Performance Evaluation of Cluster based Routing Protocols in WSNs

Ritu Rani[1]*, Anuj Kumar[2]

[1, 2]Computer Science Engineering Department, Kurukshetra Institute of Technology & Management, Kurukshetra, Haryana, INDIA

Abstract: The energy efficiency, lifetime, deployment of nodes, fault tolerance, latency, high reliability and robustness are the important constraints of routing protocols use in wireless sensor network (WSNs). The routing protocols on clustering structure have been focused by researchers from recent years. The clustering techniques are generally used for purpose of saving energy and increase the lifetime of the wireless sensor network. In this paper, we purposed and evaluate the four different types of routing protocols: LEACH, DEEC, SEP and T-DEEC. The MATLAB simulator is used to analyze the performance of these protocols by selecting number of alive nodes, number of dead nodes, number of packets as performance parameters including the power consumption and overall network performance. The simulation results show that our proposed algorithm performs better as compared to others in terms of network lifetime and stability.

Index Terms: Wireless Sensor Networks, Clustering, Energy Consumption, Network Life time, Stability.

1. Introduction

Wireless Sensor Networks (WSN) is a set of hundreds to thousands sensor nodes which senses the physical environment in terms of temperature, light, sound, vibration, humidity etc. The wireless sensor network is working on the problems of low-power communication, sensing, energy storage, and computation [1]. Sensor networks have a wide variety of applications with varying characteristics requirements and usability. Many areas such as military environment, disaster management, medical and health care, Industrial fields, home networks, detecting chemical etc. have potential application of WSNs.

The high energy nodes are randomly selected for processing/sending data while low energy nodes are used for sensing and send information to the cluster heads in Hierarchical-based routing Clustering technique increases the lifetime of the network by reducing energy consumption. The cluster network have two main components, base station(BS) and cluster head(CH). The hierarchical WSN shown in Figure 1, is composed of the upper tier anchor nodes including base-stations with electric source and the lower-tier mobile nodes which access and communicate to the network [2]. The sensor network can be non-hierarchical or flat in the sense that every sensor has the same role and functionality.
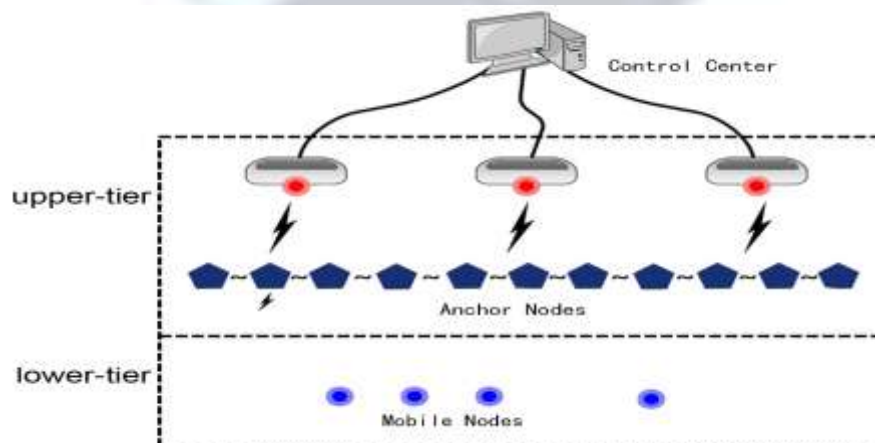

Figure 1.   Schematic view of hierarchical network

The connections between the nodes are set in short distance to establish the radio communication. A sensor network can be hierarchical or cluster-based hierarchical model, where the network is divided into clusters comprising of number of nodes. This paper is organized as follows. In section 2 we give a brief summary of the hierarchical routing protocols for WSNs. In section 3, the simulation results for Low Energy Adaptive Cluster Hierarchy based protocol (LEACH), Stable Election protocol (SEP), distributed energy-efficient clustering (DEEC) and Threshold-distributed energy-efficient clustering (T-DEEC) routing protocols are summarized. Finally, in section 4, we conclude the paper.

2. Related Work

Hierarchical Routing Protocols (HRPs) is an energy efficient protocols that provide self-organization capabilities that allow large scale network deployment. Generally, in a hierarchical architecture, some nodes take responsibility to perform high energy transmission while the rest perform normal task. Power-aware algorithm is used to select eligible high energy nodes to relay the data from normal nodes to the base station (BS) [3]. HRPs can be categorized into two types, cluster-based HRPs and chain-based HRPs [4].

A large number of hierarchical routing protocols for WSNs has been proposed in the literature. LEACH has the tremendous performance in terms of energy conservation in almost all later HRPs [5]. SEP (Stable Election Protocol) [5] is proposed in which every sensor node in a heterogeneous two-level hierarchical network independently choose itself as a cluster head (CH) based on its initial energy relative to that of other nodes [6]. In DEEC, the CHs are elected by a probability based on the ratio between the residual energy of each node and the average energy of the network [7]. Threshold distributed energy efficient clustering (TDEEC) algorithm is used to increase the energy efficiency and stability of the heterogeneous wireless sensor networks [8].

3. Performance Parameters

The life time, number of nodes alive and number of data packets received at base station are the various performance parameters used to study and evaluate the clustering protocols These used metrics allow to conclude about the stability period of the network which is the time interval from the start of network operation until the death of the first sensor node, unstable period of the network which is the time interval from the death of the first node until the death of the last node, energy consumption, the data send that are received by the base station(BS) and the lifetime of the network which is number of rounds until the first node die which is simply the stability period of the network. We have simulated our wireless sensor network in a sensing field of 100m*100 m. The Simulation parameters used are listed in table 1.

Table 1: Simulation Parameters

Network Field	100*100
Number of nodes	100
E_o (Initial energy of normal nodes)	0.5 Joule
Message Size	4000 Bits
E_{elec}	50 nJ/bit
E_{fs}	10 nJ/bit/m^2
E_{amp}	0.0013 pJ/bit/m^4
E_{DA}	5 nJ/bit/signal
do(Threshold Distance)	70 m
p_{opt}	0.1

4. Simulation Results

In this section we present the simulation results of LEACH, SEP, DEEC and TDEEC protocols using MATLAB. The following are the important performance parameters that have great importance in discussing of simulation results.

Stability Period: The time duration between the starting of the network process and expiry of very first node in the network.

Instability Period: The time duration between the expiry of very first sensor node and very last sensor node of the network.

Network Life Time: Time duration between the network process initialization and the expiry of the very fast alive sensor node in network.

Cluster Heads (CH), per round: These are the some percentage (%) of the nodes that collect the sensed information of their associated cluster members and directly send to base station (BS).

Alive Nodes per round: These are the total number of nodes that have not ill yet expected all of their energy.

Packets to Base Station (BS): These are total data packets that are successfully sent from their cluster heads to base station.

We analyze the performance of four HRPs on the basis of selected network parameters such as stability period, network life time and throughput.
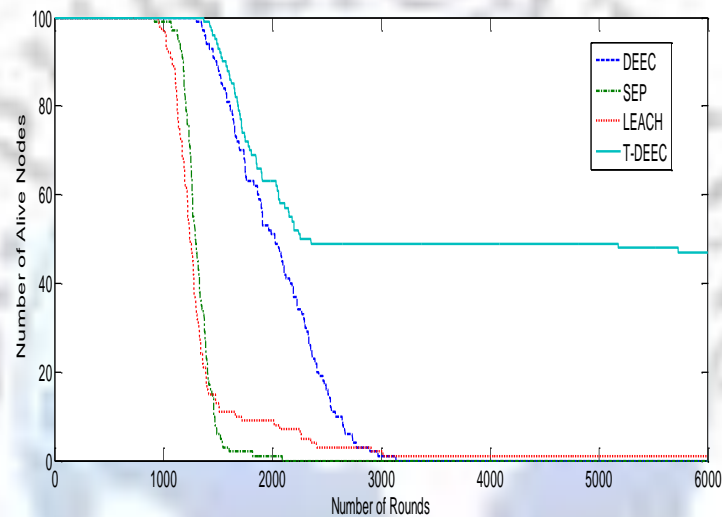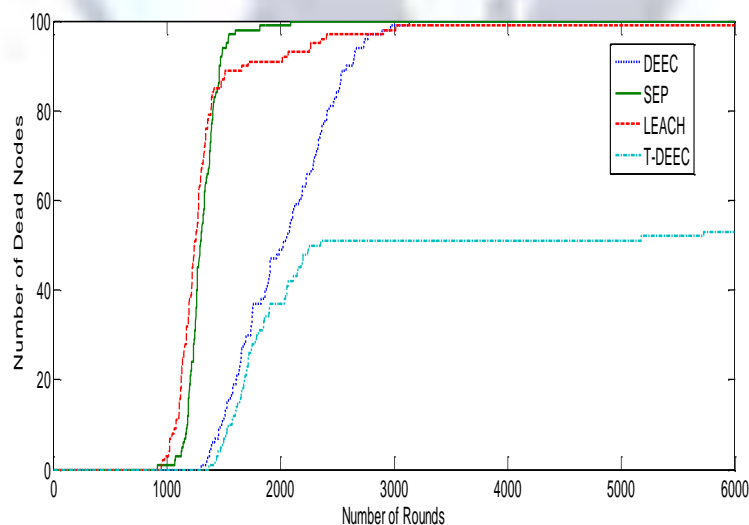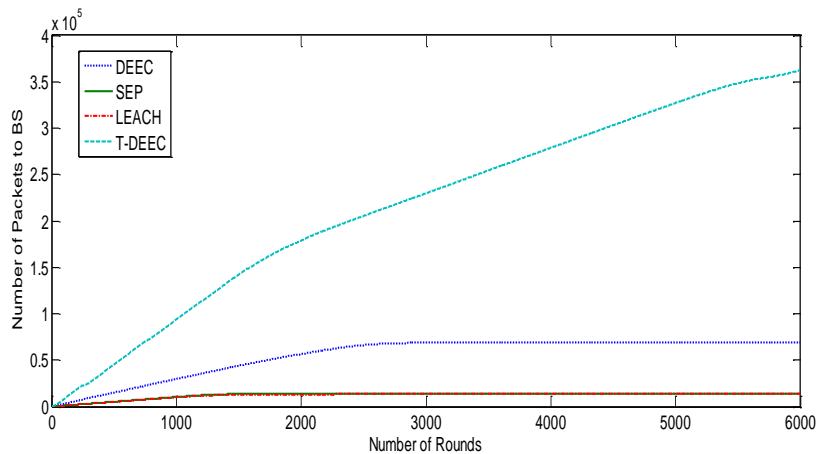

Fig. 2: Average number of Alive nodes per round.

Fig. 3: Average number of Dead nodes per round for four protocols.

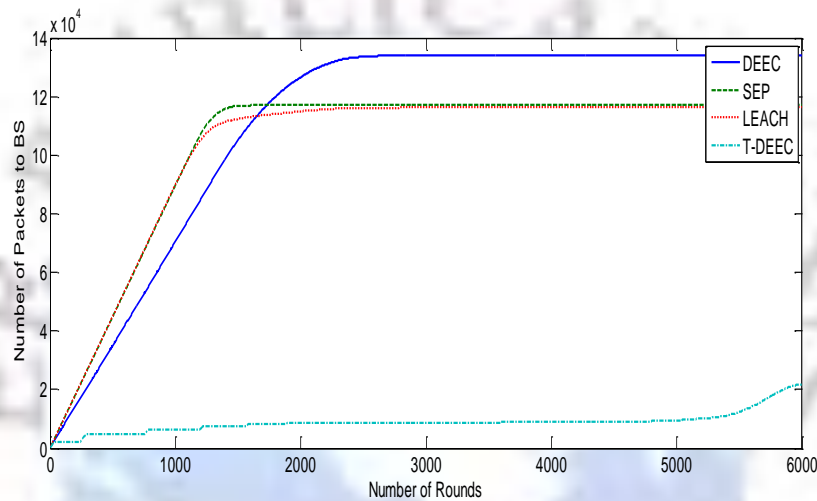**(Fig. 4: Packet sent to base station (BS) Versus Time rounds).**
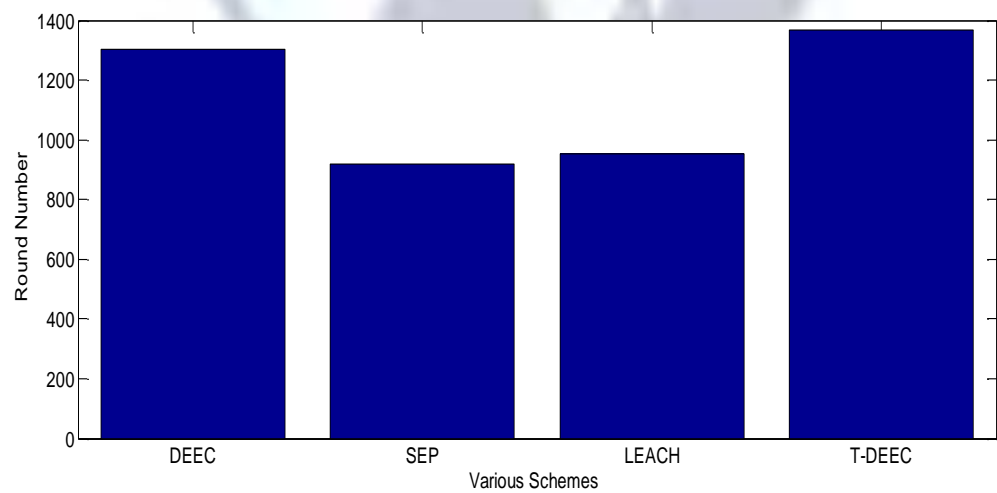

Fig. 5: Count of Cluster Head

Fig. 6: Stability versus instability periods (as measured by no. of rounds).

In Fig. 2 it is observed that network life time is enhanced quiet significantly in case of T-DEEC as compared with other clustering approaches i.e. LEACH, SEP, and DEEC. Fig. 3 shows that instability period of network also improved. Fig. 4 gives a picture of throughput (TP) and Fig. 5 represents cluster heads (CHs) selected in every round for different HRPs. For 20 simulations randomly for our protocols we compute the mean maximum possible rounds of communications for different value of Eo and compare the results to SEP, DEEC and LEACH protocols. The Fig. 6 represents different value of the initial energy the First Node Died round (FND). The results prove more the T-DEEC performances, where its FND round is always larger than the remaining protocols.

Conclusion

In recent years, we may choose suitable routing protocols for different applications, but the network life time and stability are still the most important issue in wireless sensor networks. In this paper we have described four clustering protocols i.e. LEACH, SEP, DEEC and T-DEEC. We conclude that T-DEEC, significantly improved network metrics and seems to be an attractive choice for WSNs by extending and enhancing overall network quality parameters.

References

[1]. F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirici, A survey on sensor networks, IEEE communications magazine 40 (8) (2002) 102–114

[2]. Nan Zhou, Xiaoguang Zhao, Min Tan, Deployment and Routing Method for Fast Localization Based on RSSI in Hierarchical Wireless Sensor Network, 2013 IEEE 10th International Conference on Mobile Ad-Hoc and Sensor Systems.

[3]. Heinzelman, W., Chandrakasan, A., & Balakrishnan, H. (2000). Energy-efficient communication protocol for wireless microsensor networks. In International conference on systems sciences (Vol. 2, pp. 10). Hawaii: Citeseer.

[4]. Al-Karaki, J., & Kamal, A. (2004). Routing techniques in wireless sensor networks: A survey. IEEE Wireless Communications, 11(6), 6–28.

[5]. Kumar, D., Aseri, T., & Patel, R. (2009). EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks. Computer Communications, 32(4), 662–667.

[6]. G. Smaragdakis, I. Matta, A. Bestavros, "SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks", in: Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA 2004), 2004.

[7]. Sha, C.,Wang, R., Huang, H.,& Sun, L. (2010). Energy efficient clustering algorithm for data aggregation in wireless sensor networks. The Journal of China Universities of Posts and Telecommunications, 17, 104–122.

[8]. P.Sini, A.K. Sharma, "Energy Efficient Scheme for Clustering Protocol Prolonging the Lifetime of Heterogeneous Wireless Sensor Networks", International Journal of Computer Applications (0975 – 8887) Vol. 6– No.2, 2010.

[9]. Soro, S., & Heinzelman, W. B. (2009). Cluster head election techniques for coverage preservation in wireless sensor networks. Ad Hoc Networks, 7(5), 955–972.

[10]. Chamam, A., & Pierre, S. (2010). A distributed energy-efficient clustering protocol for wireless sensor networks. Computers Electrical Engineering, 36(2), 303–312.

[11]. R .V. Biradar, V. C.Patil, S. R. Sawant, R. R. Mudholkar, "Classification and Comparison of Routing Protocols in Wireless Sensor Networks," Special Issue on Ubiquitous Computing Security Systems, 2009, Vol. 4, Issue 2, pp. 704-711.

[12]. Ali Norouzi, Abdul Halim Zaim, "An Integrative Comparison of Energy Routing Protocols in Wireless Sensor Network" Wireless Sensor Network, Journal, 2012, Vol. 4, pp. 65-75.

[13]. Vijey Thayananthan, Ahmed Alzranhi."Enhancement of energy conservation technologies in wireless sensor network" Procedia Computer Science, 2014, Vol.34.pp79-86.

[14]. M. Kadi, Iyad Alkhayat, "The effect of location errors based routing protocols in wireless sensor networks", Egyptian Informatics Journal, 2015, Vol.16, pp 113-119.

[15]. B. Manzoor, N. Javaid, O. Rehman1, M. Akbar, Q. Nadeem, A.Iqbal1,M. Ishfaq, "Q-LEACH: A New Routing Protocol for WSNs, Elesevier, Procedia Computer Science 19(2013) 926–931.