistic clustering technique, nodes are selected to become the cluster head depending on calculated probability [6]. We change in the parameters for cluster heads election in the above three protocols. Then by simulation result we will show the variation in the results.

4.2 Network Lifetime

If the protocol can completely utilize the presence of some advance nodes that have extra energy to increase network lifetime then it will be very beneficial [3]. The lifetime can be defined either the number of rounds until the first nodes dies or a certain percentage of nodes are dies. Simulation is performed by varying the fraction of m advance nodes with the constant extra energy [3]. The comparisons for the three protocols are further analyzed and the results are shown in Figure 4. It can be seen that, the presence of advanced nodes gives no effect to LEACH and TEEN protocol while the network lifetime improves SEP protocols.

5. SIMULATION RESULTS

The simulation results for LEACH, SEP and TEEN protocols are shown in Figures 1,2,3. It is observed that there are distinct variations in the number of cluster heads elected per round for all three protocols as shown in Figures 1, 2, 3. In LEACH and TEEN protocols, the optimal number of cluster heads is set to 5% [4]. It can be seen that the variation of number of cluster heads for LEACH and TEEN protocols which is far from near optimal, 5. In SEP protocol, the optimal number of cluster heads is 10 due to the presence of advanced node [7]. The variation of number of cluster heads. This means, the SEP protocol manages to minimize the variation in the number of cluster heads elected. The comparison for the three protocols are further analysed and the results are shown in Figure 4. It can be seen that, the presence of advanced nodes gives no effect to LEACH and TEEN protocol while the network lifetime improves SEP protocols. Simulation result for this are as follows: As stability factor SEP is better than other two LEACH and TEEN because First node dead (FND) at 832,824 and 764 round in SEP, TEEN and LEACH which is show in Figure 5.

6. CONCLUSION

In this paper, we analysed energy efficient three protocols LEACH, TEEN and SEP clustering algorithms for heterogeneous wireless sensor network. The simulation results show how the election criteria for cluster heads election such as Initial Energy Eo, probability with presence of advance nodes with different energy level and base station area affect the number of cluster heads elected, and the network lifetime. Simulation results are provided to show the comparative effectiveness of different clustering algorithm on network lifetime, cluster heads selection. We have evaluated the performance of LEACH,TEEN and SEP using MATLAB.

Table 2: Simulation Summary

Protocol	Elected Cluster Head heterogeneous network	FND(First Node Dead) in rounds	Life Time
LEACH	13(variation)	764	comparatively less
SEP	24 (variation)	832	comparatively best
TEEN	14 (variation)	824	comparatively better

It is observed that there is significant improvement in the lifetime in case of SEP protocol in comparison with LEACH and TEEN protocols because the number of rounds is maximum i.e. SEP is more stable because FND at 834 round which is maximum as compare to LEACH and TEEN values of which are 764 and 824 round. Simulation summary shows in Table 2.

7. REFERENCES

[1] [1] Younis, M., Youssef, M. and Arisha, A. 2003 "Energy- aware management in cluster-based sensor networks", Computer network 43 (5).

[2] [2] Heinzelman, W. R., Chandrakasan, A., Balakrishnan, January 2000 "Energy- efficient communication protocol for wireless microsensor

network". In Proceedings of the 33rd Hawaii International Conference on System Sciences(HICSS.33)

[3] [3] Dahnil, D.P.; Singh, Y.P.; Chin Kuan Ho; 2010." Analysis of adaptive clustering algorithms in wireless sensor networks", Communication Systems (ICCS), 2010 IEEE International Conference.

[4] [4] Heinzelman,W.R.,Chandrakasan,A. P,,Balakrishnan, H , October 2002."An application-specific protocol archietecture for wireless microsensor networ", IEEE Transactions on wireless communication,1(4):660-670,

[5] [5] Garg Kumkum,"Mobile Computing: Theory and Practice"

[6] [6] O. Younis, M. Krunz, S. Ramasubramanian, 2006. "Node clusturing in wireless sensor network: Recent developments and deployement challenges," IEEE In Newyork, Vol 20, No 3., pp 20-25.

[7] [7] S. George, I. Matta, A. Bestavros. 2004 “SEP: A Stable Election Protocol for clustered heterogeneous Wireless Sensor Networks”. In Proceedings of Second International Workshop on Sensor and Actuator Network Protocol and Applications (SANPA), Boston, MA, August.