A single-hop clustering and energy efficient protocol for wireless sensor networks

Somasekhar Kandukuri, Nour Murad, Richard Lorion

▶ To cite this version:

HAL Id: hal-01221984

http://hal.univ-reunion.fr/hal-01221984

Submitted on 10 Nov 2017

A Single-hop Clustering and Energy Efficient Protocol for Wireless Sensor Networks

Somasekhar KANDUKURI, Nour MURAD, and Richard LORION
Laboratory of Energy, Electronics and Process (LE^2P)
University de La Reunion 15 avenue Rene Cassin CS 92003
97744 Saint Denis CEDEX 9, Reunion - France
Email: somasekhar.kandukuri@univ-reunion.fr

Abstract—**Energy efficiency is an active research area in WSNs technology. There is an extensive research work going towards this direction and existing mechanisms fail to address the problem completely due to its limited specificity. This work focuses on the idea of enhancing the network lifetime on the basis of cluster-heads (CHs) remaining energy levels. Thus, instead of changing CHs at every round for dynamic clustering, we propose two sorts of CH threshold function as energy threshold function and optimal CH range threshold function for maximizing the network lifetime. Simulation results show that our protocol maximizes the network lifetime and captures the data three times more than the other known energy-efficient protocols in the literature.**

I. INTRODUCTION

In sensor networks, clustering protocols have the higher network performances in terms of network lifetime, less transmissions and low latencies than the traditional communication methods. In Wireless Sensor Networks (WSNs), there has been a great deal of research conducted on energy efficient clustering protocols, and several well-known works have also been studied in the literature, such as [1], [2], [3], [4], [5], [6], [7], [8] and [9].

This paper presents a Single-hop Clustering and Energy-Efficient Protocol (SCEEP) for prolonging the network lifetime based on Cluster-Heads remaining energy and optimal CH range levels. It is mainly considered to reduce the communication over-heads and unnecessary cluster-head changes at every round.

The organization of this paper is as follows. Section II describes the proposed SCEEP algorithm and features of the work are presented. Simulation results and comparisons are discussed in section III. Final section concludes the paper and suggestions for future work are given.

II. SCEEP ALGORITHM

In SCEEP, we consider a homogeneous sensor network model with an initial amount of energy for sensor nodes. We used first order energy model [2] to design this work. Our approach mainly targets to reduce the communication overheads and unnecessary cluster-head (CH) changes at every round. In this proposal, we have been followed two kinds of clustering principle to elect the cluster-heads. The first principle follows LEACH algorithm of Eq.(1) to initialize the random sensor network at time interval t, and the mathematical expression of the CH probability threshold function is given as

$$P_i(t) = \begin{cases} \frac{K}{N-K(R \ mod \ N/K)} & C_i(t) = 1 \\ 0 & C_i(t) = 0 \end{cases} \quad (1)$$

Where K denotes the initial amount of optimal cluster head range, N is the total number of nodes in the network, R is the current round and, $C_i(t) = 1$ if the node i has not been already a cluster head in the last N/K rounds at given time instances t, otherwise $C_i(t) = 0$. According to Eq. (1), nodes always have the equal chances to become a cluster head for every round, regardless how much high or little amount of residual energy in the nodes have had. In this scenario, cluster topology or CH changes occur every round without considering the remaining energy levels of the nodes, which may lead to earlier nodes death and communication overheads or degrading the network lifetime. For avoiding the communication overheads and maximizing the network lifetime, we propose the second principle of clustering threshold function, which has been designed based on CHs remaining energy and fixed optimal cluster-head ranges at every round. However, the recent literature works have presented some advanced energy-efficient protocols in [7], [8] and [9], based on nodes residual energy of the network or using different sorts of nodes in the cluster-topology like a heterogeneous model, in which they still failed to reduce the communication and computational costs completely. In our approach, CHs check their energy status and optimal CHs range through the Algorithm 1 before calling for new cluster-heads request, as we can see it below. The proposed significant features of SCEEP protocol are the following

1) Initial set-up phase of the network, we use LEACH cluster-head selection algorithm to elect the CHs during its first round.

2) After completion of the network first round (in seconds) simulations, current CHs check their energy levels $E_{CH_i(t)}$ to continue their intra-cluster communications with the nodes or not, by using energy threshold function E_{Th}. According to the network setup, the energy threshold value can vary based on the given initial energy levels of the nodes. If the current CH energy levels is greater than or equal to the energy threshold level, it continues its intra-cluster activities to receive the data among the cluster member nodes, otherwise CH destroys the current cluster and calls for the new cluster formation.

3) In this case, we fixed an optimal CHs threshold function $\hat{P}_{Th}$, if the CHs optimum level $\hat{P}$ is lower than the optimal threshold range, then it goes back

to the Cluster-head election mechanism for electing new cluster-heads. In this regard, we fixed the optimal threshold range at 3.

4) If current CHs are higher than or equal to the minimum required CHs range, then it continues receiving the data from their corresponding member nodes.

Algorithm 1 Cluster-Head threshold functions

1: procedure : $Init(P_i(t), K, R, N)$
 $E_{CH_i(t)}, E_{Th}, \hat{P}, and \hat{P}_{Th}$
 Parameters: $t \leftarrow nodes\ threshold\ function\ time\ instances$
 $E_{CH_i(t)} \leftarrow current\ CH\ remaining\ energy\ level$
 $R(RoundNumber) \leftarrow is\ the\ round\ iteration\ time$
 $in\ seconds$

2:     if $P_i(t) \leq K/(N - K(R\ mod\ N/K))$ then
3:         Start Cluster formation
4:         Count_CHs
5:     else if $E_{CH_i(t)} \geq E_{Th}$ then
6:         if $\hat{P} \geq \hat{P}_{Th}$ then
7:             Continue Data reception
8:         else
9:             Return to the network initialization $P_i(t)$
10:        end if
11:    else if $E_{CH_i(t)} < E_{Th}\ AND\ \hat{P} < \hat{P}_{Th}$ then
12:        Send `CH_candidates_clear()`
13:        Send `Clusters_Clear()` to destroy
14:        Return to the network initialization $P_i(t)$
15:    end if
16: end procedure

III. SIMULATION RESULTS

In this simulation, SCEEP sensor network has been placed with 101 static sensor nodes, which are randomly distributed in a field of $400m \times 400m$. The initial energy of the node is $0.5\ J$ and each data transmission size is equal to $4\ kb$.

The results of SCEEP simulations are shown in Fig. 1 and 2. We presented some measurement metric analysis through both figures. According to the fig. 1, the packet reception rate is between SCEEP and DEEC, DDEEC 3 times more. In Fig. 2 SCEEP, where the First Node Dies (FND) metric shows at round 172 while other protocols FND are at round 28 and 36 respectively. When comparing with Half of the Nodes Alive (HNA) metric, we can clearly observe the differences, where the pointed line indicates in Fig. 2 at 50 nodes alive, SCEEP extends the network lifetime 500 rounds ahead than the other protocols. From the above analysis and proofs, SCEEP indeed have outperforming results than the other protocols. In fact, DEEC and DDEEC are developed with powerful nodes consideration of heterogeneous network model, such as normal and advanced nodes, even though SCEEP extends the network lifetime better than the other protocols.

IV. CONCLUSION

We proposed SCEEP distributed clustering protocol. The experimental results showed that the SCEEP have better performances than the other known protocols. FND and HNA
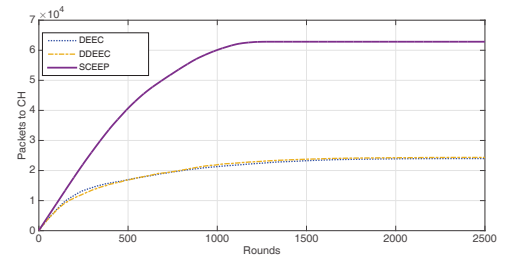

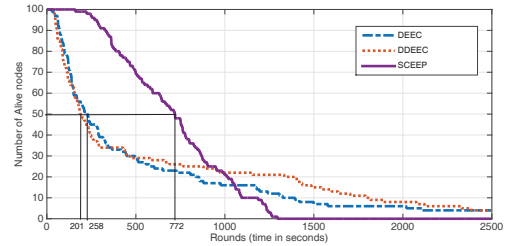Fig. 1: Number of data bits received to the CH over time.

Fig. 2: Number of nodes alive over time.

metrics demonstrate that SCEEP maximizes the network lifetime and captures 3 times more data than the other protocols. Additionally, we are working on to develop an advanced CH threshold function for initialization of the network or set-up phase clustering for multi-tier multi-hop heterogeneous model for large scale sensor networks. Furthermore, we are also interested to develop SCEEP on TelosB sensor Network setup for measuring the system efficiency and throughput.

REFERENCES

[1] O. Younis and S. Fahmy, "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," *Mobile Computing, IEEE Transactions on*, vol. 3, no. 4, pp. 366–379, 2004.

[2] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," in *System sciences, 2000. Proceedings of the 33rd annual Hawaii international conference on*, pp. 10–pp, IEEE, 2000.

[3] W. M. McEneaney and W. H. Fleming, eds., *Stochastic analysis, control, optimization and applications: a volume in honor of W. H. Fleming.* Systems & control, Boston: Birkhuser, 1999.

[4] S. Lindsey and C. S. Raghavendra, "PEGASIS: Power-efficient gathering in sensor information systems," in *Aerospace conference proceedings, 2002. IEEE*, vol. 3, pp. 3–1125, IEEE, 2002.

[5] V. Loscri, G. Morabito, and S. Marano, "A two-levels hierarchy for low-energy adaptive clustering hierarchy (TL-LEACH)," in *IEEE Vehicular Technology Conference*, vol. 62, p. 1809, IEEE; 1999, 2005.

[6] J. J. Lotf, M. Hosseinzadeh, and R. M. Alguliev, "Hierarchical routing in wireless sensor networks: a survey," in *Computer Engineering and Technology (ICCET), 2010 2nd International Conference on*, vol. 3, pp. V3–650, IEEE, 2010.

[7] R. Ibrahim, Q.-D. Ho, and T. Le-Ngoc, "An Energy-Efficient and Load-Balancing Cluster-Based Routing Algorithm for CSMA-Based Wireless Sensor Networks," in *Vehicular Technology Conference (VTC Spring), 2013 IEEE 77th*, pp. 1–5, IEEE, 2013.

[8] L. Qing, Q. Zhu, and M. Wang, "Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks," *Computer Communications*, vol. 29, pp. 2230–2237, Aug. 2006.

[9] B. Elbhiri, R. Saadane, S. El Fkihi, and D. Aboutajdine, "Developed Distributed Energy-Efficient Clustering (DDEEC) for heterogeneous wireless sensor networks," in *I/V Communications and Mobile Network (ISVC), 2010 5th International Symposium on*, pp. 1–4, IEEE, 2010.