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Multi Parameters Based Heterogeneous Clustering Algorithm for Energy Optimization in WSN

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***Abstract*—Wireless Sensor Network (WSN) consists of tiny sensor nodes that are able to sense data from vicinity and send this data to the sink or Base Station (BS). The main issue during data collection is the non-rechargeable energy resource or battery. So the data collection should be energy efficient for long use of WSN. As we know that clustering is one of the most efficient technique for saving energy in WSN. Purpose of the paper is to find out multi-factor based clustering process having four conflicting factors: a) delay based on remaining energy, maximum power transmission etc., b) average lifetime of normal sensor nodes, c) lifetime of CHs, and d) maximum power consumption by any normal node. The algorithm is developed with an economical approach for finding CHs using a fitness function. Optimal path is also found utilizing the ʲdδ distance. Results are far better than the traditional algorithms.**

***Index Terms*—Wireless sensor network (WSN); Clustering; Delay; Re-cluster; Lifetime of Nodes; Lifetime of CH; Maximum Power Consumption**

I. INTRODUCTION

Wireless sensor networks (WSNs) consist of spatially distributed autonomous sensor nodes [1], which cooperatively collect the information from the surrounding process this information and send the information to the sink. Recently Micro-Electro-Mechanical-System (MEMS) emerged as an advanced technology, that increases the application of WSN [17], like: in disaster management , health and military etc [2]. But due to the implementation in remote areas, it is impossible to replace or charge the battery, that means enrgy is the main constraint in WSN. So the use of available power should be in effective way. Many researcher provided solutions [3] [7] [8] [13] [14] - [16] for this issue. Routing [3] - [6] and clustering [8] - [12] are the most effective techniques to reduce power consumption. Clustering algorithms divides the whole network into some clusters, Every cluster contains a Cluster Head (CH) that is responsible for collecting the sensed information and convey this information to the sink or Base Station (BS). This information transmits directly or hop by hop. BS assumes to be easily accessed by the user to collect the sensed information.

The base algorithm [18] divided the area into clusters and used only delay to select the CHs. Here, we have proposed clustering preprocessing strategy to select the CHs which considers several factors: a) delay based on remaining energy, maximum power transmission etc., b) average lifetime of normal sensor nodes, c) lifetime of CHs, and d) maximum power consumption by any normal node. Re-clustering is done to restructure the clusters that also helps in reduction of energy consumption. Route identification technique is used to find an optimal path from source to destination.

Remaining paper is illustrated as: Literature review is presented in section 2. Section 3 contains the proposed approach in detail. Comparison among proposed algorithm, LEACH and base algorithm is described in section 4. Conclusion is explained in section 5.

II. RELATED WORK

WSN is an important field of research from last few years due to the digitalization phase. Heinzelman et al. [19] proposed one of the most important heuristic clustering algorithms Low Energy Adaptive Clustering Hierarchy (LEACH) that contains two phases in each round, first round is CH selection and another is for data transmission. CHs are selected based on probabilistic approach based on threshold value in first phase and selected CHs broadcast a CH selection message to all its neighbor and normal sensors join the CHs on the basis of signal strength that demonstrate the distance indirectly. A Time Division Multiple Access (TDMA) schedule is provided to each node for sending the sensed data. CHs are responsible to convey the information to the sink. After aggregation the data CHs forward the collected information to the BS. To reduce the load among all the nodes, CHs selection phase is repeated. Randomnes is a big disadvantage of LEACH algorithm that makes the CHs based on probability and did not consider other factor like residual power etc.

Many researchers [21], [22] provided central control to the BS using LEACH. In it, BS is having all the information about the location of nodes and residual energy of nodes. It selects the CHs based on different factors that helps in enhancing the lifetime of network but make the process complex for large network, so it is a fruitful solution for small and medium networks only.

LEACH-B [23] algorithm is based on the reduction of CH number in succeeding rounds by examining the remaining power of nodes. This approach fixes the CHs for each round by taking care of residual energy and balance the consumption of energy to enhance the network lifetime.

Halder et al. [24] used archimedes spiral model is used to make uniformity of distance among the nodes. It starts from the center and process to outside area. LEACH-C [25] is an advance version of LEACH where nodes that have higher energy than average of total network are only able to be the CHs. H-LEACH (Hybrid-LEACH) [26] used a partition approach for clustering and data collection. But efficient clustering in partition is provided by Aditya et al. [27] using re-cluster. Efficient clustering is also provided to provide information about any abnormal activity in pipelines [29]. Node placement [31], data aggregation [30] are also very helpful techniques for reducing the energy consumption. Multi-objective problem solutions [28] are also used to in various clustering approaches.

Here, we have proposed a clustering approach by considering that the network is a heterogeneous network where all nodes are of different characteristics and the proposed clustering considers a fitness function that is based on many factors.

III. PROPOSED WORK

Here we have described our proposed approach considering various factors and the advantage of choosing these factors. Network model-

Here we have assumed that many sensors of different charac- teristics are distributed in a region and are static in nature. BS has storage and a battery having capability to perform infinite processing. BS knows the location of nodes, residual energy of nodes and also having the ability to perform computations. BS is also static in nature means its location is fixed. All nodes having information regarding the location of BS.

A. Clustering-

Clustering is the technique to divide the whole network into clusters so that the energy consumption could be minimized. The clusters should also be optimized to make energy consumption optimized.

Here we have proposed the clustering algorithm based on four conflicting factors. Fitness function is designed to make coordination among these factors and also to select the best CHs. The factors are as follows:

1. Delay considering total transmission power required, residual energy etc.,
2. Lifetime of CHs,
3. Average lifetime of nodes, and
4. Maximum power consumption by any node.

Coordination among factors shows the solution will have lower delay with high lifetime of nodes and CHs, and also perform load balance by taking care of maximum power consumption by any node. This combination will lead to the higher lifetime of whole WSN. Clustering phase performs following steps:

1) ***Cluster Formation:****:* We divided the whole WSN into optimal number of clusters same as in base paper [18]. CHs are chosen in next phase.

2) ***CH Determination:****:* After creation of clusters, we need to identify a CH in each cluster. Here, we describe the CHs selection approach to select the optimal CHs using four conflicting factors. It compiles following steps:

a) ***Step 1****:* **Delay Calculation:**

Delay is inversely proportion to the remaining power of nodes. Its minimum value is required and it confirms higher remainin power of sensors. So lower delay will help in enhancing the lifetime of WSN.

$$\text{Delay}=\left(\frac{\left(E_{initial}-E_{residual}\right)}{E_{initial}}+r\right)*RTD$$

where r - random number (0<r<1), RTD - round trip delay.

b) ***Step 2****:* **Computation of CH Lifetime:**

CH lifetime determines the number of rounds till the node can work as a CH before being out of energy. The higher value of CH lifetime shows that the node is a good option to choose as a CH since it will increase the total lifetime of WSN.

c) *Step 3:* Computation of Average of Nodes Lifetime:

It shows the average lifetime of member nodes in the cluster if a node is chosen as a CH. Its higher value shows that how much time the normal nodes will send the data if the node becomes a CH. It is calculate as

$$Node_{i-}\ Life = E_{res}\_Node_i\ /Transmission\_Energy\_Needed\_Node\_to\_CH$$

d) Step 4: Maximum Power Required by Node:

It shows maximum transmission power required by a particular node in the cluster to transmit data to the respective CH. Its lower value is required to restrict the overhead on a single node and confirms load balancing during the transmission of data to CH. It is calculated as:

$$Max\_Power\_Node = MAX(E_T\_NodesInCluster\_to\_CH)$$

where ET - Transmission energy required.

e) Step 5: Computation of Fitness Function:

Fitness function helps in making a cooperation among the considered conflicting factors to optimized the energy consumption by selecting the effective CHs. Here we computes the fitness function as:

$$\text{Fitness Value} = \alpha * F1 - \beta * F2 - \gamma * F3 + \eta * F4$$

where, factor F1=Delay, F2=CH Life, F3=Avg Nodes Life, and F4=Max Power Node, α=0.25; β=0.3; γ=0.3; and η=0.15. Algorithm is explain in algorithm 1 using all .

f) Step 6:

Fitness value is calculated for all nodes in each cluster and node having lower fitness value will be chosen as a CH for that particular cluster and rest nodes will work as normal nodes.

3) Re-Cluster : Since the CHs are selected from each cluster, now there is a chance that the member sensor node is far from the selected CH in that cluster and nearer to a CH selected in other cluster. So the re-cluster phase is included to reduce some extra energy consumption. In this phase clusters are formed again according to the selected CHs and each member sensor node join the nearest CH.

Algorithm 1: CH selection approach to find optimal CHs.

Data- Transmission energy required E(T), BS and Nodes Location, Initial Power(i)
Result: CH in each cluster

start
for each node k do
for every round do
Compute Eres of k;
Compute Delay for k;
Compute Avg_Nodes_Life;
Compute Max_Power_Node;
End
End
Let Sa(fuz_Value), Sb(fuz_Value) as the fuzzy values of sensors Sa and Sb;
$E_{minimum}$ is computed as the minimum power required to collect information and transmit to the sink:// Process for all sensors in the cluster;
for every sensor in the cluster; if((Sa(Fit_Value)<Sb(Fit_Value)&&Eres(k)>($E_{minimum}$ +threshold)
{
Now Sa will be a sensor with optimal fuzzy value;
Sa announced as the selected CH
}
else
{
Sa will work as a member sensor and sense the data from its vicinity
}
end
End

B Route Selection Approach:

Now there is a need to select the most favorable route to transfer the sensed information to the sink. So here we have where, factor F1=Delay, F2=CH Life, F3=Avg Nodes Life, and F4=Max Power Node, α=0.25; β=0.3; γ=0.3; and η=0.15. Algorithm is explain in algorithm 1 using all .

g) ***Step 6****:* Fitness value is calculated for all nodes in each cluster and node having lower fitness value will be chosen as a CH for that particular cluster and rest nodes will work as normal nodes.

3) ***Re-Cluster*** *:* Since the CHs are selected from each cluster, now there is a chance that the member sensor node is far from the selected CH in that cluster and nearer to a CH selected in other cluster. So the re-cluster phase is included to reduce some extra energy consumption. In this phase clusters are formed again according to the selected CHs and each member sensor node join the nearest CH updated the route selection process provided in the base paper [18] by considering the $^{J}d_0^{J}$ distance as this distance plays an important role in energy consumption. Algorithm2 describes the process in detail [32].

IV. Result and Experimental Simulation

We have used MATLAB to model our WSN for exper- imental purpose. Since MATLAB provides a realistic and object oriented support so it shows the actual and clear energy dissemination and information collection process using our proposed algorithm, base approach (EEHC) and LEACH ap- proach. So MATLAB provides a clear comparison among the algorithms. We have taken many cases for the variable number of nodes and BS position. We have used two parameter number of dead nodes after each rounds and total remaining energy of nodes after each round. Dead nodes comparison is shown

Algorithm 2: Path selection approach for information collection using WSN

Data: Network after Re-cluster phase
Result: Optimal Path between CH and Sink
for *every node k* do
if *(Sensor acts as a member)* then
transmit the information to the nearest CH;
end
if *(Sensor acts as a CH)* then
if *(Sink Distance <d_0)* then
transmit the information to sink directly;
else
if *($Eres_k$ > (Transmission Power to d_0 distance + Threshold))* then
transmit the information to a CH that has a distance near and less than d_0, if there is no such CH then transmit information to the nearest CH;
end
else
transmit the information to the nearest CH;
end
end
end
end
if *(s is an obstacle)* then
Process Shortest Path finding approach on vertex V1;
Process Dijkstra (G, Source)
for *every vertex u in G* do
distance cost (u)= ; ∞
previous vertex (u)=undefined;
distanceTo(Source)=0;
Set=all vertex in G;
while *Set is not empty* do
v=vertex in Set having the lowest distance(u);
remove vertex v from Set;
for *every nearest vertex u of v* do
new distance=distance cost(u)+ distance cost(v,u);

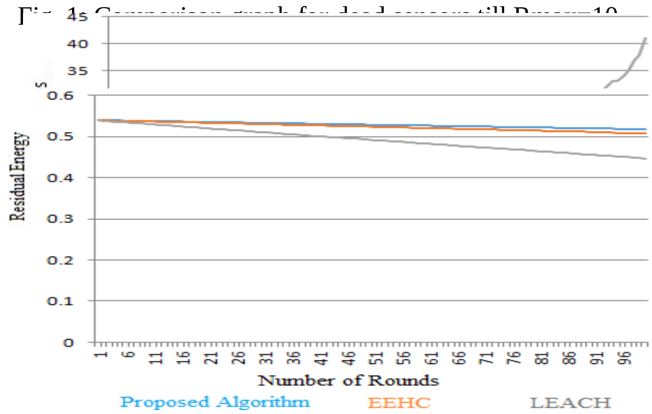
```
if
    (new distance < distance cost(u))
 then
distance_cost(u)=new distance;
previous_ vertex(u)=v;
return_previous vertex();
end
end
end
end
end
else
Transmit the information to nearest CH or BS.
else
Identify sensor k.
end
```

by 1, 3, 5, and 7 figures and remaining power comparison is shown by 2, 4, and 6 figures. Results verifies that proposed algorithm is the most favourable approach among all three compared algorithms.

TABLE I. Parameters used for Simulation

Parameter Name	Values
Size of Network	100m x 100m
Position of Sensors	Randomly deployed
Primary Power	1J
Deployed sensors count	varying
Transferral Energy	100W
Rounds	varying

CASE 1: When position of BS = (0, 0), Total sensors = 500



till Rmax=100

CASE 2: When position of BS = (50,50), Total sensors = 100

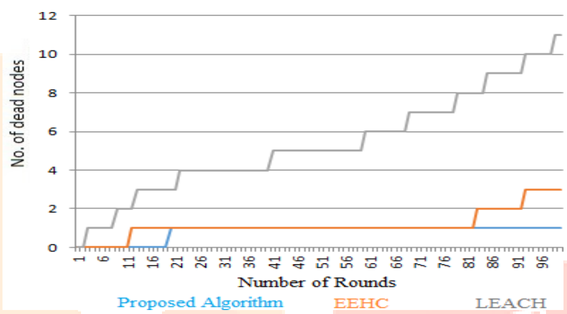


Fig. 3: Comparison graph for dead sensors till Rmax=100

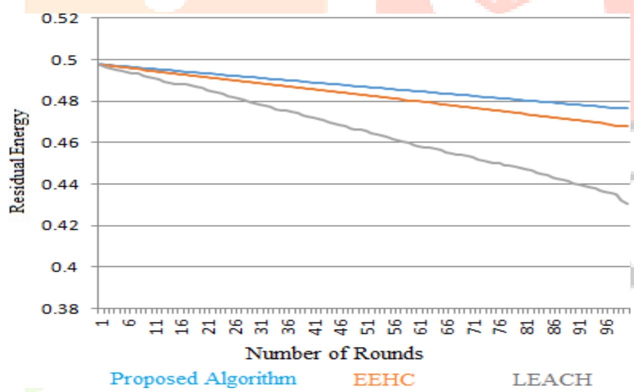
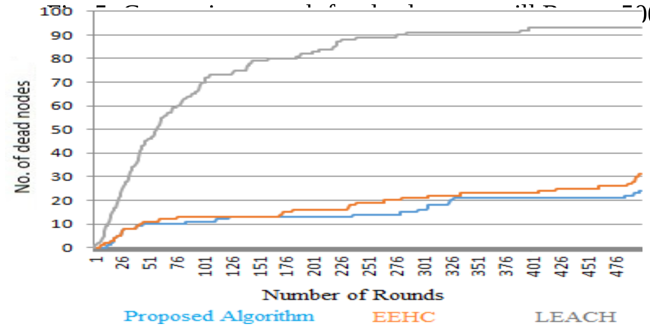


Fig. 4: Comparison graph for remaining energy of network till Rmax=100

CASE 3: When position of BS = (200,200), Total sensors= 10



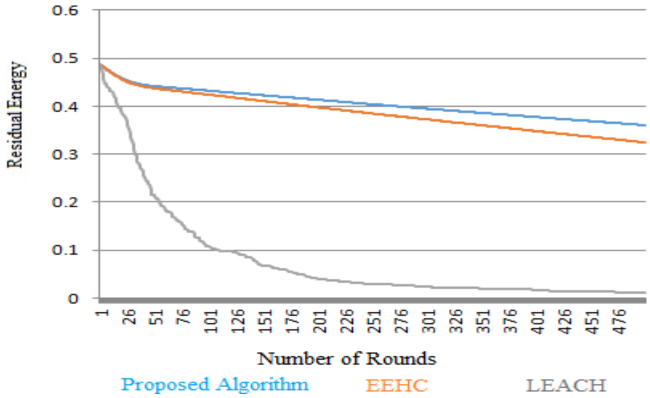


Fig. 6: Comparison graph for remaining energy of network till Rmax=500

CASE 4: When position of BS = (0,0), Total sensors = 100

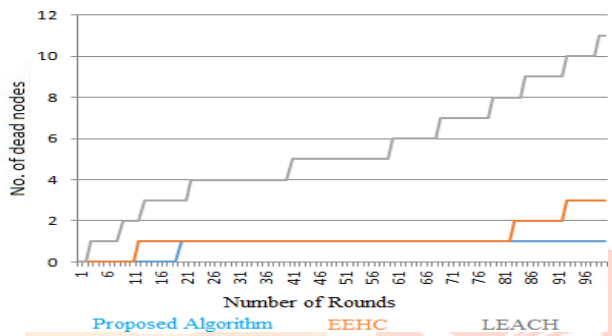


Fig. 7: Comparison graph for dead sensors till Rmax=100

V. CONCLUSION

Clustering approach helps in power utilization during information gathering process. CH selection using single factor is not a fruitful process because there are many other conflicting factors that strike the network lifetime. The proposed method provides a clustering process that makes a cooperation among four conflicting factors. So the identified CHs using proposed process are more favorable than other algorithms because the selected CHs are of higher lifetime and also having high remaining power. The member sensors are also have higher lifetime and no member node consumes large amount of energy. Re-cluster phase also reduces energy consumption and provides lower distance to CH. Path identification technique is also provide utilization of power during packet forwarding. Results verify the superiority of proposed algorithm over base and LEACH algorithm.

REFERENCES

[1] F. Zhao, L. J. Guibas, and L. Guibas, Wireless sensor networks: an information processing approach. Morgan Kaufmann, 2004.

[2] I. F. Akyildiz, and I. H. Kasimoglu, "Wireless sensor and actor networks: research challenges." Ad hoc networks 2, no. 4: 351-367, 2004.

[3] N. Chilamkurti, S. Zeadally, A. Vasilakos, and V. Sharma, "Cross-layer support for energy efficient routing in wireless sensor networks." Journal of Sensors, 2009.

[4] T. Meng, F. Wu, Z. Yang, G. Chen, and A. V. Vasilakos, "Spatial reusability-aware routing in multi-hop wireless networks." IEEE Trans- actions on Computers 1: 244-255, 2016.

[5] C. Busch, R. Kannan, and A. V. Vasilakos, "Approximating Congestion+ Dilation in Networks via" Quality of Routing" Games." IEEE Trans. Computers 61, no. 9: 1270-1283, 2012.

[6] A. Dvir and A. V. Vasilakos, "Backpressure-based routing protocol for DTNs". InACM SIGCOMM Computer Communication ACM, Vol. 40, No. 4, 405-406, 2010.

[7] Y. Yao, Q. Cao, and A. V. Vasilakos, "EDAL: An energy-efficient, delay- aware, and lifetime-balancing data collection protocol for wireless sensor networks." In Mobile ad-hoc and sensor systems (MASS), 2013 IEEE 10th international conference on, pp. 182-190. IEEE, 2013.

[8] Y. Zeng, K. Xiang, D. Li, and A. V. Vasilakos, "Directional routing and scheduling for green vehicular delay tolerant networks." Wireless networks 19, no. 2: 161-173, 2013.

[9] X. Luo, Y. Hu, and Y. Zhu, "Topology evolution model for wireless multi-hop network based on socially inspired mechanism." Physica A: Statistical Mechanics and its Applications 416: 639-650, 2014.

[10] M. Li, Z. Li, and A. V. Vasilakos, "A survey on topology control in wireless sensor networks: Taxonomy, comparative study, and open issues."

Proceedings of the IEEE 101, no. 12: 2538-2557, 2013.

[11] X. Hu, Y. Li, and H. Xu, "Multi-mode clustering model for hierarchical wireless sensor networks." Physica A: Statistical Mechanics and its Applications 469: 665-675, 2017.

[12] X. M. Zhang, Y. Zhang, F. Yan, and A. V. Vasilakos, "Interference- based topology control algorithm for delay-constrained mobile ad hoc networks." IEEE Transactions on Mobile Computing 14, no. 4: 742-754, 2015.

[13] K. Han, J. Luo, Y. Liu, and A. V. Vasilakos, "Algorithm design for data communications in duty-cycled wireless sensor networks: A survey." IEEE Communications Magazine 51, no. 7: 107-113, 2013.

[14] L. Xiang, J. Luo, and A. Vasilakos, "Compressed data aggregation for energy efficient wireless sensor networks." In Sensor, mesh and ad hoc communications and networks (SECON), 2011 8th annual IEEE communications society conference on, pp. 46-54. IEEE, 2011.

[15] Y. Yao, Q. Cao, and A. V. Vasilakos, "EDAL: An energy-efficient, delay- aware, and lifetime-balancing data collection protocol for heterogeneous wireless sensor networks." IEEE/ACM Transactions on Networking (TON) 23, no. 3: 810-823, 2015.

[16] Y. Xiao, M. Peng, J. Gibson, G. G. Xie, D. Z. Du, and A. V. Vasilakos, "Tight performance bounds of multihop fair access for MAC protocols in wireless sensor networks and underwater sensor networks." IEEE Transactions on Mobile Computing 11, no. 10: 1538-1554, 2012.

[17] F. T. Jaigirdar and M. M. Islam, "A new cost-effective approach for bat- tlefield surveillance in wireless sensor networks". In: IEEE networking systems and security, pp 16, 2016.

[18] K. J. Elma and S. Meenakshi, "Energy Efficient Clustering for Lifetime Maximization and Routing in WSN", International Journal of Applied Engineering Research 13.1: 337-343, 2018.

[19] 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.

[20] W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor net- works." IEEE Transactions on wireless communications 1, no. 4: 660- 670, 2002.

[21] D. Kumar, T. C. Aseri, and R. B. Patel, "EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks." computer communications 32, no. 4: 662-667, 2009.

[22] F. Bajaber, and I. Awan, "Adaptive decentralized re-clustering protocol for wireless sensor networks." Journal of Computer and System Sciences 77, no. 2: 282-292, 2011.

[23] M. Tong, and M. Tang, "LEACH-B: an improved LEACH protocol for wireless sensor network." In Wireless Communications Networking and Mobile Computing (WiCOM), 2010 6th International Conference on, pp. 1-4. IEEE, 2010.

[24] S. Halder and A. Ghosal, Lifetime maximizing clustering structure using archimedes spiral based deployment in WSNs. Integrated Network Man- agement (IM), (2015) IFIP/IEEE International Symposium on. IEEE, 2015.

[25] J. Lee, T. Kwon, and J. Song, "Group connectivity model for industrial wireless sensor networks." IEEE Transactions on Industrial Electronics 57, no. 5: 1835-1844, 2010.

[26] V. Gupta, and M. N. Doja, "H-LEACH: Modified and Efficient LEACH Protocol for Hybrid Clustering Scenario in Wireless Sensor Networks." In Next-Generation Networks, pp. 399-408. Springer, Singapore, 2018.

[27] Aaditya, R. Kumar, and P. Rajpoot, "Optimized H-LEACH algorithm for clustering to improve lifetime of WSN", Proceedings of 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT-2018), pp 2393-2398, in press..

[28] P. Rajpoot, and P. Dwivedi, "Matrix Method for Non-Dominated Sort- ing and Population Selection for Next Generation in Multi-Objective Problem Solution." In 2018 8th International Conference on Cloud Computing, Data Science & Engineering (Confluence), pp. 670-676. IEEE, 2018.

[29] N. Verma, N. Pandey, and P. Rajpoot, "Energy Efficient Protocol to Supervise Overground Pipelines using WSN", Proceedings of 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT-2018), pp 1818- 1823, in press.

[30] P. Rajpoot,"Data Aggregation and Distance Based Approach to Boost Life Span of WSN". International Journal of Engineering Technology Science and Research, IJETSR, Volume 4, Issue 11, 2017.

[31] S. H. Singh, R. Verma, and P. Rajpoot, "Partition Based Strategic Node Placement and Efficient Communication Method for WSN", Proceedings of 2018 3rd IEEE International Conference on Recent Trends in Elec- tronics, Information & Communication Technology (RTEICT 2018), pp 1807-1812, in press.

[32] P. Rajpoot, S. H. Singh, R. Verma, K. Dubey, S. K. Pandey, and S. Verma, "Multi-Factor Based Energy Efficient Algorithm for Clustering and Routing in WSN", Soft Computing: Theories and Applications: Proceedings of SoCTA 2018, Springer, (2018), in press.