

A Novel Clustering using GA adaptive cluster Niching Optimization

Er. Priyanka¹, Er. Vishal Walia², Dr. Rahul Malhotra³

¹Resesarch Scholar, M.Tech ECE, RIEIT, Railmajra, er.priyanka189@gmail.com

²Associate Professor, RIEIT, Railmajra, walia.vishal@gmail.com

³Director, GTBKiet, Malout, blessurahul@gmail.com

Abstract

We propose a Novel Niching Genetic algorithm (GA) for optimized clustering in wireless sensor networks. Clustering protocol is needed for achieving efficient energy utilization and hence prolonged network lifetime in wireless sensor networks. Though conventional GA has been used for optimizing cluster head selection but we propose a niching approach with GA to find optimized sub-clustering for load balancing incase of uneven clusters. Results show a significant improvement in number of alive nodes and energy consumption of nodes. Cluster Heads are regularly optimized using GA based on fitness function value. Decision for niching is based on energy consumption, distance from base station and average cluster node count.

1. Introduction

In recent years, Wireless sensor networks (WSNs) [1] have attracted considerable attention due to their potential applications in all fields. WSN was first inspired by the US military for enemy surveillance and object tracking [2]. A WSN typically comprises of interconnected low-power, multi-functioning sensor nodes operating in an unattended environment. These nodes possess computational as well as sensing capabilities. Additionally, each sensor node consists of a wireless radio transceiver and a small microcontroller. But sensor nodes depend on a battery as an energy source, which is a limited source of energy and needs to be used efficiently for prolonged node lifetime. Replacing battery sources frequently is not a good option as it is practically not feasible. So, prolonged network lifetime, scalability, node mobility and load balancing are important requirements for any WSN. Use of large batteries with high capacities makes sensor nodes bulky. For this reason, sensor nodes are implemented as compact, low cost and power-efficient devices connected with each other to perform monitoring and computational tasks. Advent of micro-electromechanical systems (MEMS) [3,4] along with evolving wireless communication technologies, have made it possible to develop tiny, cheap, and smart sensors nodes. But optimized use is still an area which needs to be explored for achieving efficient node usage.

Initially, Direct Transmission (DT) and Minimum Transmission Energy (MTE) were two classical approaches proposed [5] for lifetime of WSNs. In DT, sensors transmit its sensed data directly to the Base Station (BS). In this approach, the sensor nodes far away from the Base Station (BS) to die first. On the other hand in MTE, sensors near the BS would die first because they act as relays for sensors that are far from the BS. Though simple and easy to implement these classical approaches did not guarantee balanced energy utilization in the network Therefore, designing energy-aware clustering protocols became an important factor for extending the lifetime of sensors. Clustering of nodes in the network is one area which needs to be optimized to minimize battery consumption in nodes. So, Clustering can be viewed as optimization problem with respect to formation of clusters and selection of cluster heads. Clustering is a non-deterministic problem due to varying number of nodes, their random location in search space and non-predictable of communicating nodes.

From the early research on clustering, a clustering scheme called Low-Energy Adaptive Clustering Hierarchy (LEACH) is proposed in [6] that distributes energy all along its network, the network being divided into clusters and cluster. Many variants of LEACH were suggested [7,8] but random CH was major drawback. Heads Hybrid Energy-Efficient Distributed Clustering (HEED) HEED [9] is a distributed algorithm which selects the CH based on

both residual energy and communication cost. It was proposed to avoid the random selection of CHs.

Lindsey proposed the PEGASIS, which was an extension of the LEACH algorithm with better robustness to node failure as compared to LEACH [10]. Dasgupta [11] applied a cluster-based heuristic algorithm which extended Maximum Lifetime Data gathering Algorithm (MLDA), where nodes are grouped into several pre-defined sized clusters. Bandyopadhyay [12] proposed a multi-level hierarchical clustering algorithm. Though over the years plethora of WSN routing protocols that minimize energy used, extending WSN life subsequently have been proposed nature inspired evolutionary algorithms (EAs) have ability to identify global minima in the search space and use constrained programming technique to transform the stochastic problem into its deterministic form. An early implementation of GA algorithm is Tur-gut[] work which applied the GA concept to improve mobile adhoc network clustering.

Jin et al [14] proposed an efficient method based on genetic algorithms (GAs) to solve a sensor network optimization minimizing the distance for cluster selection. Zhang et al [15] proposed improved LEACH-SAGA protocol which used simulated annealing and genetic algorithm to cluster the sensor nodes, at the same time. Results showed improved reasonable cluster head distribution with lower level of power consumption. But as the number of nodes in network keep changing an adaptive, dynamic clustering approach was needed than algorithm which worked predefined dynamics.

Cerpa [16] described the Adaptive Self Configuring sensor Networks Topology. Ma et al [17] proposed an Adaptive Assistant-Aided Clustering Protocol using Niching Particle Swarm Optimization (AAAC-NPSO) . The proposed protocol is based on energy efficient clustering with application-specific dynamics of node. Result exhibit good performance with respect to system lifespan and data delivery by optimizing energy dissipation in the networks.

In this paper we propose a novel Niching based GA optimization of clustering, wherein random clustering according to minimum distance criteria are formed. GA is applied to largest cluster in the network based on distance as well as distance criterion from base station and at each step CH are rotated making the

network adaptive to changing dynamics of network and effective load balancing.

2. PROPOSED ALGORITHM:

In the early 1970s, Genetic algorithm was developed by John Holland, inspired by biological evolution processes such as reproduction, mutation, crossover and selection. In Genetic Algorithm, the principles of natural selection and evolution are used. At each generation, a coded form of a possible solution for the population of individuals is maintained. This is called the chromosome. A chromosome is made up of genes. The various chromosomes are evaluated using a fitness function. The chromosome with the best fitness value is used for generating the next population. After the evaluation step, the population for the next generation is made using selection, crossover and mutation operations.

Through competition and cooperation among the population, evolutionary optimization approaches usually find very good solutions efficiently and effectively if not the best. But niching method can be incorporated into EAs to maintain formation of multiple stable subpopulations within a single population, with an aim to locate multiple optimal or suboptimal solutions [18,19].

In our work we combine GA and niching approach for load balancing of large sized clusters. So GA plays role of conventional algorithms to optimize the cluster heads as well as used in conjunction with niching to identify to find energy efficient, balanced clustering. Initially all the nodes in the network are distributed randomly in the set up phase as shown in figure 1.

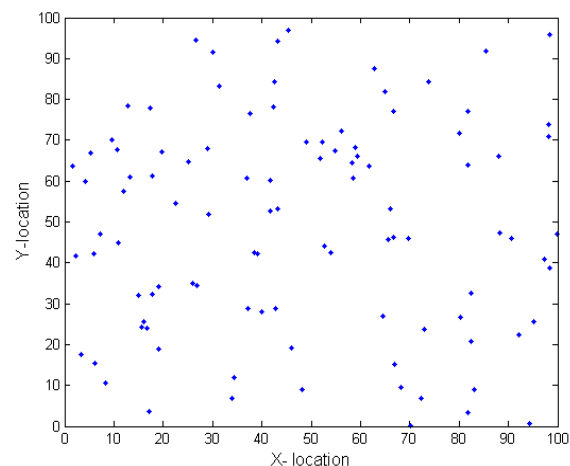


Figure 1: Initial Node distribution distributed randomly 100 nodes

All these nodes are then randomly initialized to energy varying between 0 and 1. These randomly distributed nodes are categorized into clusters identified by minimum distance criterion described by:

$$d = \sqrt{(x_{CH} - x_n)^2 + (y_{CH} - y_n)^2} \quad (1)$$

Where, x_{CH} is x-location of CH and y_{CH} is y location of CH while x_n is x-location of node in question and y_n is y-location of the node. If minimum distance criterion is satisfied for any CH the node is included in that particular cluster. But before distributing initial cluster heads are identified based on criterion that nodes with more than 90 % of maximum energy qualify for being CH.

Figure 2 shows the distribution of clusters initially based on minimum distance criterion. The figure shows seven clusters formed identified with CH with node numbers 7, 16, 27, 28, 72 and 80. Careful observation reveals each cluster has different

number of nodes which though makes network flexible according to energy and distance conditions of the CH but it may lead to load imbalance. Moreover the initial node distribution and CH choice needs optimization. This is done using GA. The red sign shows location of Base station (BS). The optimization is done based on fitness function which is based on average energy of cluster nodes with respect to total energy of all the nodes in the network.

$$Fitness = \frac{E_{rn}}{E_{avgrn}} \quad (2)$$

Where E_{rn} is remaining energy of the node 'n' and E_{avgrn} is the average is energy of all nodes in the given cluster. Now based on these fitness values CH for each node is optimized using GA.

After each iteration based on remaining energy of nodes in the cluster CH is optimized and rotated among nodes in a particular cluster.

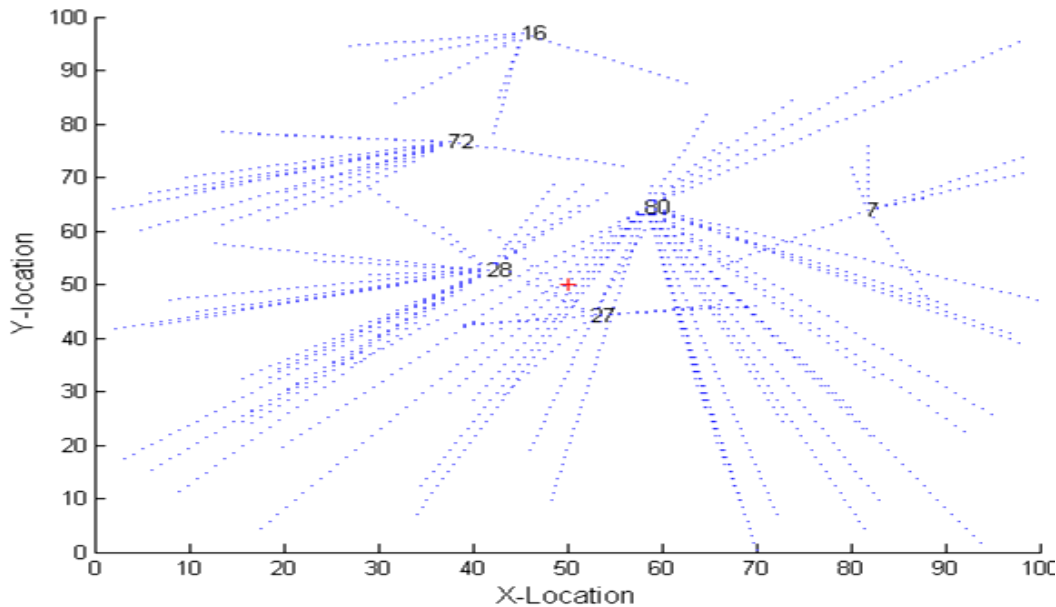


Figure 2: Initial Cluster formation with cluster Nodes specified

Next phase of applying GA is using niching for finding sub-cluster of the largest cluster in the network, if needed. The decision for is made based on the threshold energy of the cluster in question. If the threshold energy is less than the average energy of the network then niching is done else if threshold energy is more than the average energy of the network no niching is needed. This implies cluster

distribution of network is optimal under given conditions. The energy model used to calculate energy has been adapted from the standard model [...]

$$E_{th} = \frac{E_{max} - E_{rCH}}{E_{max}} \cdot \frac{d(CH,BS)}{d_{avg}} \cdot \frac{N_{ci}}{N_{avg}} \quad (3)$$

Where, E_{max} is the maximum energy in the cluster, E_{rCH} is energy of the cluster Head, $d_{(CH,BS)}$ is distance between the CH and BS, d_{avg} is the average distance between the BS and nodes in the network,

N_{ci} is nodes in cluster and N_{avg} is the average number of nodes in the clusters across the network. In this case, $E_{avg} = 0.5690$ while $E_{th} = 0.2136$ this implies load imbalance and hence calls for niching in largest cluster of the network.

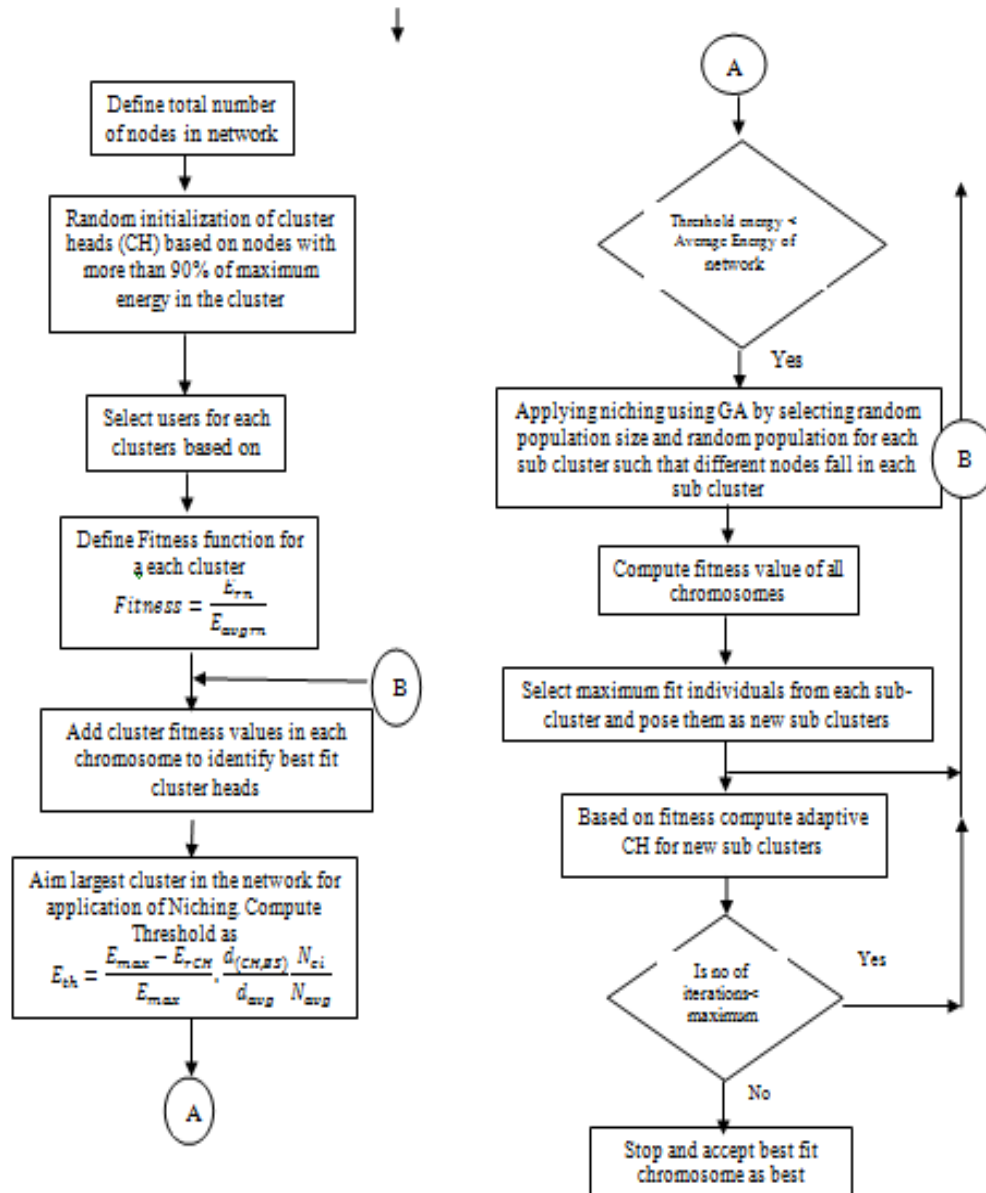


Figure 3: Flow Chart of proposed Niching GA Algorithm

3. RESULTS & DISCUSSIONS

We evaluated the performance of the proposed niching algorithm for 100 nodes randomly distributed in a 100m x 100m network area with the BS located at (x = 50, Y = 50) . The value of $\alpha = 0.6$ though it may vary from 0.2 and 0.9. The length $l = 100$ bytes has been chosen for each round of packet transmission

As can be seen from figure 4 the final cluster heads have been changed from initial CH based on GA optimization.

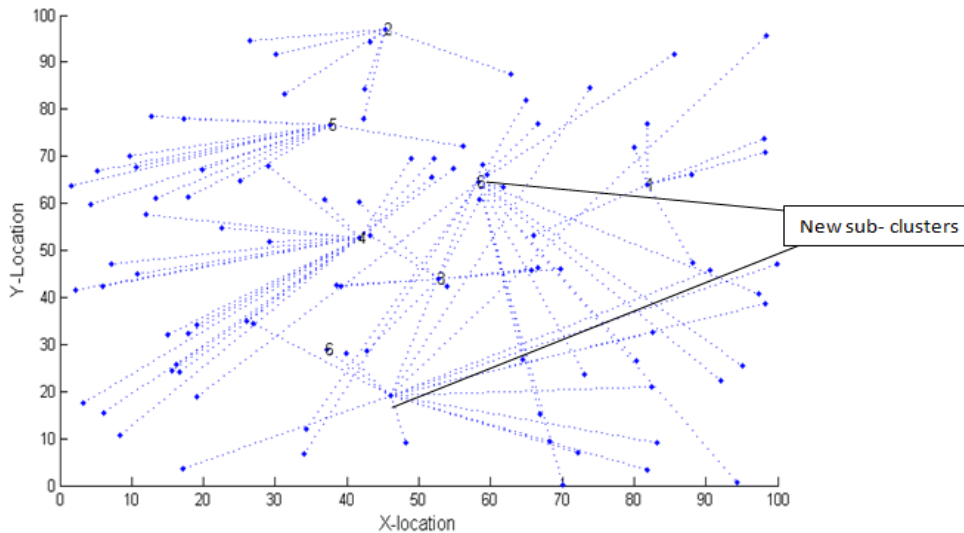


Figure 4: Final cluster distribution after application of Niching GA

On analysis of results in comparison to LEACH [6] and adaptive assistant Cluster protocol based on niching PSO (AACP-NPSO)[17] we find a remarkable improvement in results for data transmission over 1200 rounds assuming packet size of 100 bytes. From results in [17] for AACP-NPSO all nodes remain alive till 1400 nodes whereas LEACH maintains all nodes alive till 1000 but our proposed algorithm maintains all nodes alive till 200 rounds which is much less. But after that number of alive nodes falls drastically to zero by 1500 rounds for AACP-NPSO whereas for LEACH alive nodes falls to zero by 1300 rounds. But our proposed algorithm attains significant improvement over number of alive nodes falling to zero as by 1200 rounds number of nodes is at 91 nodes implying only 9 nodes falling dead. This shows a remarkable performance over all previous

algorithms for clustering. All result have been compared with almost similar parameters as mentioned in [17] though limitations in similar conditions may be doubtful with respect to values of E_a and E_s of standard energy model.

These results can be seen in figure 5 which show fall in number of alive nodes is not drastic but gradual. This implies balanced consumption of energy in the network which is the main objective of any clustering protocol. These observations can also be made from graph of energy initially distributed among all 100 nodes in the network shown in figure 6. The graph in dotted line shows initial energy distribution while solid line shows remaining energy after 1200 rounds. Low valley of graph touching x axis mark dead nodes while rest all have only slight fall in energy.

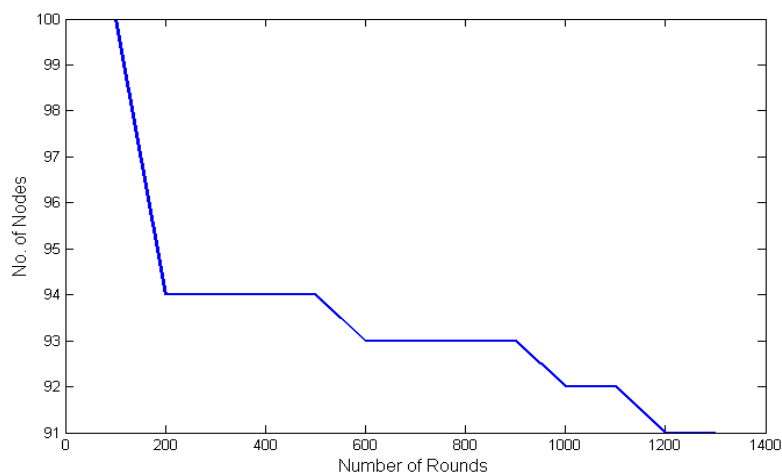


Figure 5: Number of alive nodes after 1200 rounds assuming each round of transmitting a packet

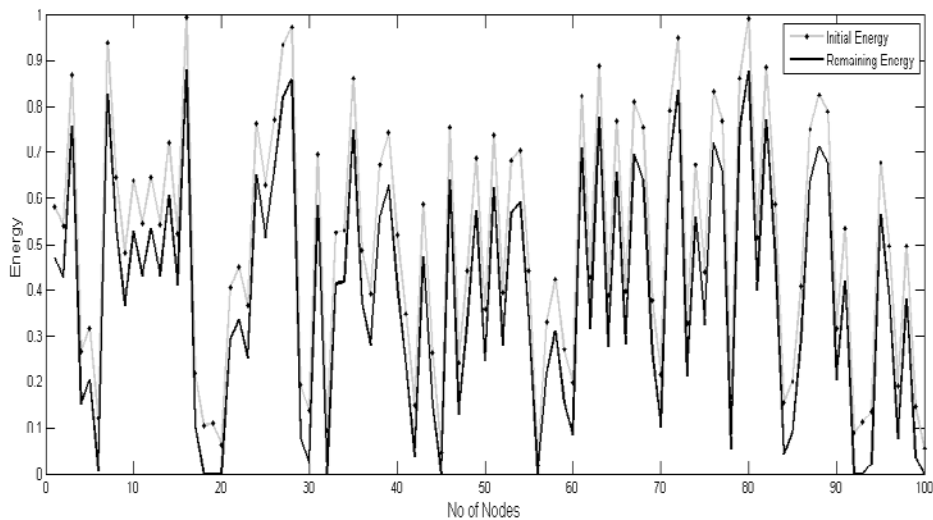


Figure 6: Energy for initial node distribution and final remaining energy

4. CONCLUSION

Our proposed as obvious from result above can prolong the network lifetime significantly compared to LEACH and AACP-NPSO. This is because our proposed algorithm produces better clustering based on minimum distance CH that are optimally distributed across the network and load balancing is done for large clusters using niching GA which achieves optimization based on both average the energy dissipation of nodes in cluster with respect to all nodes in network as well as on distance of CH from BS. Additionally cluster count is given weight age with respect to average number of nodes in clusters across the network. The adaptive ability of proposed algorithm with changing dynamics of network is advantage it offers over existing algorithms. On the contrary, in LEACH and AACP-NPSO some nodes have to transmit long distances in order to reach a CH sub-optimal clustering. Moreover LEACH fails because CH have higher energy consumption than other nodes and it rotation based on remaining energy is necessary for efficient energy utilization in the network.

In future this work may be extended to the implementation of proposed algorithm hardware and multi-hop routing among the CHs to further improve energy efficiency. Niching may be extended to more than one large sized cluster.

5. REFERENCES

1. Yu and P. Chong, "A survey of clustering schemes for Mobile Ad Hoc Networks", IEEE Communications Surveys and Tutorials, 2005, Vol 7, No.1, pp. 32-47.
2. C. Y. Chong and S. Kumar, "Sensor networks: evolution, opportunities, and challenges," Proceedings of the IEEE, 2003, Vol. 91, No. 8, pp. 1247 – 1256.
3. O. Younis, M. Krunz and A. Ramasubramanian, "Node Clustering in Wireless Sensor Networks: Recent Developments and Deployment Challenges", IEEE Network, 2006, pp. 20-25.
4. I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Network", IEEE Communication Magazine, 2004, Vol. 40, No. 8 pp. 102-114.
5. A. Mohammed, S.M. Ahmed1, N. Sabor and S. Sasaki, " A New Energy-Efficient Adaptive Clustering Protocol Based on Genetic Algorithm for Improving the Lifetime and the Stable Period of Wireless Sensor Networks", International Journal of Energy, Information and Communications, 2014, Vol.5, Issue 3, pp.47-72.
6. W. B. Heinzelman, A. P. Chandrakasan, H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks", IEEE Trans. Wireless Communication, 2002, Vol. 1, No. 4, pp. 660-770.
7. V. Loscri, G. Morabito and S. Marano, "A Two-Level Hierarchy for Low-Energy Adaptive Clustering Hierarchy", IEEE 62nd Vehicular Technology Conference, (2005) September 25-28, pp. 1809-1813.
8. M. B. Young, A. Al-zou'bi, Y. Khamayseh and W. Mardini, "Improvement on LEACH Protocol of

- Wireless Sensor Network (VLEACH)", International Journal of Digital Content Technology and Its Applications, vol. 3, no. 2, (2009), pp. 132-136.
9. O.Younis, S.Fahmy, HEED: A hybrid energy-efficient distributed clustering approach for Ad Hoc sensor networks, IEEE Transactions on mobile computing, 2004, Vol. 3, No.4, 366-379.
 10. S. Lindsey and C. S. Raghavendra, "PEGASIS: power efficient gathering in sensor information systems", Proceedings of the IEEE Aerospace Conference, 2002, March 9-16, Big Sky, MT, United states .
 11. Dasgupta, Koustuv, Kalpakis, Konstantinos, and Namjoshi, Parag, "An efficient clustering-based heuristic for data gathering and aggregation in sensor networks", In IEEE Wireless Communications and Networking Conference, (2003).
 12. S. Bandyopadhyay and E. J. Coyle, "An energy efficient hierarchical clustering algorithm for wireless sensor networks", In Proceedings of the IEEE Conference on Computer Communications (INFOCOM), (2003).
 13. D. Turgut, S. K. Das, R. Elmasri and B. Turgut, "Optimizing Clustering Algorithm in Mobile Ad Hoc Net-works Using Genetic Algorithmic Approach," In Proceedings of the Global Telecommunications Conference (GLOBECOM), Taipei, November 2002, pp. 62-66.
 14. S. Jin, M. Zhou and A. S. Wu, "Sensor network optimization using a genetic algorithm", In: Proceedings of the 7th world multicongress on systemics, cybernetics, and informatics, (2003).
 15. Haitao Zhang, Shiwei Zhang and Wenshao Bu, " A Clustering Routing Protocol for Energy Balance of Wireless Sensor Network based on Simulated Annealing and Genetic Algorithm", International Journal of Hybrid Information Technology Vol.7, No.2 (2014), pp.71-82.
 16. A. Cerpa and D. Estrin, "ASCENT: Adaptive Self-Configuring Sensor Networks Topologies," IEEE Transactions on Mobile Computing (TMC) Special Issue on Mission Oriented Sensor Networks, Vol. 3, No. 3, 2004, pp. 90-100.
 17. D.Ma, P. Xu and J. Ma, "An Adaptive Assistant-Aided Clustering Protocol for WSNs Using Niching Particle Swarm Optimization", IEEE Conference on Software Engineering and Service Science, 2013, pp 648-651.
 18. X. Li, "Niching Without Niching Parameters: Particle Swarm Optimization Using a Ring Topology", IEEE Trans. Evol. Comput., vol. 14, no. 1, pp.150-169
 19. D.Ma, P. Xu and J. Ma, "An efficient node partition clustering protocol using Niching Particle Swarm Optimization ", IEEE Conference on Software Engineering and Service Science, 2013, pp 644-647.