An Improved Energy Efficient Routing Algorithm (FCM and DE) in MANET's

Neha Pachauri[1], Dr. Neelesh Gupta[2]

[1] M.Tech Student, Electronics and Communication, AKGEC, Ghaziabad, U.P, India
[2] Professor, Electronics and Communication, AKGEC, Ghaziabad, U.P, India

ABSTRACT

MANET stands for Mobile ad hoc network which consists of devices that are autonomously self organizing, self configuring in networks. MANETs are very important in situation like disaster, search & rescue operations, in battle field for communication, military environment etc. Since each & every nodes are battery driven & hence have limited battery power it is mandatory to use this power in a very limited manner. For this Average energy consumption must be very low so that every node can be participated in network for transferring data for long time. So this can increase lifetime of network. Here combination of Fuzzy C- Mean clustering (FCM) and Differential Evolution (DE) is used for reduction in average energy which will increase the network lifetime. After that simulation study of various existing protocols with this proposed algorithm is done so the comparison can be made between this algorithm.

Keyword: *MANET, FCM, DE, Cluster Member, Cluster Head, Mobile nodes etc.*

1. INTRODUCTION

MANET is a special type of network which is infrastructure less or footing its establishment in all fields due to high efficiency of their autonomous and self-governing mobile nodes. Mobile ad hoc networks are also called de-centralized networks because there is no central device which controls the network, such as router or switch. All devices have same status and free to create link with other ad hoc networks where link is available. The devices in this type of network are free in moving and also provide the services of host and router forwards the packet to destination. During data communication from sender to receiver, there are many constraints in the path finding, node selecting, and detection of link failures, route maintenance, route repair, retaining routing tables and to take correct decision of packet forwarding towards the direction of exact destination. MANET consists of number of mobile nodes which operates on battery. A mobile node has a finite energy which is degrading soon when use in continuous communication. Therefore, these nodes must to be conserved energy to maximize the life time of the network.[1]

A Cluster is a group of linked nodes working together for same purpose & belongs to same topological structure. Each cluster comprises a cluster head to manage the cluster & co-ordinate with other clusters through inter or intra communications [2]

Basic terminology is as follows:

A. Cluster: It refers to a collection of nodes, grouped for the functioning for same purpose.

B. Cluster Head (CH): Cluster head is a special node which has certain extra responsibilities. All the information is passed through this node only.

C. Cluster Gateway (CG): A node which is common member of more than one cluster is called as Cluster Gateway.

D. Cluster Member Node (CMN): The nodes which are the member of a cluster.

As mobile nodes move around in the network, the structure of cluster changes according to the specified criterion in the algorithm and in large network, complete information is maintained within cluster using proactive

routing algorithms that is intra-cluster routing while the inter-clustering routing is achieved by using reactive routing algorithms. The performance of a cluster also depends upon the number of cluster member nodes in the cluster.[3]. Clustering is an important approach to solving capacity and Scalability problems in mobile ad hoc networks where no physical infrastructure is available & connected dominating set (CDS) is a special cluster structure where the cluster heads form a connected network without using gateways.[4]

2. LITERATURE REVIEW

Mahendra Maiti et.al (2018) [1] proposed an energy efficient common content distribution approach based on teaching learning based optimization technique which work on two phases –teaching phase & learning phase in which mobile terminal & node have been used interchangeable throughout this work. The teaching phase establishes of the base station by sending the invited data packets to selected channels. In learning phase, the Cluster members know the from their corresponding Cluster heads. Thus learning is corresponding to receive side of the essential data. The residual nodes that make up the main portion of the network population (NP) remain idle. Based on bit rate, as well as data packet size energy for transmission &reaction of data packet was calculated

Siqian Yang et.al (2018) [2] proposed a neighbour discovery protocol, named Centron, among the mobile devices in the crowded region by considering the massive collisions reduces the successful delivery probability. The protocol encourages the mobile nodes to construct core groups. With the help of the negotiations among the core members, the core group act as a "big mobile node". Two channels were used to separate the negotiation & discovery out.

Yaser.M. Khamayseh et.al (2018) [3] proposed an algorithm which divides in two parts source node side & observational node side which is used to create a design for monitoring and observing transmission. Proposed algorithm increase PDR by 45.6% in dense network & 41% in sparse network.

J.C Dunn et.al (2008) [4] proposed the fuzzy algorithm for detecting signals (presence or absence) in clusters. This fuzzy algorithm seems significantly less flat to the cluster-splitting tendency. This may less easily diverted to uninteresting locally optimal partitions.

Shafiq Alam et.al (2014) [5] discussed the progress of clustering based on PSO. Author surveyed and presented the results of growing trends in the literature of swarm intelligence, PSO and PSO-based data clustering. Outlined different application of PSO which can be relevant to clustering. And found that PSO is simple enough to modelled and capable for use in diverse new application domains.

Ayub Shokrollahi et.al (2017) [6] proposed ECAFG to lengthen the network lifetime of WSN by using FCM algorithm, that balanced cluster size and GFS for CHs selection. Calculation of energy, the distance to the BS and the distance to the corresponding cluster centre were used as inputs for fuzzy logic and GA which was used to optimize fuzzy rules. Results study show that this algorithm has better performance in reducing the energy consumption as compared with LEACH, CHEF and LEACH-ERE algorithms, results into increase in network lifetime.

Meenakshi Sharma et.al (2012) [7] discussed three protocols of routing which are EEE LEACH, LEACH and DTx in WSN. EEE LEACH has greater energy efficiency with better lifetime of network than LEACH protocol. Author tried to compute it's transmission time and throughput .Then compared the results with LEACH and DTx. But EEE LEACH takes long time to transmit the data which causes degradation of its throughput value. Therefore EEE LEACH protocol is inefficient in terms of transmission time and throughput.

Avinash More et.al (2017) [8] provided an introduction on coverage concepts used in sensor networks. An energy efficient coverage protocols based on area coverage taken into consideration. The objective of the coverage protocols is to keep a necessary set of working nodes on while turning off the redundant nodes for effective coverage and energy efficiency. Energy conservation can be achieved by reducing coverage overlap and optimal node scheduling which would increase the node and network lifetime.

Pratyay Kuila et.al (2014) [9] presented a DE based algorithm for Wireless sensor networks with the help of an efficient vector encoding with an extra phase so that performance can be improved. Author assumed that gateways are directly communicated with BS which may not be realistic for large network. An efficient fitness function for increasing life time of network is used. The fitness function care the energy consumption of both the gate-ways and the sensor nodes. The results shown that the DE based algorithm converge more rapidly than traditional DE and GA.

Nikolaos A. Pantazis et.al (2013)[10] concentrated on the protocols that are energy efficient & developed for WSN. Author found that the flat protocols can be ideal solution for a small size network having fixed nodes. For large network they may become infeasible just because of link and overhead. The hierarchical protocols can solve that problem and produce scalable and efficient solutions by dividing the network into clusters and maintain consumption of energy efficiently, by performing data aggregation.

Sweta Potthuri et.al (2016) [11] proposed a hybrid DE based Simulated Annealing which is used to increase the lifetime of network with the help of prolonging the death of the CH's. This includes a fitness function for consideration which helps to calculate the residual energy, distance between CH from nodes. Experimental results shows that the lifetime of the network with proposed algorithm has been increased by 40%

3. PROBLEM STATEMENT

The biggest challenge is to design a MANET's with efficient energy consumption without affecting QoS. Increase in data packet size & decrease in bit rate lead to greater energy consumption, hence network lifetime decreases. In our present work, investigation of some other algorithms that will increase the network lifetime & reduce the average energy consumption like for content distribution approach is used to calculate the Average energy consumption that will successfully utilized in the network.

With this survey it is clear that some routing protocols & Energy efficient algorithms have certain advantages & limitation which is expressed in Table 1.

Table -1 Various Energy Efficient Protocols & Comparison[7]

Scheme	Advantages	Limitation
LEACH	Low energy, ad-hoc, distributed protocol	It is not applicable to networks deployed in large regions and the dynamic clustering brings extra overhead
LEACH-C	Energy for Data transmission is less than LEACH	Over head
APTEEN	Low energy consumption	Long delay
TEEN	It works well in the conditions Like sudden changes in the sensed attributes such as temperature	A lot of energy consumption and overhead in case of large network
PEGASIS	The transmitting distance for most of the node is reduced	No consideration of the BS location about the energy of nodes when one of the nodes is selected as the head node
VGA	It may achieve energy efficiency and maximization of network lifetime	The problem of optimal selection of local aggregators as master aggregators is NP- hard problem
TDD	It can be used for multiple mobile sinks in a field of	The source node builds a virtual grid structure of dissemination points to supply data to mobile sinks
BCDCP	Low energy consumption	Performance gain decreases as the sensor field area becomes small

4. PROPOSED WORK

In various researches, different type of energy efficient algorithm has been presented for minimizing the energy consumption. Still realizing a true energy efficient MANET is a big challenge. In Proposed work two algorithms are taken into consideration for achieving the proposed results such as Fuzzy C-Mean Clustering Algorithm (FCM) & Differential Evolution(DE). FCM is used for clustering purpose and & DE is used for cluster head selection

4.1 PROPOSED ALGORITHM

Here two algorithms(FCM+DE) are proposed to achieve the results which are discussed as follows:

a) FCM is a method of clustering which allows one piece of data to belong to two or more clusters. This method is developed by Dunn et.al(1973)[4] and improved by Bezdek in 1981. It is frequently used in pattern recognition. It is based on minimization of the following as in Eqn (4.1).

$$j_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m}\left\|x_i - c_j\right\|^2, \qquad 1 \le m < \infty \quad (4.1)$$

Where m is any real number greater than 1,uij is the degree of membership of xi in the cluster j as in Eqn.(4.2), xi is the ith of d-dimensional measured data, cj is the d-dimension center of the cluster by Eqn.(4.3), and ||*|| is any norm expressing the similarity between any measured data and the center. Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership uij and the cluster centers cj.

$$u_{ij} = \frac{1}{\sum_{k=1}^{C}\left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{m-1}}}, \quad (4.2)$$

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^{m} \cdot x_i}{\sum_{i=1}^{N} u_{ij}^{m}} \quad (4.3)$$

This iteration will stop when$\max_{ij}\left\{\left\|u^{(k+1)}{}_{ij} - u^{(k)}{}_{ij}\right\|\right\} < €$, where €is a termination criterion between 0 and 1, whereas *k* are the iteration steps. This procedure converges to a local minimum or a saddle point of J_m.

b) DE is a stochastic and population based evolutionary algorithm that is widely applied in solving many optimization problems. It consists of four stages such as initialization of population vector, mutation, crossover and selection Pratyay Kuila et.al (2014)[9]

(i) Initialization of the population vector: The following is the suggested vector representation scheme. The vectors are displayed in a particular manner so that the complete assignment of all the mobile nodes to the Base Station s indicated by every vector. The i^{th} population vector at the G^{th} generation is represented via following notation in Eqn (4.4):

$$\vec{X}_{i,G} = [X_{1,i,G}, X_{2,i,G}, X_{3,i,G}, \ldots\ldots\ldots\ldots X_{N,i,G}] \quad (4.4)$$

Where N is the dimension of the vector and value of the jth component, i.e.,Xj,1,G maps the assignment of the sensor node. Each component is initialised with a uniformly distributed random number Rand (0, 1] which means 0 <Rand (0, 1] ≤ 1. Random number generation of the individual component is done independently. The important part is that these vectors depict a part of the algorithm for clustering. It is already mentioned that the vector dimensions are equal to the number of sensor nodes and hence any alteration of the number of sensor nodes would impact on the dimension of the vector, which will result in re-clustering.

(ii) Mutation Operation: In this case, the standard DE mutation operation is followed. The reason behind is, if the algebraic subtraction of the two vector component is done, then the component of the resultant vector can become negative. So the algorithm has to be in a way that it can produce the difference vector components in a manner to suit the range only when difference vector components are chosen. A similar situation can appear while the arithmetic addition of the vector is done in the mutation process.

(iii) Crossover: Following the mutation operation, an operation called crossover is done between the donor vector and the target vector. The crossover generates a new child vector called a trial vector. In this process, the binomial cross over operation is done with a pre-assumed crossover rate (say Cr). The trial vector components are selected from random numbers between 0 and 1. If the random number chosen for the j^{th} component of the trial vector become less than Cr, then the j^{th} component of the donor vector is chosen to be the j^{th} component of the trial vector.

(iv) Improved Selection: The selection operation decides which vector from the target vector and newly generated trial vector will survive to the next generation. Both of the vectors are evaluated by the derived fitness function. The trial vector replaces the target vector if the trial vector has better fitness value; otherwise the target vector retained in the population. If the trial vector have the better fitness values then next process to check the lesser distance from base station and centroid, which node have less distance from base station and centroid and better fitness value that node will select the cluster head**.**The same technique of teaching phase by modifying the cluster formation by FCM clustering algorithm in which the selection of cluster head (learner phase) by DE optimization technique.

In proposed work, main aim is to minimize the average energy consumption for data packet size 5 MB & bit rate 3 Mbps-20 Mbps which is basically for 4G connection so that network work for long duration without any loss in data

5. SIMULATIONS & RESULT

Creation of Simulation environment is using MATLAB (R 2015 a).MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and proprietary programming language developed by Math Works. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

Table 2 Simulation Parameters

S.N	Parameters	Value
1	Area	1000 x 1000 meter square
2	$E_{Tx/s}$	0.5 x S_T
3	$E_{Rx/s}$	0.3 x S_T
4	S_T	1 MB, 2 MB, 5 MB, 7MB, 10 MB
5	P_{cr}	6 J, 9 J for 3G and 4G
6	Number of nodes	10-200
7	Cluster Formation(10-50nodes), 50-100 nodes), (100-200 nodes)	2 cluster,5 Clusters, 10 Clusters

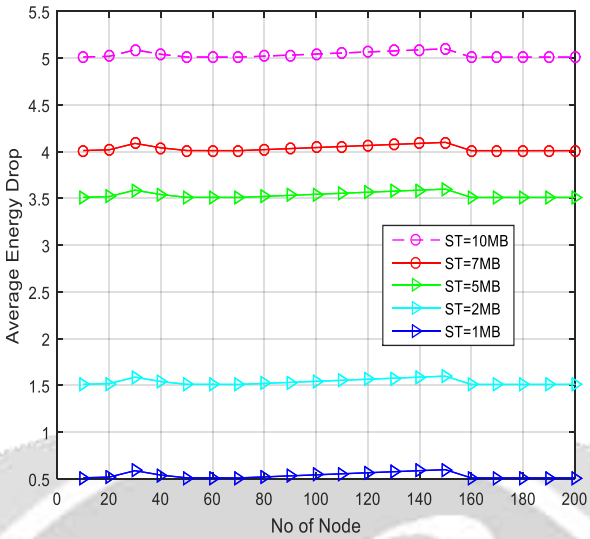

Chart 1Variation in Average Energy Drop

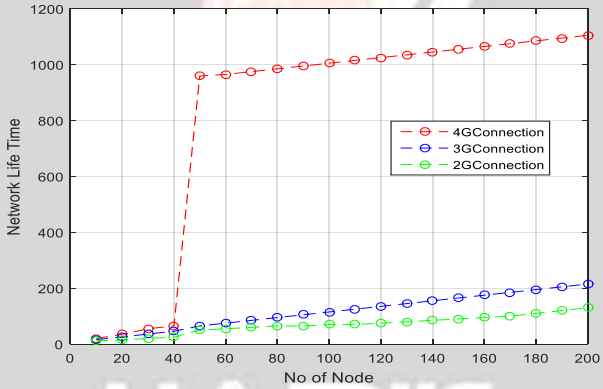

Chart 2 Network Lifetime with 200 Mobile nodes with Bit rate (4G)

From chart 2, it can be observed that 4G & 3G connections lead to significant reduction in energy drop that make the algorithm energy efficient. So this energy can be utilized for communication between mobile nodes.

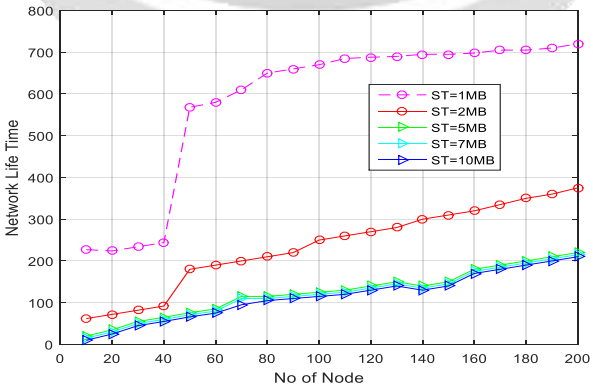

Chart 3 Network Lifetime with 200 Mobile Nodes with different data packet size

Table 3 Simulation Results

S.N	Parameters Evaluated	Existing Value [1]	Proposed Outcomes	Result Achieved
1	Average Energy drop with data packet size(5MB)	5J	5J-3J	3.5J
2	Average Energy drop with bit rate(3Mbps-20Mbps)	12 J	12J-10J	10.5370 J
3	Network lifetime with increasing Data packet size(5MB)	65 rounds	65-70 rounds	200 rounds
4	Network lifetime with increasing bit rate(3Mbps-20Mbps)	20 Rounds	20-25 Rounds	220 rounds

6. COMPARISION RESULTS

A comparative study for Proposed FCM-DE with various energy efficient algorithms is performed for energy & network lifetime as shown in Fig 7.1 & 7.2 for which average energy drop is calculated with algorithms like TLBO, U+M, K-mean and Non Cooperative.

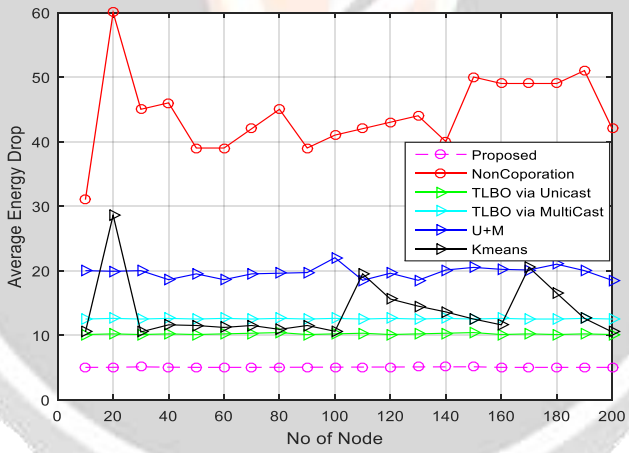

Chart 4 Comparison between proposed FCM-DE with TLBO and others in terms of average energy drop of nodes.

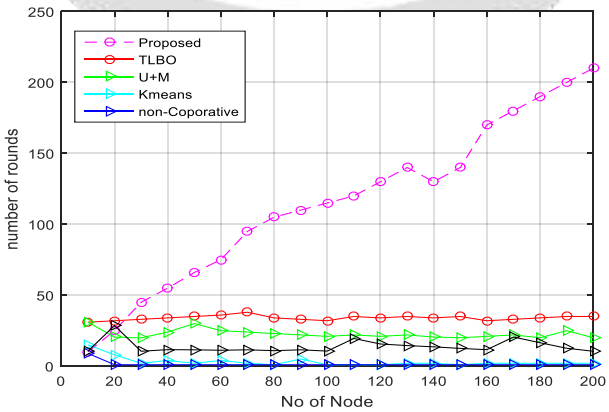

Chart 5 Comparison between proposed FCM-DE with TLBO and others in terms of average energy drop of nodes.

FCM-DE compared with other algorithms such as ECAFG, LEACH, CHEF and LEACH-ERE in Meenakshi Sharma et.al (2012)[7]has the smallest SD of cluster size since the formed clusters using FCM algorithm with optimized number of cluster have a balanced distribution of cluster members in the FCM-DE as shown in Fig 7.3 & 7.4.

$$Std = \sqrt{\sum_{i=1}^{C} \frac{(NP - AvgNP)^2}{c}} \qquad 7.1$$

Here, c is the number of clusters generated by FCM, NP is the number of per clusters and Avg NPis the average number of all cluster members. The comparative analysis of SDs based on cluster size

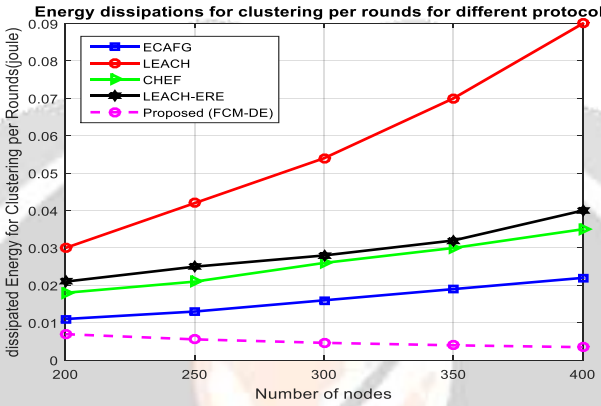

Chart 6 Comparative analysis of Energy dissipations for clustering per round for various protocols with respect to number of nodes.

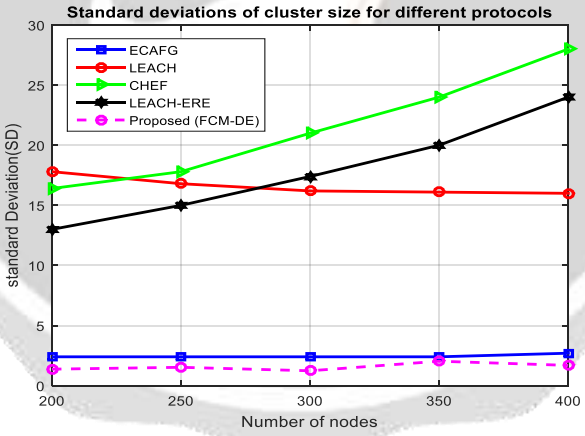

Chart 7 Comparative analysis of Standard deviations with different protocols on the variation of number of nodes.

7. CONCLUSIONS

Both the life span of a mobile node as well as the consumption of energy are both equally significant. It results in better network lifetime such that network performance does not deteriorate too early. The goal of the present work was to minimize energy consumption to prevent the link failure between two nodes while maximizing the network lifetime. Average energy drop among nodes is an indicator of energy efficiency of the entire routing process. This research considers the existing literature in MANET, and then proposed energy efficient improved techniques for the improvement of energy efficiency by minimizing average energy drop with the help of FCM &DE. Simulation studies show that average energy drop for varying data packet size is minimized up to certain level as compared to teaching learning based optimization technique. From Results it is also shown that for increasing data Packet size leads more consumption in energy.In future work this method can also be used in WSN.

8. ACKNOWLEDGEMENT

The authors can acknowledge any person/authorities in this section. The authors would like to thank the Ajay Kumar Garg Engineering College (Affiliated to Dr.A.P.J Abdul Kalam university,Lucknow), Ghaziabad (U.P), India, for his guidance and support throughout the completion of this work & helped me to overcome the hurdles. The authors would like to thank the reviewers for their helpful comments.

9. REFERENCES

[1] MahendraMaiti, Srijit Mukherjee , and Parag Kumar GuhaThakurta,2018, "An energy efficient teaching learning based optimization approach for common content distribution in mobile ad hoc networks", Computers and Electrical Engineering, Vol.78, pp 1-16.

[2] Siqian Yang ,Cheng Wang, and Chang jun Jiang, 2018,"Centron: Cooperative neighbor discovery in mobile Ad-hoc networks", Computer Networks ,Vol.136, pp 128-136.

[3] Yaser M Khamayseh, ShadiA. Aljawarneh ,and Alaa Ebrahim Asaad, 2018,"Ensuring Survivability against Black Hole Attacks in MANETS for Preserving energy efficiency", Sustainable Computing: Informatics and Systems,Vol.18, pp 90–100.

[4] J.C Dunn, 1973, "A fuzzy relative of the ISODATA process and its use in detecting compact well-separated clusters", Vol 3, No 3, pp 32-57.

[5] Shafiq Alam, Gillian Dobbie, Yun Sing Koh, Patricia Riddle, Saeed Ur Rehman, 2014, "Research on particle swarm optimization based clustering: a systematic review of literature and techniques", Swarm and Evolutionary Computation, Vol 17, pp.1-13.

[6]Ayub Shokrollahi. and Babak Mazloom-Nezhad Maybodi, 2017, "An energy-efficient clustering algorithm using fuzzy C-means and genetic fuzzy system for wireless sensor network", Journal of Circuits, Systems and Computers, Vol 26, No 1, pp.1750004-1 175004-22.

[7] Meenakshi Sharma and Anil kumar Shaw, 2012, "Transmission time and throughput analysis of EEE LEACH, LEACH and direct transmission protocol: a simulation based approach", Advanced Computing, Vol.3, No 6, pp.75-82.

[8] Avinash More and Vijay Raisinghani, 2017, "A survey on energy efficient coverage protocols in wireless sensor networks", Computer and Information Sciences, Vol 29, No.4, pp.428-448.

[9] Pratyay Kuila and Prasanta K. Jana., 2014, " A novel differential evolution based clustering algorithm for wireless sensor networks", Applied soft computing, Vol.25, pp.414-425.

[10] Nikolaos A. Pantazis, Stefanos A. Nikolidakis and Dimitrios D. Vergados, 2013, "Energy-efficient routing protocols in wireless sensor networks: A survey", IEEE Communications, Vol 15, No 2, pp.551-591.

[11]Sweta Potthuri, T. Shankar, A. Rajesh ,2016, "Lifetime Improvement in Wireless Sensor Networks using Hybrid Differential Evolution and Simulated Annealing (DESA)", Electrical Engineering.

BIOGRAPHIES

	Neha Pachauri currently pursuing M.Tech (Electronics & Communication) from Ajay Kumar Garg Engineering College, Ghaziabad India. She has an experience of over 2.5 year in the field of telecommunication for rollout of Reliance 4G as a Project coordinator. Her area of interest is in the field of Wireless Communication. She has written a paper on "Traffic Density control & accident indicator using Wireless Sensor Networks", for National conference (ETEC-2018) & "Clustering schemes in MANET-An Overview" in (ETEC-2019).