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EDEEC-ENHANCED DISTRIBUTED ENERGY EFFICIENT CLUSTERING PROTOCOL FOR HETEROGENEOUS WIRELESS SENSOR NETWORK (WSN)

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ABSTRACT

Wireless Sensor Networks (WSNs) consists of widespread random deployment of energy constrained sensor nodes. Sensor nodes have different ability to sense and send sensed data to Base Station (BS) or Sink. Sensing as well as transmitting data towards sink requires large amount of energy. In WSNs, conserve energy & prolonging the lifetime of network are great challenges. Many routing protocols have been proposed in order to achieve energy efficiency in heterogeneous environment. This paper focuses on clustering based routing technique: Enhanced Distributed Energy Efficient Clustering Scheme (EDEEC). EDEEC mainly consists of three types of nodes in extending the lifetime & stability of network. Hence, it increases the heterogeneity and energy level of the network. Simulation results show that EDEEC performs better than DDEEC & DEEC.

***Keywords*: Clustering, Cluster-Head (Ch), Deec, Ddeec, Edeec, Energy Efficiency, Wsn**

I. INTRODUCTION

WSN is the network which consists of hundred of tiny and compact sensor nodes that senses the physical environment. WSN have a wide variety of application including military, temperature, humidity, pressure, lightning condition [1] etc. Sensor nodes in WSNs are power constrained because of limited battery resources. Every sensor node consist sensing unit, processing unit, a transceiver unit and a power unit [2].

Routing protocols plays an important role in conserving energy in WSNs. Clustering techniques [3] are used to minimize the energy consumption and hence increases the lifetime of network.

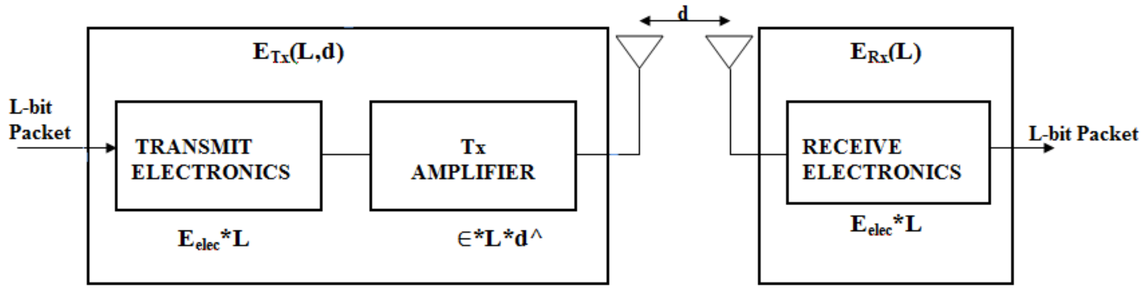
Clustering technique can be implemented in two types of networks, homogeneous & heterogeneous networks. Homogeneous networks are those in which nodes are equipped with same initial energy while heterogeneous networks are those where initial energy differ.

Low Energy Adaptive Clustering Hierarchy (LEACH) [4] is an example of heterogeneous WSNs, however, LEACH performance is poor in heterogeneous networks because in this algorithm the low energy nodes die more rapidly as compare to high energy nodes. Stable Election Protocol (SEP) [5], Distributed Energy Efficient Clustering (DEEC) [6], Developed Distributed Energy Efficient Clustering (DDEEC) [7] are the examples of heterogeneous networks.

DEEC [6] is cluster-based algorithm in which Cluster-Heads (CHs) are selected by probabilities based on ratio of residual energy of nodes and average energy of network. DEEC consists of two types of nodes i.e. normal nodes and advanced nodes where advanced nodes have more chances to be a CH than normal nodes. EDEEC follows the thoughts of DEEC and adds another type of node called super node to enhance the heterogeneity.

The remainder of the paper is organized as follows: section 2 contains the radio energy dissipation model, section 3 explains the heterogeneous network model, section 4 describes our proposed work EDEEC, section 5 lists the parameters used for simulation & also gives the result, section 6 consists of conclusion and section 7 consists of references.

II. RADIO ENERGY DISSIPATION MODEL



Here, we use radio energy model based on [8]. The energy dissipated by node for radio transmission E_{Tx} (L,d) of message of L bits over a distance d to run both the transmitter electronics and transmitter amplifier is expressed as:

$$E_{Tx}(L,d) = \begin{cases} L \times E_{elec} + L \times \epsilon_{fs} \times d^2 & \text{if } d \leq d_o \\ L \times E_{elec} + L \times \epsilon_{amp} \times d^4 & \text{if } d \geq d_o \end{cases}$$

Similarly, energy dissipated by a node for the reception E_{Rx} (L) [9] of message of L bits to run the receiver electronics is expressed by:

$$E_{Rx}(L) = E_{elec} \times L$$

where E_{elec} is transmitter electronics dissipation per bit is equal to receiver electronics dissipation per bit and ϵ_{fs} & ϵ_{amp} are transmit amplifier dissipation per bit per square meter.

Here, both the free space (d^2 power loss) and the multipath fading (d^4 power loss) channel models are used, depending on the distance between the transmitter (Tx) and receiver (Rx). If the distance is less than a threshold d_o, the free space channel model will be used otherwise multipath channel model will be used.

III. HETEROGENEOUS NETWORK MODEL

Here, we describe the network model. Assume that there are N sensor nodes, which are uniformly distributed within a M * M square area.

EDEEC considers three types of sensor nodes [10] with different energy levels i.e. normal nodes, advanced nodes, super nodes. Normal nodes have energy E_o. Let m be the fraction of advanced nodes have a times more energy than normal nodes i.e. $E_o(1+a)$ while m_o is the percentage of total number of nodes N have b times more energy than normal nodes called super nodes i.e. $E_o(1+b)$. As N is the total number of nodes in the network, then Nmm_o, $Nm(1-m_o)$ and $N(1-m)$ are the numbers of super, advanced, and normal nodes in the network, respectively.

The total initial energy of super nodes in WSN:

$$E_{super} = Nmm_oE_o(1+b)$$

The total initial energy of advanced nodes in WSN:

$$E_{advanced} = Nm(1-m_o)E_o(1+a)$$

The total initial energy of normal nodes in WSN:

$$E_{normal} = N(1-m)E_o$$

The total initial energy of three-level heterogeneous WSNs is calculated as:

$$E_{total} = E_{super} + E_{advanced} + E_{normal}$$

$$E_{total} = Nmm_oE_o(1+b) + Nm(1-m_o)E_o(1+a) + N(1-m)E_o$$

$$E_{total} = NE_o[1+m(a+m_ob)]$$

The three-level heterogeneous WSN has $\mathbf{m(a+m_ob)}$ times more energy as compared to the homogeneous WSN.

IV. EDEEC PROTOCOL

EDEEC uses the same views of probabilities for CH selection depends on initial energy, remaining energy levels of nodes & average energy of the network as proposed in DEEC.

The average energy of r^{th} round is estimated from equation (1) is follows as:

$$\bar{E}(r) = \frac{1}{N} \times E_{total} \times \left[1 - \frac{r}{R}\right] \quad (1)$$

where R denotes the total rounds of network lifetime.

R can be calculated as:

$$R = E_{total} / E_{round} \quad (2)$$

where E_{round} is the energy dissipated in network in single round as:

$$E_{round} = k\,(2*N*E_{elec} + N*E_{DA} + k*\epsilon_{amp}*d^4_{toBS} + N*\epsilon_{fs}*\, d^2_{toCH} \quad (3)$$

where k is the number of clusters, E_{DA} is the cost expended in data aggregation by CH, d_{toBS} is the average distance between CH & BS and d_{toCH} is average distance between CH members & CH.

d_{toBS} & d_{toCH} is calculated as:

$$d_{toBS} = \frac{M}{\sqrt{2\pi k}} \quad , \quad d_{toCH} = 0.765 \times \frac{M}{2} \qquad (4)$$

By finding the derivative of E_{round} w.r.t k to zero, we get optimal number of cluster k_{opt} as:

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}} * \frac{\sqrt{\epsilon fs}}{\sqrt{\epsilon amp}} * \frac{M}{d_{BS}^2} \qquad (5)$$

During each round, node decides whether to become a CH or not based on threshold calculated by suggested percentage of CH and the number of times the node has been a CH so far. This decision is taken by nodes by choosing a random number between 0 & 1. If number is less than threshold T(s), the node become a CH for current round. Threshold is calculated as:

$$T(s_i) = \begin{cases} \frac{p_i}{1-p_i(r \bmod \frac{1}{p_i})} & \text{if } s \in G \\ 0 & \text{otherwise} \end{cases} \qquad (6)$$

p_i is suggested percentage of CH, r is current round & G is the set of nodes that has not been cluster-head(CH) in previous $1/p_i$ rounds. Therefore, EDEEC consider Normal, Advanced and super nodes. The probability for these three types of nodes is:

$$p_i = \begin{cases} \frac{P_{opt} \times E_i(r)}{(1+m(a+m_o b))\bar{E}(r)} & \text{if } s_i \text{ is the normal node} \\ \frac{P_{opt} \times (1+a) \times E_i(r)}{(1+m(a+m_o b))\bar{E}(r)} & \text{if } s_i \text{ is the advanced node} \\ \frac{P_{opt} \times (1+b) \times E_i(r)}{(1+m(a+m_o b))\bar{E}(r)} & \text{if } s_i \text{ is the super node} \end{cases} \qquad (7)$$

Threshold for CH selection is calculated for normal, advanced and super nodes by putting in equation (6):

$$T(s_i) = \begin{cases} \frac{p_i}{1-p_i(r \bmod \frac{1}{p_i})} & \text{if } p_i \in G' \\ \frac{p_i}{1-p_i(r \bmod \frac{1}{p_i})} & \text{if } p_i \in G'' \\ \frac{p_i}{1-p_i\left(r \bmod \frac{1}{p_i}\right)} & \text{if } p_i \in G''' \\ 0 & \text{otherwise} \end{cases} \qquad (8)$$

G' is the set of normal nodes that has not been become CHs during previous $1/p_i$ round of epoch where si is the normal node. G'' is the set of advanced nodes that have not been become CHs during past $1/p_i$ rounds of epoch. G''' is the set of super nodes that has been not become CHs during last $1/p_i$ rounds of epoch.

V. SIMULATION & RESULTS

This section presents simulation result for DEEC, DDEEC, EDEEC for three level heterogeneous WSN using MATLAB.

Table 1 Simulation Parameters

Parameters	Value
Network Field	(100 m, 100 m)
E_o (Initial Energy of Normal Nodes)	0.5 J
Message Size (L)	4000 bits
E_{elec}	50 nJ/bit
ϵ_{fs}	10 pJ/bit/m^2
ϵ_{amp}	0.013 pJ/bit/m^4
E_{DA}	5 nJ/bit/signal
d_o (Threshold Distance)	70 m
P_{opt} (Suggested Percentage)	0.1
Number of Nodes (N)	100

The performance metrics use for evaluation of clustering protocols for heterogeneous WSNs is FND, HND, LND, Number of Alive Nodes, Network Remaining Energy. We consider a network containing 20 normal nodes having 0.5J energy, 30 advanced nodes having 1.5 times greater energy than normal nodes & 50 super nodes having 3 times greater energy than normal ones.

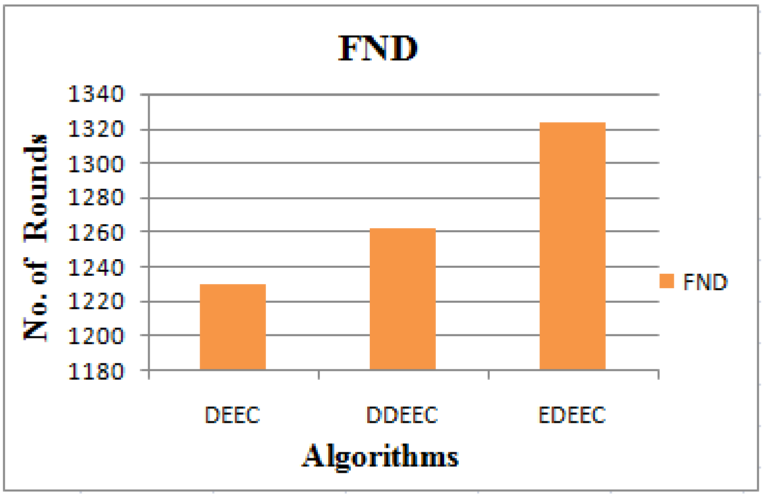


fig.1 (a) first node dead comparison

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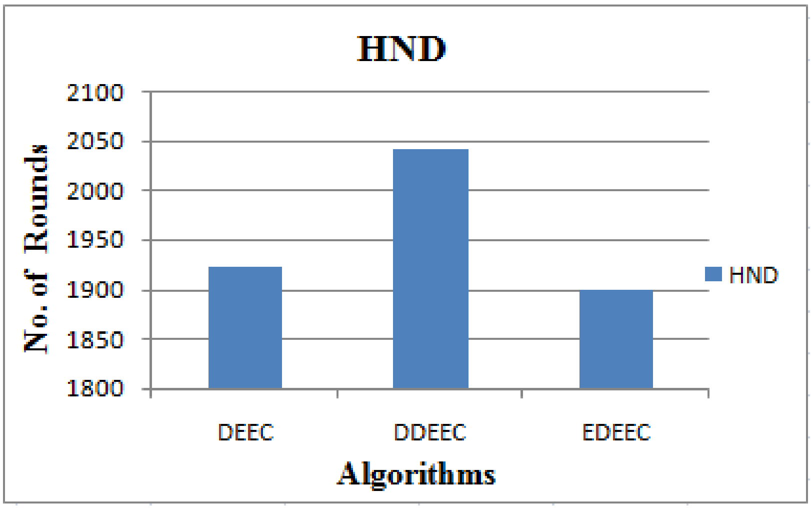

fig.1 (b) half node dead comparison

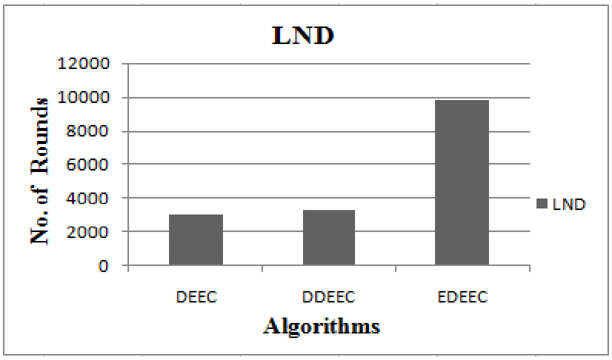

fig.1 (c) last node dead comparison

Table 2 FND, HND, LND Comparison of DEEC, DDEEC, EDEEC

ALGORITHM	FND	HND	LND
DEEC	1231	1922	3013
DDEEC	1263	2041	3223
EDEEC	1324	1900	9778

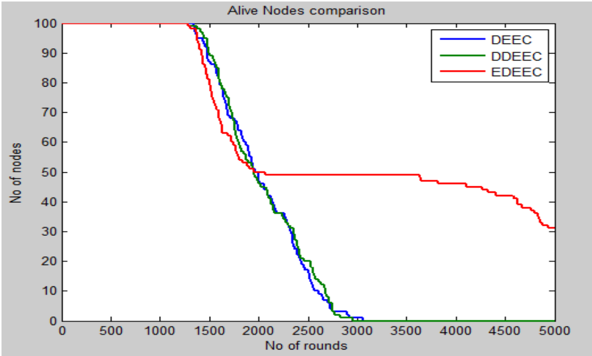

fig.2 number of alive nodes

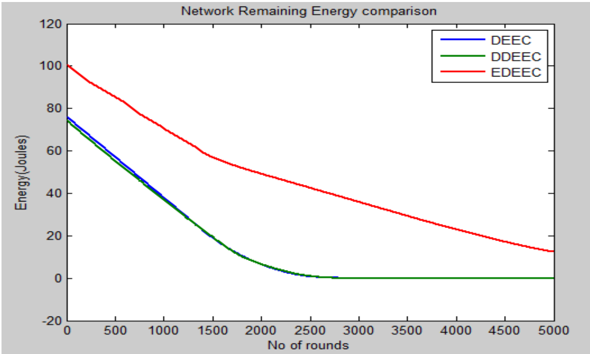

fig.3 network remaining energy comparison

Table 2 shows the dead node comparison for DEEC, DDEEC and EDEEC. Fig.1 (a) Shows that first node dies for DEEC, DDEEC and EDEEC at 1231, 1263, 1324 rounds respectively. Fig.1(b) shows that half node dies at 1922, 2041, 1900 rounds & Fig.1(c) Shows that last or all the nodes dies at 3013, 3223, 9778 rounds. Fig.2 shows that Number of Alive Nodes & Fig.3 shows that Network Remaining Energy in EDEEC is more than that of DDEEC, DEEC.

VI. CONCLUSION

Due to limited energy resources, energy conservation is one of major challenge in design of protocol for WSNs. The ultimate objective of this protocol is to achieve the energy efficiency by prolonging network lifetime. EDEEC is an adaptive as well as energy aware routing protocol. This protocol increases heterogeneity by including concept of super nodes. The simulation analysis shows better results than that of DEEC & DDEEC. EDEEC is most efficient among all protocols.

REFERENCES

[1] I.F.Akyildiz, W.Su*, Y.Sankarasubramaniam, E.Cayirci, “Wireless sensor networks: a survey”, Computer Networks 38, pp. 393-422, 2002.

[2] Kazi Chandrima Rahman, "A Survey on Sensor Network", Journal of Cases on Information Technology (JCIT), Volume 01, Issue 01, ISSN 2078-5828, 2010.

[3] Shio Kumar Singh, M P Singh, D K Singh, "A Survey of Energy-Efficient Hierarchical Cluster-Based Routing in Wireless Sensor Networks", International Journal of Advanced Networking and Applications, Volume 02, Issue 02, pp. 570-580, 2010.

[4] Meena Malik, Dr. Yudhvir Singh, Anshu Arora, "Analysis of LEACH Protocol in Wireless Sensor Networks", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 2, February 2013.

[5] Georgios Smaragdakis, Ibrahim Matta, Azer Bestavros, "SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks", Second International Workshop on Sensor and Actor Network Protocols and Application (SANPA), 2004.

[6] Li Qing*, Qingxin Zhu, Mingwen Wang, "Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks", Computer Communication 29, pp. 2230-2237, 2006.

[7] Brahim Elbhiri, Saadane Rachid, Sanaa Elfkihi, Driss Aboutajdine, "Developed Distributed Energy-Efficient clustering (DDEEC) for heterogeneous wireless sensor networks", 5th International Symposium on I/V Communications and Mobile Networks (ISVC), ISBN 978-1-4244-5996-4, September 2010.

[8] Wendi Rabiner Heinzelman, Anantha Chandrakasan, Hari Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks", Hawaii International Conference on System Sciences, January 4-7, 2000.

[9] Stefanos A.Nikolidakis[1,*], Dionisis Kandris[2], Dimitrios D.Vergados[1] and Christos Douligeris[1], "Energy Efficient Routing in Wireless Sensor Networks Through Balanced Clustering" Algorithms, ISSN 1999-4893, pp. 29-42, 18 January 2013.

[10] Giuseppe Anastasi*, Marco Conti[#], Andrea Passarella*, Mario Di Francesco*, "Energy Conservation in Wireless Sensor Networks: a Survey", Ad Hoc Networks, May 2009.