Optimized Energy Conservation Procedure for Heterogeneous Wireless Sensor Network

DOI : 10.36909/jer.ICCEMME.15625

R K Yadav, Rashmi Mishra*

Delhi Technological University, Delhi, India

*Email: dtuphd.rashmi@gmail.com; Corresponding Author.

ABSTRACT

A WSN is composed of device with dissimilar energy levels. For saving energy, a grouping algorithm is obligatory and it also intensification the epoch time of the network and the firmness epoch of the network. For securing the energy conservation of the network, energy-efficient grouping etiquettes are designed for the HWSN. We projected the protocol for the energy-efficient grouping scheme which is an enhanced version of the protocols such as EDEEC, SEP, DEEC, and DDEEC. Simulation outcomes demonstrate that the proposed mechanism is well recovering than the SEP (A Stable Election Protocol), DEEC (Distributed Energy Efficient Grouping Protocol), EDEEC (Enhanced Distributed Energy-Efficient Protocol), DDEEC (Developed DEEC) in standings of the network duration, number of packets delivered to the BS, amount of CH selected and number of nodes alive per smoothed. The CH will be selected founded on the original energy and the left-over energy of the device.

Key words: WSN; Heterogeneous; CH Selection; Residual Energy;

INTRODUCTION

In Wireless Sensor Network, the nodes are established in the atmosphere by considering the energy level, interval from the BS, computation power, and sensing range. With the advancement of the technology, the radio transceiver, and Micro-Electro-Mechanical Systems, and this is also feasible that we combine the sensing and the computing units in one sole unit known as device. The group of these device will form a network known as a wireless sensor network. In the literature, several protocols mainly focus on the energy conservation of the network by considering the gateway node, which means the processing, computation, and transmitting the communication to the BS (BS) through the used the gateway device. But the node heterogeneity is another thing that is considered by most protocols for reducing energy consumption. In most of the protocols, various parameters are considered for designing the algorithm such as the movement of the BS, CH selection, Security, the conservation of the energy, etc. The wireless sensor network is self-possessed of small device and these devices will accumulate all the sensed packets and advancing the packets to the CH in one situation and another, transmit the accumulated packets to the CH and then CH will aggregate and accumulate the packets to the BS. The network is also categorized or parameterized into single-hop and multi-hop. Mostly single-hop consumes more energy for the transmission of packets from one place to another where multi-hop consumes less energy but there is one major drawback of the multi-hop protocol is energy hole problem. But, in together the apparatus, the BS is exploited. So, to manage the energy consumption on all the device, a grouping mechanism is used for aggregating the packets and transmit them to the BS (Devika G et al., 2020). When nodes are ready, they are establishing randomly in the atmosphere as per the requirement in the sensing field. These originally clumsy nodes interconnect with each other and form a network. Because of the advanced acquaintance danger in some areas such as enemy territory, nuclear plants, etc., the devices will be established or dropped aloft (Irum, M., et al,2020).

Another way for balancing the energy among the nodes is to have advanced nodes as CH. Advanced nodes are more powerful as compare to the member node, it would expand the network duration and produce better performance (Fakhrosadat Fanian et al., 2020). A WSN contains of a device, BS, CH, and the monitoring system. Devices are dynamic whereas the BS and the CHs will be in static mode but sometimes these nodes must support dynamic behavior depending on the architecture of the network example in the health monitoring system. The device will collect packets in two modes, i.e., epoch or continual. Epoch packets collection is used by the device when certain events get occur: traffic reporting, fire prevention system. The continual measures obligatory and therefore produces certain traffic from route to the sink. Continual events varieties the cluster steadily used it chooses the CH randomly among all the senor nodes. Epoch events are good for those events which are suggestively vacillating. The second form of the network prototype is Intra-network packet processing. It is required to reduce the packets reduction, as multiple devices will transmit the packets and the packet of the same packet is obtained by the CH. The CH aggregates the packets from the multiple sources using a certain function such as max, min, and mean. All the devices also used the function moderately (Hasan Jafari,2018). Energy is saved during the packets aggregation phase if the algorithm consumes less energy in computation as compared to the communication. Some of the protocols used the efficient packets aggregation function and some of the protocols used the signal processing technique to save energy by removing the noise from the signal and it is also called as packets fusion technique and beamforming technique. These techniques produce a more accurate signal by reducing the technique. The third network prototype is node placement and its abilities. The deployment of the device is either deterministic or self-moving. Depending upon the need and the requirement the deployment prototype is used. In the deterministic deployment, devices are established physically and all the packets are conducted through a pre-defined path. Therefore, grouping is not required or is not a mandatory step. However, in the self-moving deployment phase, the devices are established haphazardly in the atmosphere and generate an ad hoc atmosphere (Manisha R. Dhage et al., 2018). If the devices are not established uniformly, then the optimal grouping becomes a stimulating chore and also if the BS and CH are located any ware then it will affect the performance on the energy saving of the nodes. In the homogeneous atmosphere, devices were established with equal capacity in terms of calculation, power, and communication and the CHs will choose among the established devices (Sohal, A.K et al., 2018). CHs will perform their duties very prudently and also excepted from sensing the packets from the atmosphere or network to avoid energy depletion.

CHs collective the statistics and transmit it to the BS using multi-hop routes used but the location of the BS and CH is very critical as announcement assortment is habitually inadequate and CH may not be able to reach the BS. So, inter-cluster communication is required and if the CH is in the range of BS then in that case, multi-hop communication is used (Venkatasubramanian Srividhya et al., 2018). The wireless sensor network is designed in two forms such as homogeneous and heterogeneous for the cluster and non-cluster atmosphere to enhancing the network duration, synchronization, etc. In the inhomogeneous atmosphere, all the devices would have the same energy level but in the heterogeneous atmosphere, node heterogeneity is considered for the communication, computation, and link connectivity. In the homogeneous atmosphere, the device, CH, and the BS is equipped with the same energy level and consumption level and the memory volume amount is the same for all the types of the node (R. Pachlor. 2018).

PROPOSED ALGORITHM

This section is divided into the following categories: CH Selection Method, Performance Criteria Used, Flow Chart, Simulation, and Results. The flow chart of the proposed algorithm is shown in figure 1. In the projected procedure, the CHs are nominated using the same properties such as left-over energy, the mean energy of the network and in the same manner used by the EDEEC (Enhanced Distributed Energy Efficient Grouping) (P. Saini et al., 2010) (Elbhiri, B. et al., 2010). Mean energy of the network is figured as:

$$\bar{E}(r) = \frac{1}{N}E_{total}\left(1 - \frac{r}{R}\right), where\ R\ is\ total\ round\ in\ network\ lifetime\ \&\ R = \frac{E_{total}}{E_{round}} \quad (5)$$

Where E_{round} shows the energy dissipated in the network and figured by using the following formula:

$$E_{round} = L(2NE_{elec} + NE_{DA} + kE_{amp}d_{toBS}^4 + NE_{fs}d_{toCH}^2 \quad (6)$$

Where d_{toCH}, d_{toBS}, and k_{opt} is figured using equation (7)

$$d_{toCH} = \frac{M}{\sqrt{2\pi k}}, d_{toBS} = 0.765\frac{M}{2}, k_{opt} = \sqrt{\frac{N}{2\pi}}\frac{M}{d_{toBS}^2}\sqrt{\frac{E_{fs}}{E_{amp}}} \quad (7)$$

As per the basic algorithm LEACH (Low-Energy Adaptive Grouping Hierarchy), the CHs are chosen in each round by using the pre-defined threshold value, and this value is chosen by the devices in between 0 and 1. If the chosen value is fewer than the pre-defined threshold value, then that node will become the CH. The author changed the threshold value. The variable used p, r, and G label the proportion of the CH, existing round and the number of nodes who are no chosen as CH and it is figured as:

$$T(s_i) = \begin{cases} \frac{p_i}{1-p_i(r mod \frac{1}{\sum_{i=1}^{n} P_{i_i}})} * \frac{Residual\ Energy\ of\ a\ node * k_{opt}}{Average\ energy\ of\ the\ Network} & if\ s_i \in G \\ 0 & otherwise \end{cases} \quad (8)$$

In DEEC (Distributed Energy Efficient Grouping), DDEEC (Developed Distributed Energy Efficient Grouping), EDEEC (Enhanced Distributed Energy Efficient Grouping), TDEEC (Threshold Distributed Energy Efficient Grouping), the same device is elected as CH after some round due to which advance and super-nodes energy level were reduced and their energy level will become same as a normal node. This problem is continuing in DEEC and EDEEC where DDEEC and EDDEEC are effective for two-level heterogeneous networks. The author has changed the function of EDEEC and save the advance node and super-node energy levels. The author also introduces the concept of that for all the types of devices which specify that all the devices have the same probability to become the CH. The probability for selecting the CH is figured using equation 9:

$$p_i = \begin{cases} \frac{p_{opt}E_i(r)}{(1+m(a+m_o b))\bar{E}(r)} & for\ N_{ml}\ nodes\ if\ E_i(r) > T_{absolute} \\ \frac{p_{opt}(1+a*mo)E_i(r)}{(1+m(a+m_o b))\bar{E}(r)} & for\ Adv\ nodes\ if\ E_i(r) > T_{absolute} \\ \frac{p_{opt}(1+b*mo)E_i(r)}{(1+m(a+m_o b))\bar{E}(r)} & for\ Sup\ nodes\ if\ E_i(r) > T_{absolute} \\ \frac{p_{opt}(1+b*m)E_i(r)}{(1+m(a+m_o b))\bar{E}(r)} & for\ N_{ml}, Adv, Sup\ nodes\ if\ E_i(r) \leq \ _{Absolute} \end{cases} \quad (9)$$

Where Th_{ab} $$Th_{ab} = zE_0\left(1 + \frac{aE_{disNN}}{E_{disNN} - E_{disAN}}\right) \quad (10)$$

The value of z=0.7

PERFORMANCE CRITERIA USED

The performance of the protocol is used to evaluate the network duration, number of CHs is selected per round, number of nodes alive, and the number of packets received by the BS. These parameters show the stability epoch of the network; Network Duration: At each iteration of the protocol, the left-over energy of the network is figured and it is also figured by the interval that the first node dies; Number of alive nodes: This instant amount shows the quantity of alive nodes per round and types of nodes alive such as normal node, advance node, and super node; Packets acknowledged by BS: It indicated the quantity of packets obtained by the BS per round; Stability Epoch: It is well-defined as the total time interval till the first node die; Unstable epoch: It is the total time in between the death of the foremost node and the last node.

SIMULATION RESULT

In the given section, the author assesses the presentation on the numerous procedures in heterogeneous WSN. We used MATLAB as a simulation tool. As shown in the table, we have considered N=100 devices which are arbitrarily dispersed in the network of 100 x100. Deprived damage of simplification, the sink station is considered to be placed in between the center of the cluster. The preliminary supremacy of the devices is different and the biased quantity of forecasting energy is .50. In the given scenario, we have established a 20% advanced node, 30% super-node as compared to the normal node energy level. Along with this, we have ignored the signal rear-ender and interfering in the wireless channel. With these system constraints, different-different protocols of the HWSN are considered for evaluating the performance such as in rapports of the numeral of nodes alive, left-over energy of the nodes, the numeral of the departed nodes in the first rounded. The parameters chosen for the evaluation are case 1: m=0.5, mo=0.4, a=1.5, b=3 and case 2: m=0.8, mo=0.6, a=2.0, b=7 and Table 1 depicts the Simulation Parameters for the sensor environment.

Table 1 Simulation Parameters

Parameters	Value
Network Field	(100,100)
Number of nodes	100
Packet Size	4000 Bits
E_{elec}	50nJ/bit
E_{fs}	$10nJ/bit/m^2$
E_{amp}	$0.0013pJ/bit/m^4$
E_{DA}	5nJ/bit/signal
D_o (Threshold Interval)	70 m
Eo (Original energy of the normal nodes)	0.5J

Evaluation of the Terminate Round of the First Node: Fig 1(a) and Fig 2(a) shows the first node dies after some rounds. In WSN, the stability and the performance of the system are depending on the node's life and it deteriorates when the first nodes die. The expiry of the opening node shows that the system goes into the unstable epoch and gradually the performance of the network goes into the decline mode. The network with the greater numeral of nodes will lead to slightly expand the network duration as compared to those networks having a lesser numeral of nodes because the greater numeral of nodes will grow the burden on the CH but expand the network duration. So, for balancing the network life, many authors have proposed many solutions for selecting the cluster-head by considering the outstanding energy, weight, cost, location of the nodes, computation power.

Table 2 The Simulation result of case 1

Algorithms	DEEC	EDEEC	DDEEC	MEDEEC
Rounds	1215	1233	1251	1281

Table 3 The Simulation result of case 2

Algorithms	DEEC	EDEEC	DDEEC	SEP	MEDEEC
Rounds	1389	1376	1368	1180	1484

Evaluation of number of nodes alive: Figure 1(b) and 2(b) shows the number of nodes alive during the network duration. It is predicated by the graph that, by introducing the super node has expand the network duration. The network life time or we can say that stability epoch of the network of the proposed system is higher than the SEP, DEEC, EDEEC. The first node dies in SEP after 1180 rounds and in EDEEC first node dies in 1376 round and our proposed algorithm, the first node dies at 1484 rounds.

Table 4 The Simulation result of case 1

Algorithms	**DEEC**	**EDEEC**	**DDEEC**	**MEDEEC**
Rounds	3899	6000	3629	6000
No. of alive nodes	0	19	0	23

Evaluation of the number of packets obtained by the BS: Figure 1(c) and Figure 2(c) shows the packets of the packet obtained by the BS. In DEEC, DDEEC, EDEEC the packets obtained by the BS are going linearly till 3000 rounds. The proposed algorithm, MEDEEC, shows the difference after the 4000 rounds.

Table 5 The Simulation result of case 2

Algorithms	**DEEC**	**EDEEC**	**DDEEC**	**SEP**	**MEDEEC**
Rounds	3800	6000	4000	5900	5900
No. of alive nodes	0	5	0	17	25

Table 6 The Simulation result of case 1

Algorithms	**DEEC**	**EDEEC**	**DDEEC**	**MEDEEC**
Rounds	6000	6000	6000	6000
Packet send to BS	>75709	>145271	>108060	>195902

Table 7 The Simulation result of case 2

Algorithms	DEEC	EDEEC	DDEEC	SEP	MEDEEC
Rounds	6000	6000	6000	6000	6000
Packet send to BS	>72015	>123267	>106520	>105045	>30550

CH selection: In heterogeneous wireless sensor network, the optimal number of CH selection is challenging task. In both the cases, MEDEEC overcome the instability of CHs by not considering the initial energy of the but by streamlining the threshold probability. By streamlining the threshold probability, the running timing of the protocol is also reduced. Due to this feature, this protocol is used in the real scenario. Figure 1(d) and Figure 2(d) shows the number of CHs selected per round.

Table 8 The Simulation result of case 1

Algorithms	DEEC	EDEEC	DDEEC	MEDEEC
Rounds	6000	6000	6000	6000
No. of CHs selected	20729	10705	20504	4292

Table 9 The Simulation result of case 2

Algorithms	DEEC	EDEEC	DDEEC	SEP	MEDEEC
Rounds	6000	6000	6000	6000	6000
No. of CHs selected	21257	12624	20954	14587	5245

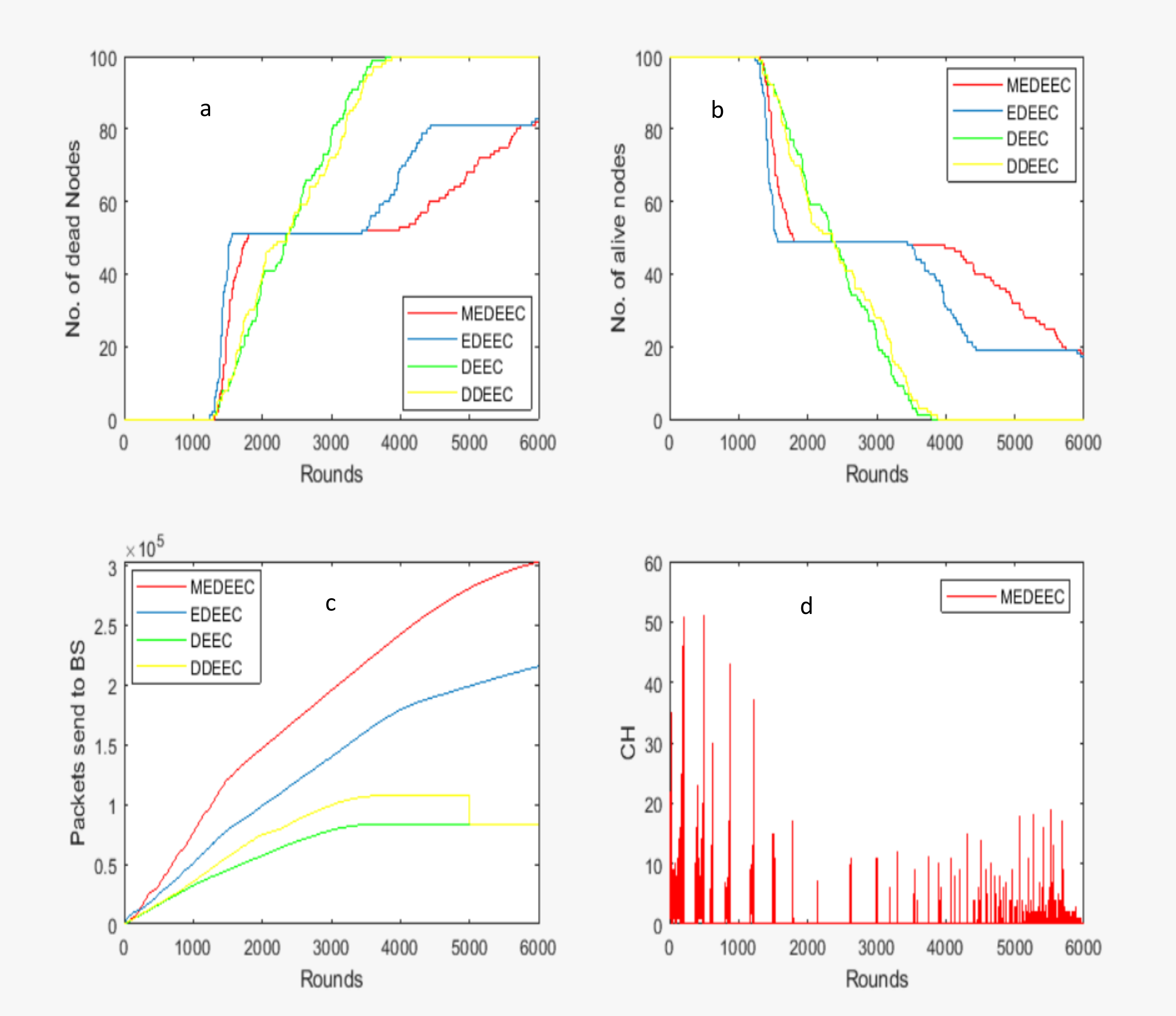

Figure 1 (a) No. of dead nodes (b) No. of alive nodes (c) Packets send to the BS (d) Cluster head selection (case 1: m=0.5, mo=0.4, a=1.5, b=3)

CONCLUSION

To improve the system epoch and the stability of the wireless sensor networks, energy well-organized routing protocols are used. Due to certain challenges such as limited energy, computational power, packet delivery ratio of the devices, routing is a very challenging task for the wireless sensor network. The main difference between the homogeneous and heterogeneous network is to ensure the energy utilization of the devices. Grouping methods are used to decrease the numeral of messages obtained by the sink nodes in a very large-scale network.

Simulation results show the effect of CH selection in the heterogeneous atmosphere and show the best protocol as compared to the others.

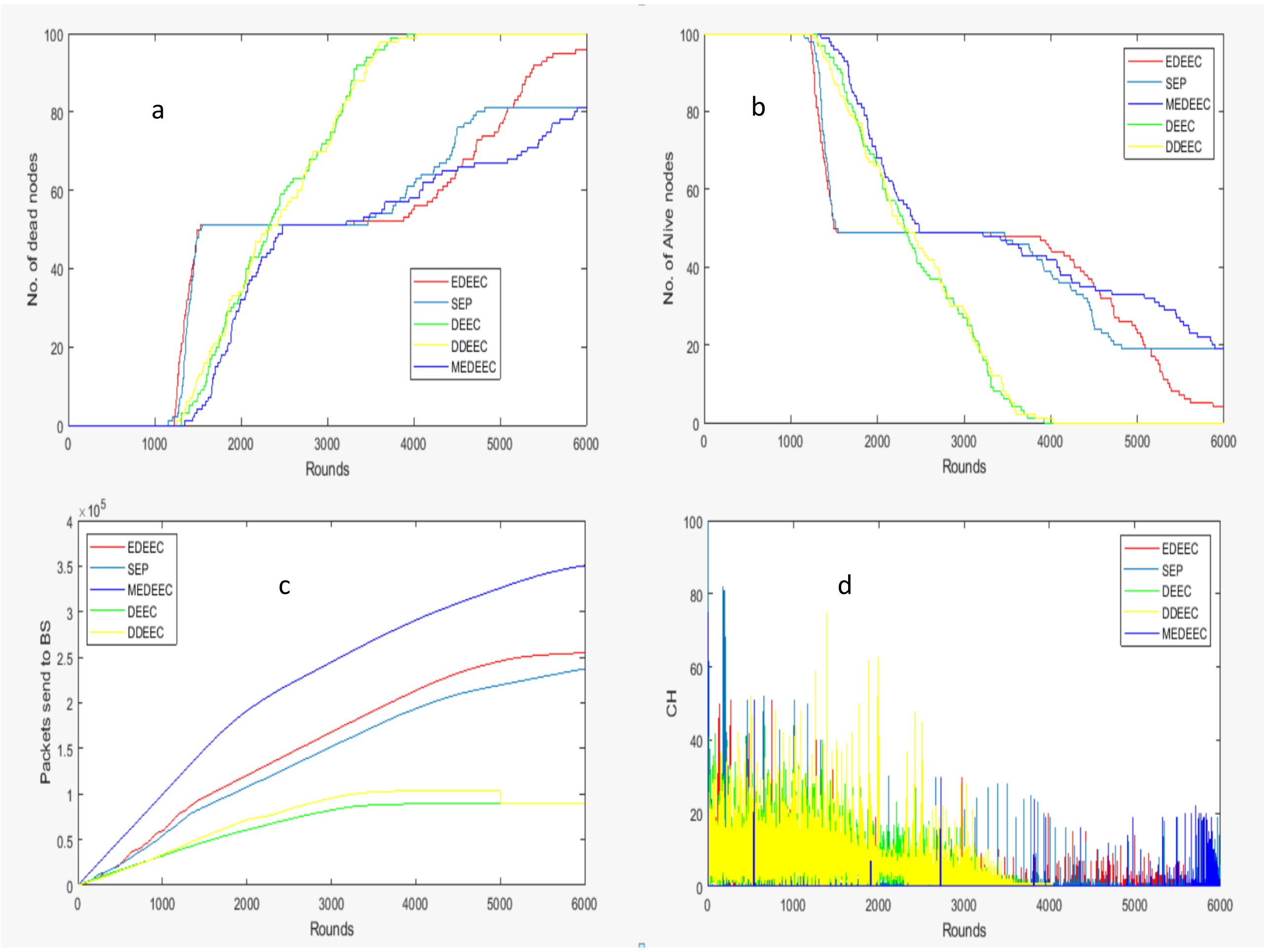

Figure 2 (a) No. of dead nodes (b) No. of alive nodes (c) Packets send to the BS (d) Cluster head selection case 2: m=0.8, mo=0.6, a=2.0, b=7

Simulation results show that the ME-DEEC is a better protocol in understandings of the stability period, alive nodes, data send to the BS and in standings of optimal amount of CH election as compared to the other protocols such as SEP, DEEC, EDEEC, DDEEC.

REFERENCES

Devika G., Ramesh D., Asha Gowda Karegowda. 2020. chapter 7 A Study on Energy-Efficient Wireless Sensor Network Protocols", *IGI Global*.

Cui, Z., Xue, F., Zhang, S., Cai, X., Cao, Y., Zhang, W., & Chen, J. 2020. A Hybrid BlockChain-Based Identity Authentication Scheme for Multi-WSN. IEEE Transactions on Services Computing:1–1.

Irum, M., Shahzad, M, && Muhammad, E. 2020. Fuzzy Logic Based Time Series Prediction Algorithm Using Nearest Neighborhood Clustering. Journal of Engineering Research. Vol 8 No. (3):135-152.

Y. Lin, J. Zhang, H.S.-H. Chung, Wai Hung Ip, Yun Li, Yu. -Hui. Shi. **2020.**
An ant colony optimization approach for maximizing the lifetime of heterogeneous wireless sensor networks, IEEE Trans. Syst. Man. Cybernet., 42 (3), pp:408-420

Fakhrosadat, F. Marjan, Kuchaki. Rafsanjani. 2019. Cluster-based routing protocols in wireless sensor networks: A survey based on methodology, Journal of Network and Computer Applications, Volume 142:111-142.

Sariga, A. Sujatha, P. 2019. A survey on unequal clustering protocols in Wireless Sensor Networks, Journal of King Saud University -Computer and Information Sciences, 304-317, Volume 31, Issue 3.

K. Sekaran, et al. 2019. Improving the Response Time of M-Learning and Cloud Computing Environment Using a Dominant Firefly Approach, IEEE Access, vol, 7, pp:30203-30212.

Hasan, J. Mousa, N. Shahaboddin, S. 2018. Optimization of energy consumption in wireless sensor networks using a density-based clustering algorithm, International Journal of Computers and Applications.

Manisha R. Dhage && V. Srikanth. 2018. Routing Design Issues in Heterogeneous Wireless Sensor Network, International Journal of Electrical and Computer Engineering (IJECE), vol. 8.

Sohal, A, K. Sharma, A.K. && Sood, N. 2018. Enhancing Coverage Using Weight Based Clustering in Wireless Sensor Networks, Wireless Pers Commun *98*;3505–3526.

Venkatasubramanian, S && Thangavelu, S. 2018. Energy proficient clustering technique for duration enhancement of cognitive radio-based heterogeneous wireless sensor network, International Journal of Distributed Sensor Networks.

Pachlor,R && Shrimankar, D. 2018. LAR-CH: A Cluster-Head Rotation Approach for Sensor Networks," in IEEE Sensors Journal, vol. 18, no. 23,pp: 9821-9828.

Sharma, D. Ojha, A. Bhondekar, P, A. 2018. Heterogeneity consideration in wireless sensor networks routing algorithms: a review, The Journal of Supercomputing.

Liu, Y., Dong, M., Ota, K., & Liu, A. 2016. ActiveTrust: Secure and Trustable Routing in Wireless Sensor Networks. IEEE Transactions on Information Forensics and Security, 11(9):2013–2027.

Rathna, R., Sivasubramanian, A. 2014. Energy Conservation in Radiation Monitoring, Journal of Engineering Research, Vol 2 No 2.

Ureshi, T.N., Javaid, N., Malik, M., Qasim, U. Khan, Z.A. 2012. On Performance Evaluation of Variants of DEEC in WSNs, Broadband, Wireless Computing, Communication and Applications (BWCCA), 2012 Seventh International Conference on:162-169.

Saini, P && Sharma, K, A. 2010. E-DEEC- Enhanced Distributed Energy Efficient Clustering Scheme for heterogeneous WSN, 2010 First International Conference on Parallel, Distributed and Grid Computing (PDGC 2010), Solan, 2010:205-210.

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

Elbhiri, Brahim. Saadane. Rachid. Alba-Pages Zamora && Driss Aboutajdine. **2009**. Stochastic Distributed Energy-Efficient Clustering (SDEEC) for heterogeneous wireless sensor networks, ICGST-CNIR Journal, vol. 9, no. 2.

Smaragdakis, G., Matta, I && Bestavros, A. 2004. SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks, Second International Workshop on Sensor and Actor Network Protocols and Applications.