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An Improved Deterministic Energy Efficient Clustering Protocol for Wireless Sensor Networks

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Abstract
In recent development, achieving the deployment of nodes, lifetime, fault tolerance, latency, energy efficiency in brief robustness and high reliability have become the prime research goals of wireless sensor network. In recent years many clustering protocols have been suggested on clustering structure based on heterogeneity. We propose improved deterministic energy-efficient clustering protocol for four types of nodes which extend the stability and lifetime of the network in team of first node get dead. Hence, it increases the heterogeneity and energy level of the network. I-DEC performs better than E-SEP, SEP and DEC with more stability and effective messages shows in simulation results.

I. INTRODUCTION

The development in sensor technology has made it possible to have low powered, extremely small sensing devices furnished with wireless communication capability, multiple parameter sensing and programmable computing. Wireless sensor network, which comprises of large number of heterogeneous and homogeneous sensor nodes which communicate in wireless fashion to achieve common objective. Due to the limited amount of the battery power could make it difficult and expensive to deploy on a large scale in WSN. Thus, battery life is one of the obstacle of deploying wireless sensor network.

To manage clustering many studies have used [1], [5], [7], [9]. Clustering process includes, for sending and processing data high energy nodes are randomly selected and for send and sensing information to the cluster heads low energy nodes are used. Clustering method includes appointing leader from respective sensor nodes and when the leader node means cluster head is appointed, they collect the data from their cluster members and send the collected data to the base station [4].On the basis of energy clustering can be done in two types of networks, heterogeneous and homogenous networks. Network in which nodes have different initial energy are heterogeneous and nodes have same initial energy are homogenous networks. For homogeneous wireless sensor networks such as LEACH [5], PEGASIS [3], and HEED [4] there are number of clustering algorithms have been suggested which does not perform well in heterogeneous networks. SEP [9] uses two types of nodes normal and advanced nodes. Normal nodes have less energy than advanced ones. It increases the stability period of the network. For networks having more than two types of energy it also does not fit.

DEC [2] is a clustering based algorithm in which cluster head is selected on the basis of the residual energy of the node means node which have high energy then other nodes in the cluster is elected as a cluster head. In this algorithm, node having more energy has a more chance to become a cluster head. Our I-DEC follows the thoughts of DEC and adds another type of node called super node to increase the heterogeneity of the network.

II. RELATED WORK

Heinzelman, et. al. [5] introduced a hierarchical clustering algorithm for homogenous wireless sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH).Leach is a cluster based protocol. In leach cluster heads are elected in random manner, in order to balance the energy consumption between the nodes by allocating the cluster head role to other nodes randomized protocol has been used in the network. PEGASIS [3] S. Lindsey and C. Raghavendra introduced Power Efficient Gathering in Sensor Information Systems (PEGASIS) protocol in 2002. It is a chain based protocol. Instead of choosing multiple nodes PEGASIS choose only one node in the chain to send data to BS. Chain formation is started at a node faraway from base station.

In 2001, A. Manjeshwar and D. P. Aggarwal [7] introduced Threshold sensitive Energy Efficient sensor Network Protocol (TEEN) protocol. Teen protocol is based on hierarchical approach ahead with the use of data centric mechanism. Two type of thresholds are broadcasted by cluster head to the nodes. One is hard threshold and second is soft threshold for sensed attributes. Teen is not good for the application where the user needs to get data on a consistent basis. A. Manjeshwar and D. P. Agarwal [8] introduced Adaptive Threshold sensitive Energy Efficient sensor Network Protocol (APTEEN) protocol in 2002.APTEEN is the extension of the TEEN. Objective of Teen Protocol is to capturing periodic data collections and reacting to time crucial events. In terms of energy consumption and durability of network, APTEEN performance lies between TEEN and LEACH Protocol. The main drawback of APTEEN is the overhead and there exist additional complexity to implement threshold function and count time.

In 2004, G. Smaragdakis, I. Matta and A. Bestavros [9] introduced Stable Election Protocol (SEP) protocol. SEP is protocol for two level heterogeneous network.SEP assumes that nodes has different energy in the real environment therefore in SEP there are two type of nodes , advanced nodes and normal nodes. Normal nodes have less amount of energy than advanced nodes In SEP cluster heads is elected on the basis of initial energy relative to that of other nodes.DEC [2] (Deterministic Energy-efficient Clustering) in which cluster head is selected on the basis of highest residual energy among other nodes. Simulation results show that the performance of DEC is better than other protocols.

Our I-DEC (Deterministic Energy-efficient Clustering scheme is based on DEC with addition of super nodes. We have extended the DEC to four-level heterogeneity. Simulation results show that I-DEC stability period is better than LEACH, E-SEP and DEC.

III. Energy Dissipation Model

Energy dissipation model used is based on [5, 10] radio hardware energy dissipation energy model. Where to run the radio electronics and the power amplifier transmitter dissipates energy and to run the radio electronics receiver dissipates energy is shown in figure 1 [5, 10].

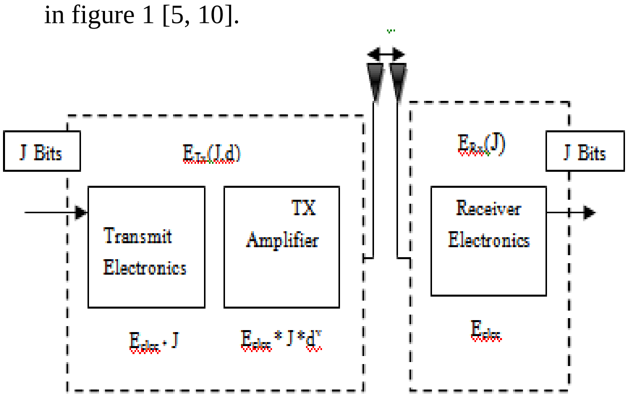

Figure: 1 Radio Energy Dissipation Model

Here both the multipath fading (d^4 Power loss) and the free space (d^2 Power loss) models were used, depending on the distance the receiver and transmitter [5, 10]. By appropriately setting the power amplifier power control can be used to invert this loss. If the distance is smaller than threshold do, free space model is used; otherwise multipath model is used. So, to transmit J-bit message a distance, energy consumption is:

$$ETx(J,d) = \begin{cases} J.E_{elec} + J.E_{fs}.d^2 & \text{if } d<do \\ J,E_{elec} + J.E_{amp}\, d^4 & \text{if } d \geq do \end{cases}$$

Energy dissipation per bit for the transceiver circuit is E_{elec} and the distance threshold swapping amplification models is d_o. Which is given by

$$d_o = \sqrt{\frac{E_{fs}}{E_{amp}}}$$

IV. Network Model

Sensor network is used with 100 × 100 network field as shown in figure 2. In I-DEC there are four types of sensor nodes. They are super nodes, advanced nodes, intermediate nodes, normal node.

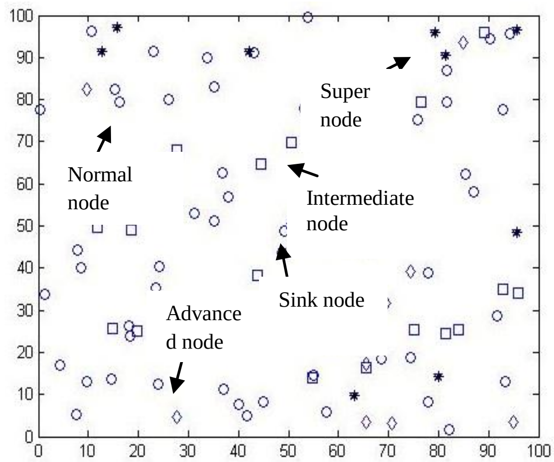

Figure: 2 Random Wireless Sensor network, showing four four-energy levels hierarchy.

V. Properties and Assumption of Network

Some assumptions have been made for the sensor nodes as well as for the network in the network model described in previous section.

- In the network sensor nodes are uniformly randomly deployed.
- At the centre of sensing field base station is located.
- Sensor nodes always have to send the data to the base station
- In terms of processing and communication all the nodes have equal capabilities.

In terms of energy levels, sensor nodes have heterogeneity i.e. different energy levels. Some nodes are equipped with more energy than the normal nodes.

VI. CLUSTER HEAD SELECTION METHOD

I-Dec implements the same strategy for cluster head selection method as proposed in DEC [2].

Since node energy is the main factor and to only use the residual energy (RE) of each node in the cluster head election. In E-DEC, at round h, the base station (BS) elects Mopt cluster heads for the network. The BS can take part in the election of cluster heads if and only if h=1, by using CSMA-MAC elected CHs broadcast their role.CM-ID, CH-ID, CM-RE(cluster member residual energy) are contained in join request message.

By this way the respective CHs know about the residual energy of CMs. After this, the piggy backed CM-REs information is checked by current CHs to decide whether they remain as a CH or transfers their role to new node having highest residual energy. From the current round all the data is communicated to BS. The next round m= h+1 starts. Since CH's is already chosen in previous round, they broadcast their role in new round.

In each round the process continuous until last node dies.

VII. PERFORMANCE CRITERIA USED

The performance parameters used to study and evaluate the clustering protocols are lifetime, number of nodes alive, number of nodes dead and number of data packets received at cluster head.

- Number of cluster heads: It is the number of cluster heads which is elected per round.
- Number of live nodes: This instantaneous measure reflects the total number of nodes and that of each type that has not yet expended all of their energy.
- Data Packets received at cluster head: It is total number of data packets or messages that are received by the base station. This measure varies linearly for all protocols.
- Number of dead nodes: This instantaneous measure reflects the total number of nodes and that of each type that has expended all of their energy.

These metrics used allow us 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, the data send that are received by the base station [9] 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 assume all the nodes having equal importance). More stable is the network; more is the lifetime of the network.

Table: 1 Various parameters and their values

Parameter	Values
Sensor field	100×100
Eelec	50nJ/bit
EDA	5nJ/bit/message
Eo	0.5J
K	4000
Popt	0.1
Efs	10pJ/bit/m2
Eamp	0.0013pJ/bit/m4
n	100

VIII. SIMULATION AND RESULTS

We assumed a hierarchical clustered heterogeneous sensor network with 100 sensor nodes which are randomly deployed over the 100m×100m area. The sink or base station is located at point (50×50) that is at the centre of sensing area. The packet size that the nodes send to their cluster heads as well as the aggregated packet size that a cluster head sends to the sink is set to 4000 bits. The initial energy of each normal node is set to 0.5 Joule. The proposed approach has been implemented in MATLAB and the performance has been evaluated by simulation. In this work, we have measured the lifetime of the network in terms of rounds when the first sensor node dies.

In Figure 3, we conduct a comparison of our I-DEC model with a probabilistic-based model. We use LEACH and E-SEP protocol to represent the probabilistic-based models that uses the simulation annealing algorithm. This analysis compares the number of elected cluster heads per round for I-DEC, E-SEP and LEACH. The solid line represents LEACH and E-SEP protocols, which reveals the inherent uncertainties in these types of models; the consequence is that the required fixed optimal number Mopt of cluster-heads election cannot be guaranteed per round. The straight line represents the election of Mopt cluster heads elected per round in our I-DEC protocol.

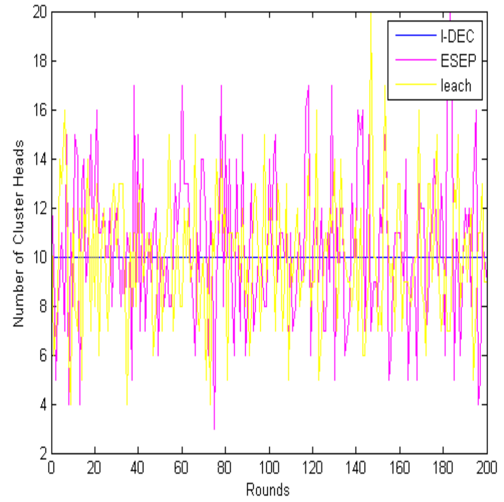

Figure: 3 Number of cluster-heads per round

Figure 4 shows the behavior of these protocols with respect to energy heterogeneity. It is worthy of note that I-DEC curve is at right angle to the knee point the gradual decent at the beginning is a result of the different energy levels of the nodes in the network at the beginning. I-DEC proves to be best up to when 50% of the nodes are alive. The curve of E-SEP and LEACH descends slowly until the end of the network because these protocols cope slowly with heterogeneity. However, based on our experiments both E-SEP and DEC outperformed the LEACH protocol. This is expected because LEACH is designed for a homogeneous scenario. For applications that have minimal monitoring requirements, LEACH, E-SEP could still be desirable.

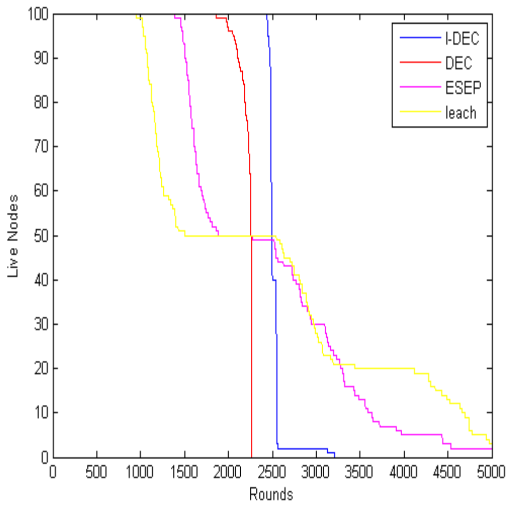

Figure: 4 Shows the live nodes in Leach, E-SEP, DEC and Proposed I-DEC Protocol

Figure 5 Represent the number of nodes dead during the lifetime of the network. Stability period and lifetime of I-DEC is longer as compared to E-SEP, Leach and DEC and unstable period of SEP-E, LEACH is longer than I-DEC. I-DEC is better than E-SEP as it uses the residual energy. In E-SEP death of nodes starts after 1450 rounds while for I-DEC it starts after 2437 rounds. Last node for SEP-E and I-DEC dies at 6000 and 3207 rounds.

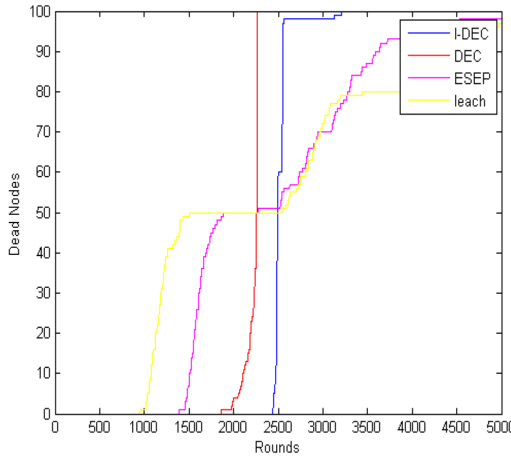

Figure: 5 Shows the dead nodes in Leach, E-SEP, DEC and Proposed I-DEC Protocol

Figure 6 Shows the number of packets send to cluster head in E-SEP, LEACH, DEC and I-DEC protocol . It shows that there is a fixed number of packets are send to cluster head in DEC and Proposed I-DEC protocol until the first node died while in E-SEP and in LEACH there is instability in packets sending to cluster head.

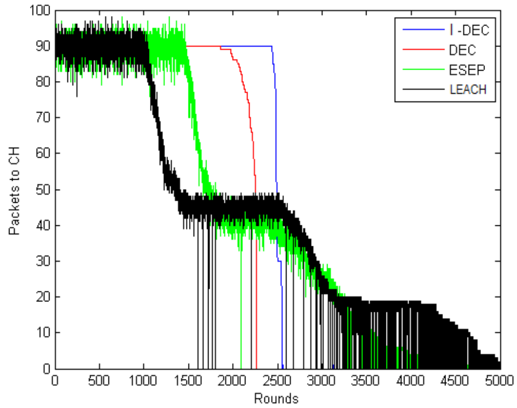

Figure: 6 Packets send to cluster head in E-SEP, LEACH, DEC and proposed DEC protocol

IX. CONCLUSION

We proposed a purely deterministic-based protocol referred to I- DEC that offers better utilization of the energy resource for low-energy sensor nodes. Both experimental and theoretical analyses are conducted to verify the performance of the I-DEC protocol. The main contributions are:

- I-DEC has successfully extended the network lifetime by being aware on heterogeneity and assigning cluster-head role to more capable nodes.
- I-DEC is able to achieve a stable election of cluster-heads, leading to an improved throughput in the network.
- I-DEC has successfully increased the stability of the network.
- Finally, DEC degrades gracefully in response to changes in the number of elected cluster-heads. Therefore it is able to offer more performance stability than the existing heterogeneous-aware protocols we have compared it with in the same domain.

REFERENCES

[1] F. A. Aderohunmu, J. D. Deng, and M. K. Purvis. *Enhancing Clustering in Wireless Sensor Networks with Energy Heterogeneity*. International Journal of Business Data Communications and Networking-(Accepted, to appear in the forthcoming issue, 2011.

[2] Femi A. Aderohunmu , Jeremiah D. Deng , Martin K. Purvis," *A Deterministic Energy-efficient Clustering Protocol for Wireless Sensor Networks*", In Proceedings of the Seventh IEEE International Conference on Intelligent Sensors, Sensor Networks and Information Processing (IEEE-ISSNIP), pages 341-346, Dec. 2011.

[3] S. Lindsey and C. S. Raghavendra, "*PEGASIS: Power Efficient Gathering in Sensor Information Systems,"*in the Proceedings of the IEEE Aerospace Conference, Big Sky, Montana, March 2002.

[4] O. Younis, S. Fahmy, "*HEED: A hybrid, energy efficient, distributed clustering approach for adhoc sensor networks*", IEEE Transactions on Mobile Computing vol 3, no 4, pp 660-669, 2004.

[5] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan. Energy efficient communication protocol for wireless microsensor networks. In Proceeding 33rd Hawaii International Conference on System Sciences, 2000.[6] Arati Manjeshwar and Dharma P. Aggrawal, "*TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks*", In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, 2001.

[7] C. Li, M. Ye, and G. Chen. An Energy-Efficient Unequal Clustering Mechanism for Wireless Sensor Networks. In Proceeding of IEEE MASS05, pages 3–17, 2005.[8] Arati Manjeshwar and Dharma P. Agrawal, "*APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks*", Parallel and Distributed Processing Symposium, Proceedings International, IPDPS, 2002.

[9] G. Smaragdakis, I. Matta, and A. Bestavros. SEP: *A Stable Election Protocol for clustered heterogeneous wireless sensor networks*. In Proceeding of the International Workshop on SANPA, 2004.

[10] W.R. Heinzelman, A.P. Chandrakasan, H. Balakrishnan, *An application specific protocol architecture for wireless microsensor networks*, IEEE Transactions on Wireless Communications 1 (4) (2002) 660–670.