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Two-phased Energy Efficient Clustering Mechanism in Wireless Sensor Network

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Abstract: Wireless Sensor Networks have limited resources especially in terms of energy of the Sensor Nodes. Clustering helps in optimal usage of energy of Networks. The present methodology also proposes a unique mechanism, where the cluster head selection process has been made two-phased. The CHs are selected based on mixed techniques of random probability and residual energy parameters. There are five characteristics used to measure the performance of the proposed mechanism. The proposed protocol performs better when compared to present established energy-efficient mechanism.
Keywords: Wireless Sensor Network, Sensor Node, Cluster Head, Residual Energy.

Introduction

Wireless Sensor Networks (WSNs) consists of highly dense deployment of Sensor Nodes (SNs). SNs are capable of sensing, analyzing, aggregating and communicating facilities. Low-power micro-electro-mechanical-systems and communicating equipment helps SNs perform their functionalities with less power consumption. SNs collect the data from their vicinity, process it and transmit the same to respective cluster heads. Cluster Heads are given the responsibility of collecting the data of their subordinate SNs, apply some methods of data reduction and transfer the aggregated data to Base Station (BS). BS utilizes the sensed data for further application specific tasks. The form of connection between SNs is either single hop or multi-hop.

In cases when all the SNs communicate directly with BS, the energy consumption is very high, whereas, the provision of Cluster Heads(CHs) reduces the same to great extent. Researchers around the globe have proposed various mechanisms for the optimized mechanisms for cluster head selection. Figure 1 represents a mechanism presenting clustering in WSNs.

Homogeneous WSNs, SNs are of equal capability in terms of battery capacity, processing capabilities and links between SNs, whereas, in heterogeneous networks, SNs vary in certain properties. The methodologies for cluster head selection are treated differently for homogeneous and heterogeneous networks. Generally, the nodes with higher capabilities are propose to be selected as cluster heads, considering the fact that these nodes will have to perform better than their subordinate SNs.

The present research paper proposes a two-tier mechanism. The proposed method is based on heterogeneous WSNs where the SNs vary according to their energy capacity. First phase of the mechanism nominates the nodes based on their random probability as was proposed in LEACH. Second phase concludes the selection process selecting cluster heads amongst the nominated SNs while comparing them according to their remaining energy and CH-to-CH distances.

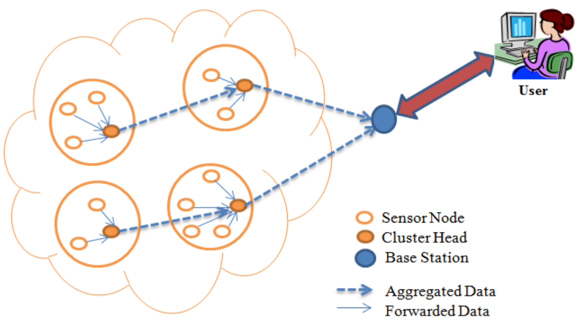

Figure 1: Communication using Clustering mechanism in WSNs

Cluster properties include the cluster size, cluster count and intra or inter cluster communication. CH properties may also include the mobility of nodes and its type. Further, it includes the clustering method that may be centralized or distributed, CH election and algorithm complexity.

In Section II, a review of the literature pertaining to CHs selection mechanisms proposed by various researchers is presented. Section III presents the methodology proposed for the present research paper. Section IV includes the results and discussions. Lastly, section V presents the conclusion and future scope which is followed by the references.

Section II: Literature review

The literature pertaining to Clustering has been categorized differently in two categories i.e. for homogeneous and heterogeneous WSNs.

Homogeneous clustering mechanisms in WSNs:

Heinzelman et al. [1] proposed Low-Energy Adaptive Clustering Hierarchy. Here the responsibilities of CHs are rotated randomly. It is a two-phased process. The CHs are selected in set-up phase and CHs are maintained in steady-state phase. The amount of information to be transferred to BS is reduced by using the data fusion and hence increases in network lifetime and scalability and reduces the energy consumption.

Manjeshwar and Agrawal[2] proposed event-driven and reactive routing protocol for time-critical situations TEEN, which uses two types of threshold: soft threshold and hard threshold.Time the data should be transferred to BS are defined by the threshold.

APTEEN proposed by Manjeshwar and Agrawal [3] enables inclusive acquisition of information. After the CH selection, four different parameters are broadcasted by the CHs to their cluster members: attributes, threshold, TDMA schedule, and count time.
Lindsey and Raghavendra [4] proposed PEGASIS, which uses chain-based multi-hop structure in which delay between the source and sink is attempted to be minimized. In PEGASIS, every node sends data to their neighbor node in a chain until it reaches to the BS; therefore the volume of energy used at each round is reduced.
An extended Probabilistic Clustering Algorithm for HEED, named Ex-HEED is presented by Huang and Wu[5]. To diminish the huge amount of nodes, two more steps in HEED is introduced and for the CH selection process only probable candidates survived. This protocol is more energy efficient than HEED. It uses the same method as in HEED only difference is that two more steps are also added in this protocol. Advantages of this protocol are that routing latency is minimized. But it increases the complexity in the network.
TL-LEACH proposed by Loscrì et al. [6] saves the energy consumption more efficiently. It uses two types of CHs to build the two level hierarchies: primary and secondary CHs and then random rotation of these CHs are performed.
Yi et al. [7] proposed PEACH, used in location-aware and location-unaware WSNs in which clusters are formed without any extra expense and also give assistance to multi-level clustering.
Chhabra and Singh [8] presented HEEC-RND, which takes into account three different factors.

Heterogeneous clustering mechanisms in WSNs:

Nodes in heterogeneous networks are having different amounts of energy. So, a paradigm of heterogeneous WSN is presented below:
Nodes heterogeneity varies from link heterogeneity, computational heterogeneity to energy heterogeneity [9]. Energy heterogeneity is of most importance.

In the following section we examine and compare different clustering techniques in heterogeneous WSNs considering energy heterogeneity of the nodes.
Smaragdakis et al. [10] presented a heterogeneous aware concept, SEP (Stable Election Protocol) which prolongs the network lifetime before the first node dies i.e. Stability Period. SEP uses weighted election probability to select the CHs. The stability period is increased, as we compare SEP with LEACH. But this protocol is used only for proactive networks.
In another clustering protocol [11], proposed by Qing et al., CHs are chosen so the probability for CH selection will be more for nodes, having more initial and residual energy. It uses two types of nodes for the two-level heterogeneity and also suitable for the multi-level heterogeneous network model. This protocol is based on LEACH and achieves longer network lifetime than LEACH.

E-DEEC proposed by Saini et al. [12] uses the same strategy as of DEEC but an additional node is added known as super node that increases heterogeneity of the network.
TDEEC proposed by Saini et al. [13], is an improvement over DEEC. It increases the energy efficiency and stability of the network therefore enhance the network lifetime of the network.
Dutt and Khanna [14] proposed ETDEEC, an enhancement of TDEEC protocol. It uses the same concept of TDEEC but a distance factor is introduced for the probability of selection of the CH. This factor is introduced to increase the energy efficiency as the nodes that are far away from the BS will not be selected as CH otherwise lots of energy would have spent during the communication through the larger distances. It improves the packet delivery ratio therefore improves the network lifetime. ETDEEC outperforms the TDEEC protocol.
Khan et al. [15] proposed Heterogeneity-aware HSEP which reduces the transmission distance among CH and BS as hierarchical clustering technique is adopted in this protocol.

Considering the above literature, it may be concluded that clustering is an open research area, where investigation can be extended to include more options for optimized utilization of the network energy.

Section III: Methodology proposed

System Model:

- BS and all participating nodes are steady.
- SNs are free to communicate with their physical neighbor.
- SNs are heterogeneous in terms of energy.
- BS is placed at certain location.
- The assumption of radio network model is as per LEACH or EECH.
- Each SN sends its data either to its nearest CH or directly to the BS.
- Node degree is applied separately in nomination as well as scrutinizing phase.

Proposed Algorithm:

- Phase 1: Setup Phase
  - Nodes deployment and initialization
  - for normal nodes
  - do
  - for(i=1 to n)
  - get (X_i,Y_i) // coordinates of node i.
  - get (En_i) // initial energy of node i.
  - deploy nodes
  - End
  - Repeat the same for super nodes and advanced nodes

- Phase 2: Cluster Head Selection and Cluster Formation
  - Nodes nominate themself as candidates to become CH.
  - Nomination is decided on the basis of the probability factors for different heterogeneous nodes.

  Selection Phase for CHs:
  - BS constructs a graph depicting the SNs as nodes and the connections joining the nodes lying within a minimum range as vertices.
  - Connected components thus formed evaluated for the energy comparisons
  - Node with maximum residual energy in the respective connected component graph is selected as CH.

  CH advertises its status on intra-network communication.

- Phase 3: TDMA schedule formation for SNs and Data Communication
  - CH allocate TDMA slots to Cluster Members

Section IV: Results and discussions

Simulation Parameters:
Number of Sensor Nodes: 200
Sensing Field Dimension: 100m x 100m
Sensor Range: 10 m
Base Station Coordinates: (50, 0)
No. of rounds: 3000

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Alive Nodes in network:

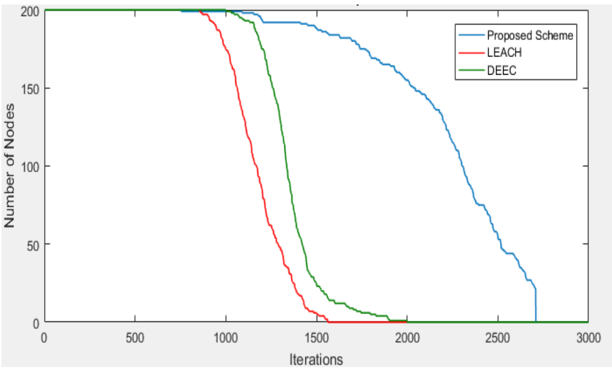

Fig 2: Simulation graph (Alive nodes v/s Iterations)

Dead Nodes in network:

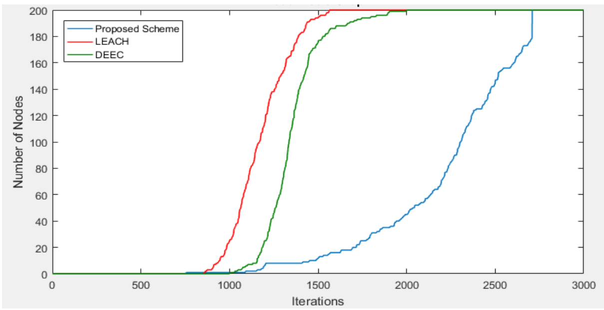

Fig 3: Simulation graph (Dead nodes v/s Iterations)

Cluster Heads in network:

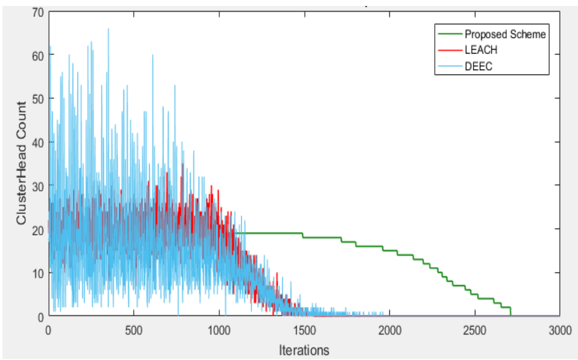

Fig 4: Simulation graph (Cluster Head Count v/s Iterations)

Packets sent to Base Station:

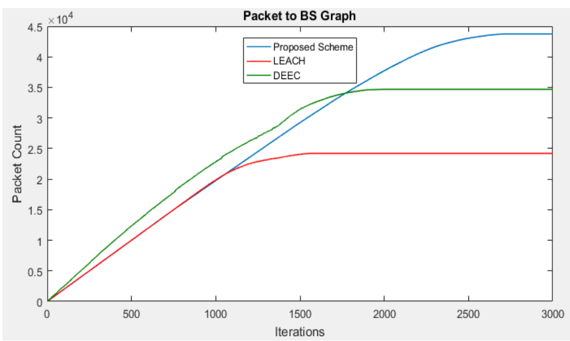

Fig 5: Simulation graph (Packets sent to Base Station v/s Iterations)

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Energy of the Network:

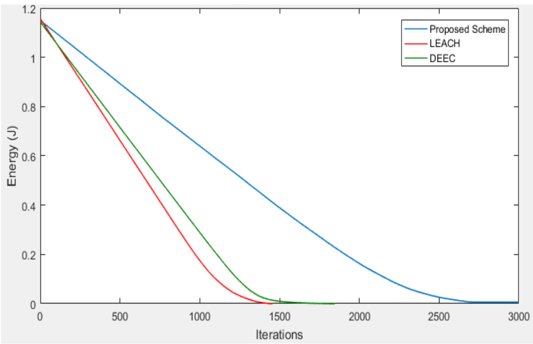

Fig 6: Simulation graph (Energy depletion v/s Number of rounds)

The proposed algorithm has been compared on parameters like alive nodes, dead nodes, number of cluster heads formed, packets sent to BS and total energy of the network.

The other protocols used for the comparison are LEACH [1] and DEEC, which are established energy efficient protocols in WSN. The proposed protocol outperforms these protocols in every selected parameter.

Section V: Conclusion

The proposed mechanism is an energy-efficient mechanism used for heterogeneous WSNs. Sensor nodes are energy variant. Cluster Head selection process is two-phased, where first phase is used to nominate the SNs based on random probabilities whereas, in second phase, cluster heads are elected based on residual energy of the participating nodes. The performance of the proposed mechanism is evaluated on simulation parameters like alive nodes, packets sent to BSs, energy of the network and network lifetime. The results are satisfactory when compared with LEACH and DEEC protocols. In future, more mechanism can be explored to decrease the energy consumed and hence prolonging the network lifetime further.

References:

[1] Heinzelman, Wendi B., Anantha P. Chandrakasan, and Hari Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," IEEE Transactions on Wireless Communications, Vol. 1, Issue 4, pp. 660-670, 2002.

[2] Manjeshwar, Arati, and Dharma P. Agrawal, "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks," In Parallel and Distributed Processing Symposium, IEEE Computer Society, Vol. 3, pp. 30189a-30189a, 2001.

[3] Manjeshwar, Arati, and Dharma P. Agrawal, "APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks," In Parallel and Distributed Processing Symposium, IEEE Computer Society, Vol. 2, pp. 0195b-0195b, 2002.

[4] Lindsey, Stephanie, and Cauligi S. Raghavendra, "PEGASIS: Power-efficient gathering in sensor information systems," In Aerospace Conference Proceedings, IEEE, Vol. 3, pp. 3-1125, 2002.

[5] Huang, Hesong, and Jie Wu, "A probabilistic clustering algorithm in wireless sensor networks," In IEEE Vehicular Technology Conference, vol. 62, Issue 3, pp. 1796-1799, 2005.

[6] Loscri, V., G. Morabito, and S. Marano, "A two-levels hierarchy for low-energy adaptive clustering hierarchy (TL-LEACH)," In IEEE Vehicular Technology Conference, Vol. 62, Issue 3, pp. 1809-1814, 2005.

[7] Yi, Sangho, Junyoung Heo, Yookun Cho, and Jiman Hong, "PEACH: Power-efficient and adaptive clustering hierarchy protocol for wireless sensor networks," Computer Communications, Vol. 30, Issue 14, pp. 2842-2852, 2007.

[8] Chabbra and Singh, “Hybrid Energy Efficient Clustering based on Residual energy, Node degree and Distance to base station (HEEC-RND) in Heterogeneous WSNs”, International Conference on Computing, Communication and Automation (ICCCA2015), pp 343-347, May 15-16, 2015

[9] Yarvis, Mark, Nandakishore Kushalnagar, Harkirat Singh, Anand Rangarajan, York Liu, and Suresh Singh, "Exploiting heterogeneity in sensor networks," 24th Annual Joint Conference of the IEEE Computer and Communications Societies, Proceedings IEEE, vol. 2, pp. 878-890, 2005.

[10] Smaragdakis, Georgios, Ibrahim Matta, and Azer Bestavros, “SEP: A stable election protocol for clustered heterogeneous wireless sensor networks,” Computer Science Department, Boston University, 2004.

[11] Qing, Li, Qingxin Zhu, and Mingwen Wang, "Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks," Computer Communications, Vol. 29, Issue 12, pp. 2230-2237, 2006.

[12] Saini, Parul, and Ajay K. Sharma, "E-DEEC-enhanced distributed energy efficient clustering scheme for heterogeneous WSN," In 1st International Conference on Parallel Distributed and Grid Computing (PDGC), IEEE, pp. 205-210, 2010.

[13] Saini, Parul, and Ajay K. Sharma, "Energy efficient scheme for clustering protocol prolonging the lifetime of heterogeneous wireless sensor networks," National Institute of Technology Jalandhar, Department of Computer Science & Engineering, International Journal of Computer Applications, Vol. 6, Issue 2, 2010.

[14] Dutt, Suniti, and O. S. Khanna, "An Enhanced Energy Efficient Clustering Scheme for Prolonging the Lifetime of Heterogeneous Wireless Sensor Networks," International Journal of Computer Applications, Vol. 76, pp. 0975–8887, 2013.

[15] Khan, A. A., Nadeem Javaid, Umar Qasim, Z. Lu, and Z. A. Khan, "HSEP: heterogeneity-aware hierarchical stable election protocol for WSNs," arXiv preprint arXiv, 2012.