Switching-Differential Evolution(S-DE) for Cluster Head Election in Wireless Sensor Network

Astha Gaur[1], Tarun Kumar[2]

[1]M. Tech Scholar, Dept. of C.S.E, GIMT Kanipla, Kurukshetra University Kurukshetra, Kurukshetra, India

[2] Assistant Professor, Dept. of C.S.E, GIMT Kanipla, Kurukshetra University Kurukshetra, Kurukshetra, India

Abstract— *Wireless sensor network consists of number of sensor nodes that capable of sensing data and transferring those data to the base station (BS).The major concerns in Wireless Sensor Networks (WSN) are energy efficiency as they use small sized batteries, which can neither be replaced nor be recharged. So it becomes the necessity to save energy and also increase the lifetime of wireless sensor network. In this paper, a switching differential evaluation (S-DE) algorithm for clustering and election of cluster heads in wireless sensor network is proposed. This paper aimed to improving the network lifetime and to reduce the complexity of network.*

Keywords—Wireless Sensor network, Switching Differential Evolution (S-DE), Clustering, Network lifetime.

I. INTRODUCTION

The Wireless Sensor Network is a collection of hundreds or thousands of tiny nodes and these sensor nodes have limited battery power. [6] In Wireless Sensor Networks, sensor nodes are able to interact with their environment through sensing or controlling the physical parameters. These Sensor nodes collect data from their environment and send it to the Sink or Base Station in order to fulfill their tasks as shown in fig 1. The energy requirement is one of the major constraints while working with wireless sensor networks. The sensor nodes present in the network are very large in number .The major part of energy in the network is consumed in the form of communication between the nodes which includes the transfer of messages between the nodes present in the network. Wireless Sensor Network (WSN) has wide area of different applications like in Monitoring Environment, health, industry, military and in Commercial Use etc. So it becomes the necessity to save energy and also increase the lifetime of wireless sensor network. [2]

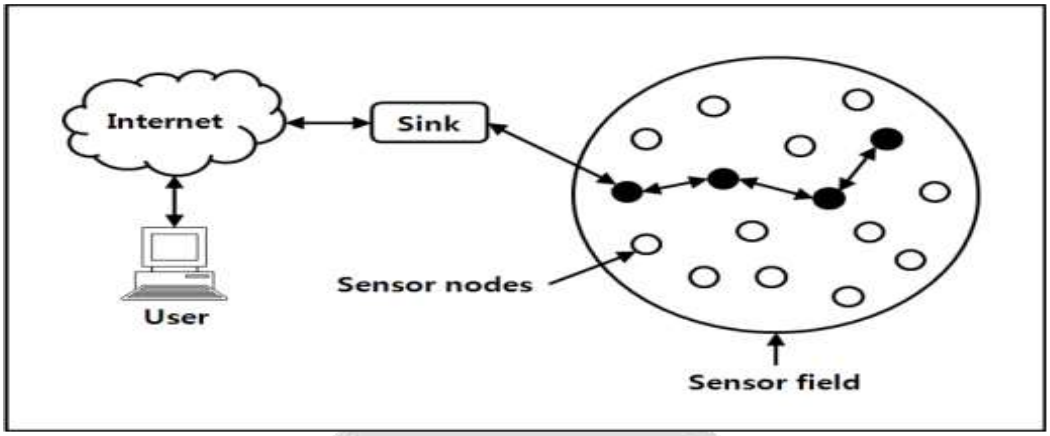

Fig- 1 : Network architecture of Wireless Sensor

Clustering plays an important role in wireless sensor network. Clustering is an approach used to manage network energy consumption efficiently. Clustering is a method to grouping sensor nodes into clusters to achieve the network scalability and improve the lifetime of wireless sensor network. The nodes in a network can be organized in hierarchical structures called clusters. [4] Each cluster consists of a cluster head which behave as a coordinator and several member nodes. The sensor nodes transmit the sensed data to its respective cluster heads. The cluster head gather and transmits the data to the Base Station. There are a number of clustering algorithms for energy efficient clustering like LEACH, Particle Swarm Optimization, Genetic Algorithms, Differential Evolution etc. In this paper, we propose a new clustering algorithm, Switching Differential Evolution(S-DE), which improve the network lifetime and to reduce the complexity of network.

II. RELATED WORK

A.Zahmatkesh et al., 2012 [1] proposed a Genetic Algorithm (GA) to reducing energy consumption of a sensor node as well as the cost of transmission. This paper uses a multi-objective genetic algorithm which generates an optimal number of sensor-clusters with cluster-heads and minimizes cost of transmission.

Norah and Mahamood 2013,[5] proposed a three-layered architecture for randomly deployed heterogeneous wireless sensor networks. Another algorithm for relay node selection also was presented. Finally, simulation has been done to demonstrate the effectiveness of the proposed algorithm to improve the network lifetime. Two simple algorithms for relay node selection also have been presented. It was shown that by introducing relay nodes at the third layer, the network lifetime can be enhanced significantly.

Pratyay Kuila et al., 2014 [7] presented a DE based clustering algorithm for wireless sensor networks. This approach introduced an efficient vector encoding scheme and an extra phase called local improvement to improve the performance of clustering algorithm. This paper also presents an efficient fitness function for extending network life time. The fitness function takes care of energy consumption of both the gateways and the sensor nodes.

Kanika Goel et al., 2015 [3] present a method for minimization of energy consumption. This paper used enhancement of DSDV protocol by Particle Swarm Optimization (PSO) for increase the lifetime of network. The Particle Swarm Optimization is a heuristic global optimization method, which is rely on swarm intelligence.

Pooja Sindhu et al., 2015 [8] used genetic algorithm with Received Signal Strength Indication (RSSI) for energy efficient clustering in WSN. Genetic algorithm is used for cluster head optimization and RSSI for cluster formation. These methods are applying for reduced energy dissipation of nodes and improve lifetime of the wireless sensor network.

Shweta Sharma et al., 2015 [9] proposes a work to increase the stability time of the wireless sensor network by developing the dynamic clustering with the help of Genetic Algorithm. The fitness function applied in genetic algorithm is modified to take in to consideration the remaining energy of the node in that area for selection of cluster head.

Sweta Potthuri et al., 2016 [10] proposed the approaches to improve the energy efficiency in clustering. In this paper, a hybrid differential evolution and simulated annealing (DESA) algorithm for clustering is proposed. The cluster heads are usually overloaded with high number of sensor nodes, it tends to rapid death of nodes due to improper election of cluster heads. This paper prolonging the lifetime of the network by preventing earlier death of cluster heads.

III. PROPOSED SWITCHING DIFFERENTIAL EVOLUTION (S-DE) OPTIMIZATION ALGORITHM

In this paper, we have proposed a Switching Differential Evolution (S-DE) Optimization algorithm. In this algorithm we used Switching Technique with Differential Evolution for increasing the lifetime and reducing the complexity of network.

A. DIFFERENTIAL EVOLUTION

Differential Evolution is a Stochastic and Global Optimization algorithm which is widely used in solving many optimization problems. it optimizes a problem by maintaining a population of candidate solutions and creating new candidate solutions by combining existing ones according to its simple formulae, and then keeping whichever candidate solution has the best fitness on the optimization problem a. In this way the optimization problem is treated as a black box that merely provides a measure of quality given a candidate solution.DE is a simple, easily adaptable algorithm for optimization like other evolutionary algorithms such as genetic algorithms which using these similar genetic operators: crossover, mutation, and selection. The main difference between genetic algorithm and differential evolution algorithm is that genetic algorithm mainly relies on crossover while differential evolution relies on mutation operation. [11] Differential evolution perform better then genetic algorithm.

- **Pseudo code of Differential Evolution**

Input:$Population_{size}$,$Problem_{size}$,$Weighting_{factor}$, $Crossover_{rate}$
Output: S_{best}
Population ← InitializePopulation($Population_{size}$, $Problem_{size}$)
EvaluatePopulation(Population)
S_{best} ← GetBestSolution(Population)
While (StopCondition())
  NewPopulation ← ∅
  For (P_i ∈ Population)
    S_i ← NewiSample(P_i, Population, $Problem_{size}$, $Weighting_{factor}$, $Crossover_{rate}$)
    If (Cost(S_i) ≤ Cost(P_i))
      NewPopulation ← S_i
    Else
      NewPopulation ← P_i
    End
  End
  Population ← NewPopulation
  EvaluatePopulation(Population)
  S_{best} ← GetBestSolution(Population)
End
Return (S_{best})

B. SWITCHING

The Switching is a way by which we do cluster head election in the network. In our work, we use Differential evaluation with Switching for decreasing the complexity of network. Switching is a technique which selects the Cluster Head on the bases of remaining energy of the nodes between specific rounds .In the cluster which node has higher remaining energy that is selected as a cluster head. For example in fig. 2, optimization algorithm selects the node C as a Cluster Head in 1st cluster for round 1.

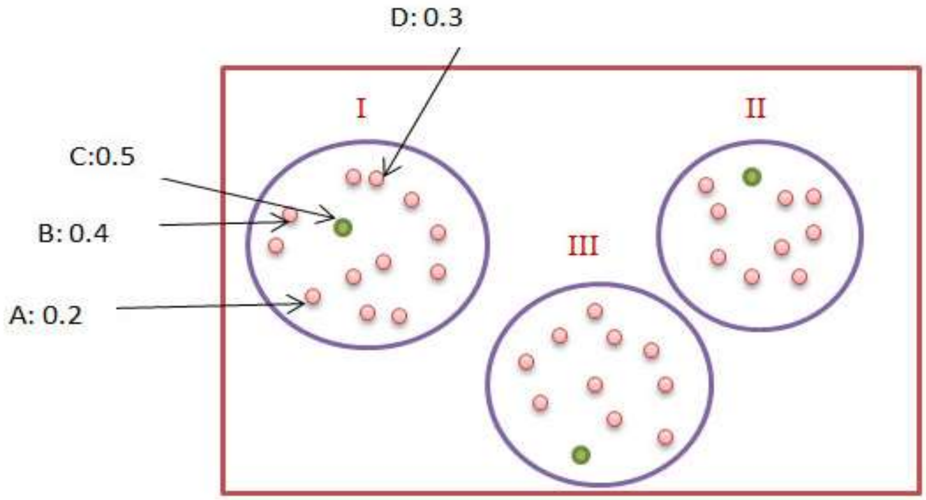

Fig. 2 Remaining Energy in First round

In next round, fig.3, we use only switching technique for cluster head selection. Switching technique selects the cluster head on the bases of remaining energy of the nodes. Which node has the higher remaining energy that node is selected as CH. In fig. 3 node E have the higher remaining energy (0.4).So node E selected as a CH.

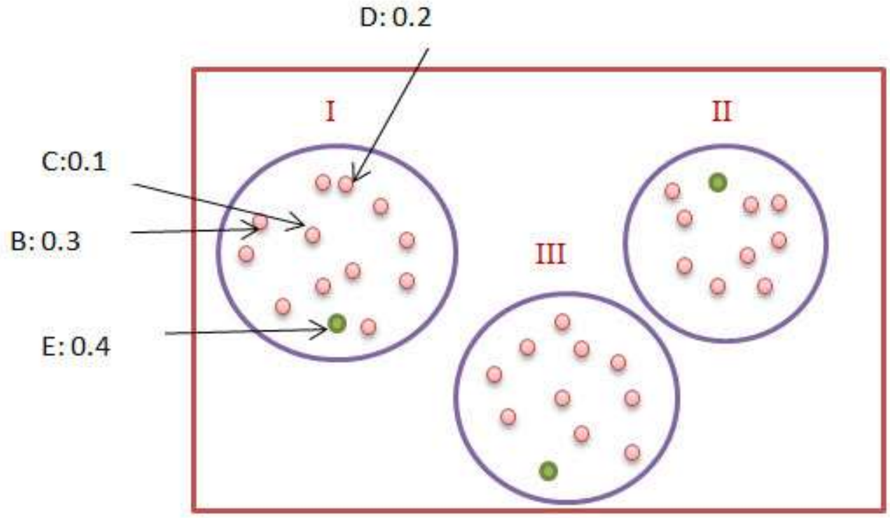

Fig.3 Remaining Energy in Next round

* D: 0.2:- Here D is a label and 0.2 is Remaining Energy.

- **Fitness Function**

The sustainability of an individual highly depends upon the fitness value. There is a fitness function based upon which fitness value of every individual is calculated. In our study, Fitness function comprises of the three parameters-

- Remaining Energy(RE)
- Distance from Cluster Heads to Base Station(BSDist)
- Total Intra-Cluster Communication Distance(ICDist)

After Scaling the fitness function, we have the fitness function as:

$$\text{Fitness} = E + \frac{ICDist}{N} + \frac{BSDist}{N}$$

IV. SIMULATION RESULTS

In this section, we present the simulation results as the performance evaluation of our proposed algorithm. The performance simulation is take place in MATLAB environment. Along with S-DE, the performance of the network is analyzed for GA algorithm. The parameters taken into consideration are noted in the table 1.

Parameters	Value
Field Size	100m X 100m
Location of Base Station	25m X 25m
Size of Population	100
Length of chromosome	N
Differential Weight(F)	0.5
Crossover Probability(CR}	0.2
Initial Energy of sensor node	0.5 J/Node
The Data packet Size	4000 bits
Transmitter Electronics	50nJ/bit
Data Aggregation	50nJ/bit/report
Transmit Amplifier	10 J/bit/m^2

Table-1: Simulation Parameters

Fig 4 shows the First Node Dead graph between GA and S-DE for 50 numbers of nodes in terms of rounds. The First node dead for GA was in 128 and for S-DE was in 206 number of round respectively. So it is Cleary shown here that the proposed algorithm performs better than the GA (Genetic algorithms).

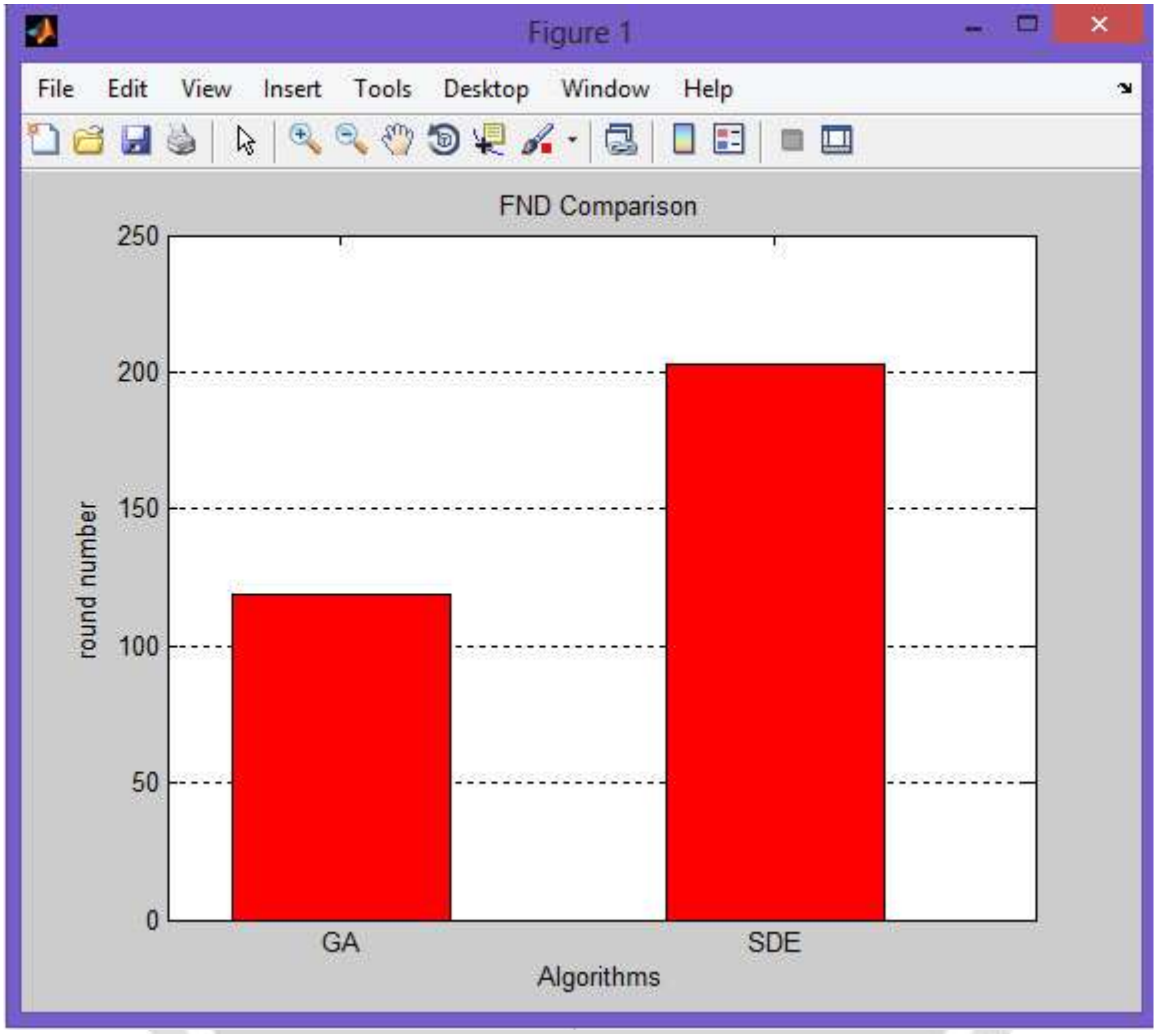

Fig-4: First Node Dead (FND) comparison over number of rounds

Fig 5 shows the comparison of half node dead. It shows the half number of node dead (50%) graph between GA and S-DE for number of nodes in terms of rounds. For 50 numbers of nodes, the half number of nodes in GA and S-DE were dead in 188 and 211 number of rounds respectively. Hence it is Cleary shown that the proposed algorithm performs better than the GA (Genetic algorithms).

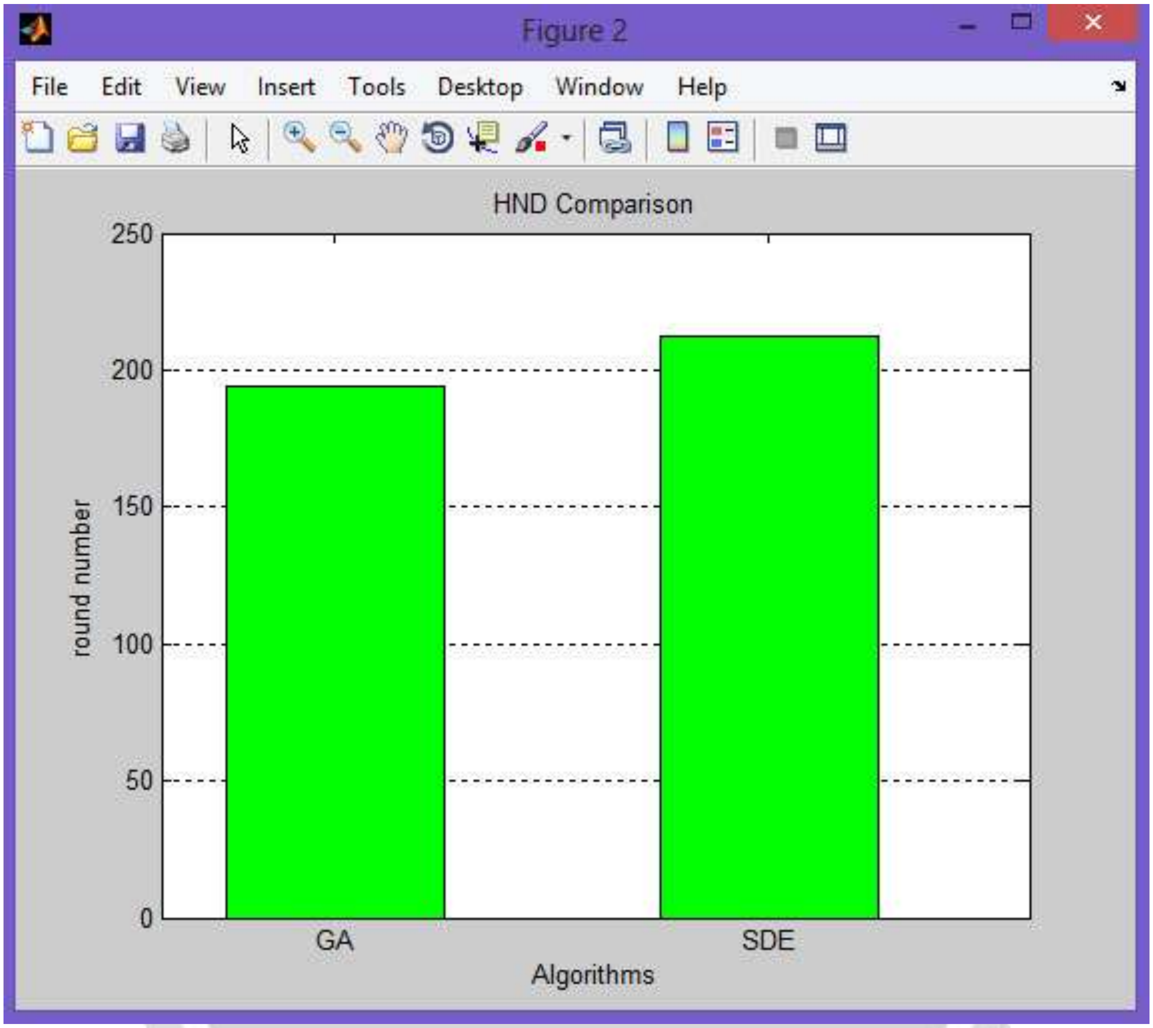

Fig-5: Half node dead (HND) comparison over number of rounds.

Fig 6 shows the comparison of the remaining energy of the network with varying number of rounds. It shows the energy remaining after every round. The batteries used in the WSN are very Minimal in size and cannot be replaced. Hence, the consumption of energy by residual energy must be as minimal as possible. From the graphs we can conclude that in the proposed S-DE algorithm, the remaining energy of the network is more than when compared to GA. The reason behind this is the selection of a suitable fitness function which generates a better candidate. The remaining node energy of all sensors at the end of simulation has been plotted in Fig 6. Energy consumption by the network is calculated by summarizing the network nodes residual energy and getting it plotted against the number of rounds of the network provides the outlook of energy requirement of the network at any stage. Reduction in energy requirement for the network directly communicates the network efficiency.

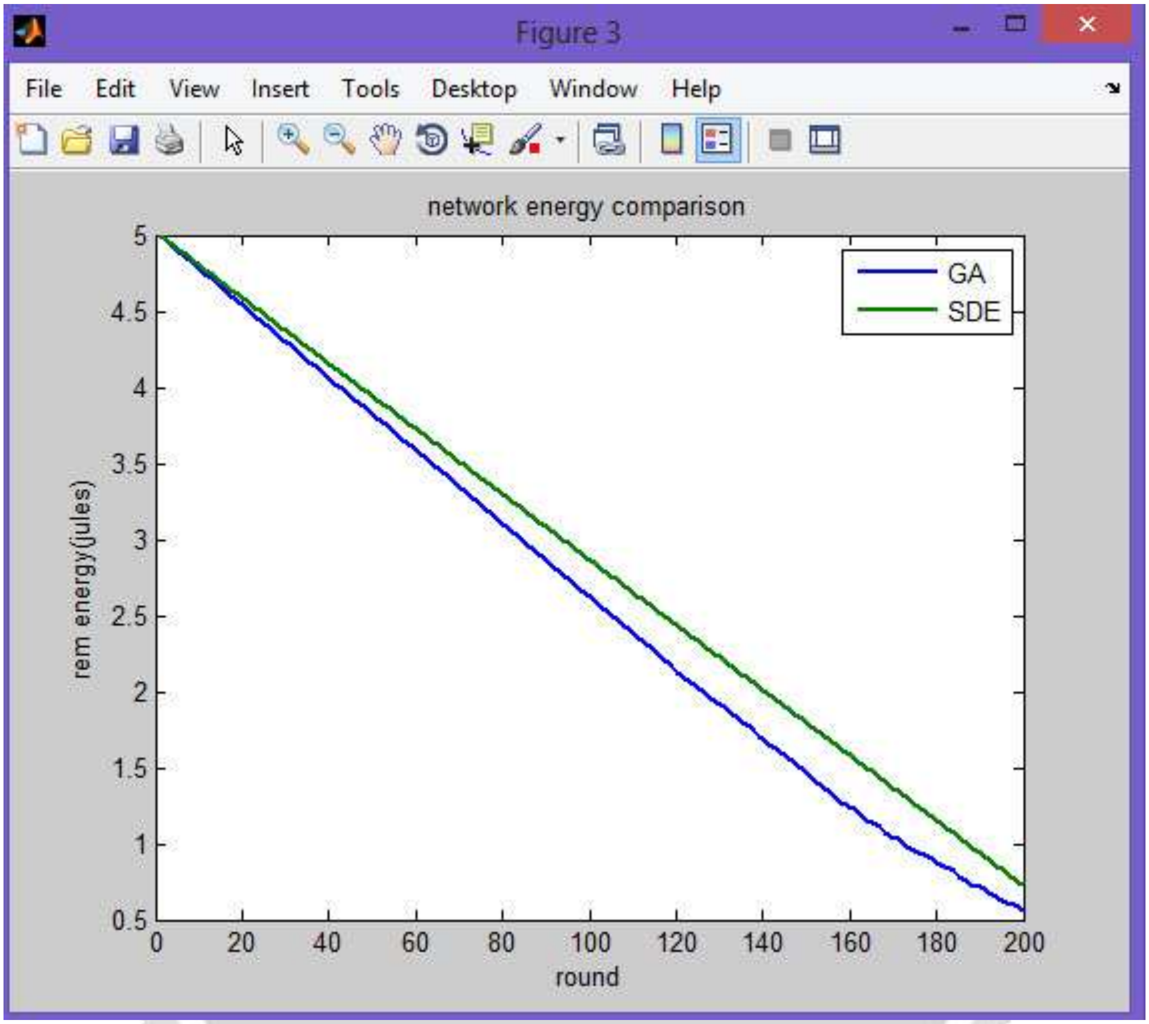

Fig-6: Remaining energy by the network/number of rounds

Fig. 7 shows comparison of node death rate of GA and proposed S-DE. Death rate of node is divided into two segments: stable region and unstable region. All the nodes are alive in the stable region and therefore unstable region have a few number of alive nodes. GA does not have a capability to consider communication of intra-cluster distance and also does not optimize number of cluster heads in each round. Proposed S-DE has a capability to optimize number and optimize the selection of cluster heads, therefore has a better load balance of network compared to previous algorithms.

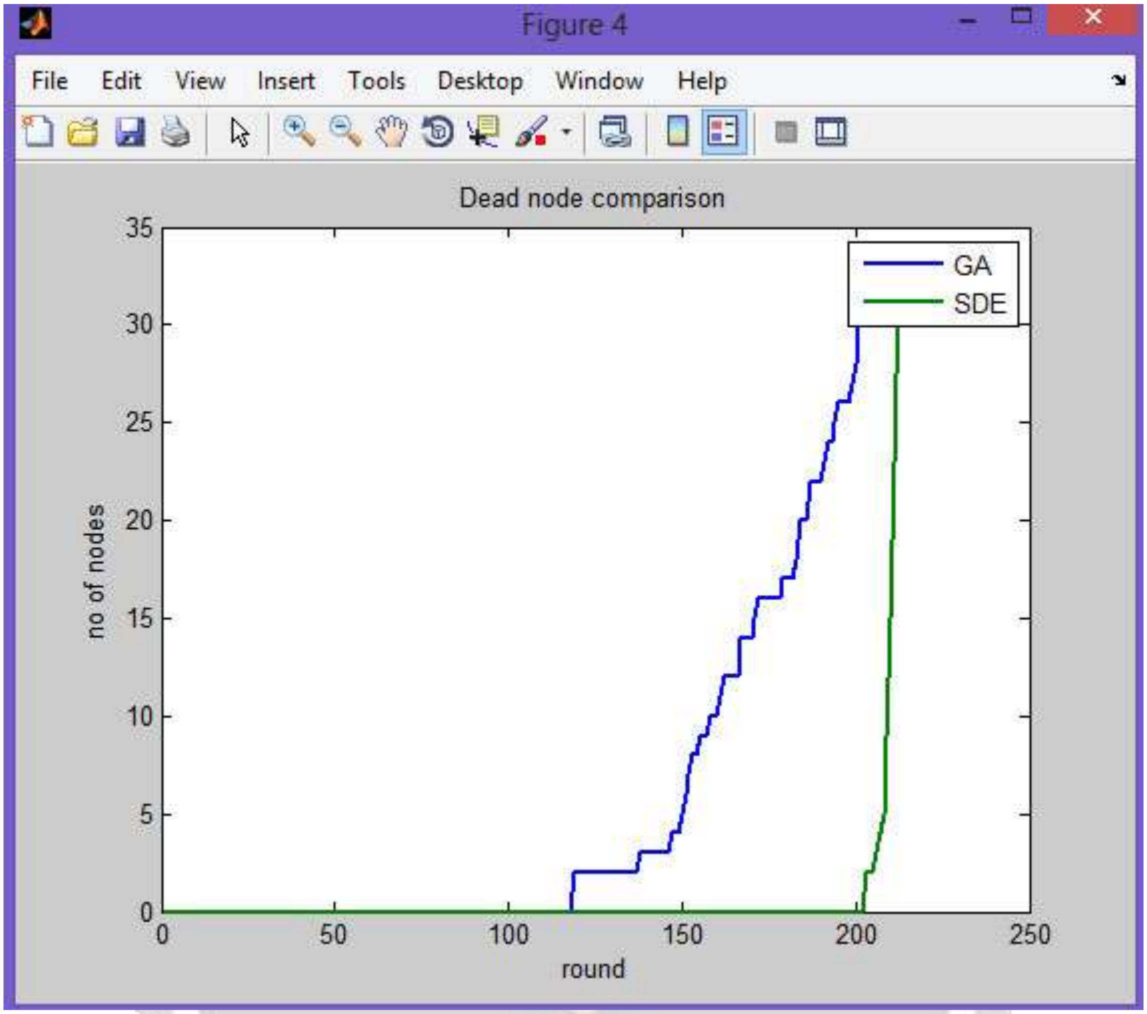

Fig-7: Dead Node Comparison

V. CONCLUSION

In this paper, Switching Differential Evolution Algorithm is proposed. It has been designed to increase the network lifetime by prolonging the death of the cluster heads. It also decreases the complexity in the network. The difference between the existing procedures and proposed algorithm include proposed algorithm keep track of the energy consumption and the selection is done to have the best results for the given scenario. This algorithm is implemented for homogenous wireless sensor networks. Algorithm can be further implemented for heterogeneous networks.

REFERENCES

1. A. Zahmatkesh and M. H. Yaghmaee, "A Genetic Algorithm-Based Approach for Energy-Efficient Clustering of Wireless Sensor Networks" International Journal of Information and Electronics Engineering, Vol. 2, No. 2, March 2012.
2. Harmanjot Kaur, Dr. Rajinder Singh Virk ,"Maximizing Energy Efficiency of Wireless Sensor Networks by Using Genetic Algorithm and Graph Theory" International Journal of Computing and Technology, Volume 2, Issue 6, June 2015.

3. Kanika Goel1and Suveg Moudgil, "An Energy Efficient Routing Algorithm For WSN Using PSO Approach" International Journal for Advance Research In Engineering And Technology, Volume 3, Issue V, May 2015, ISSN 2320-6802.
4. Mohit Saini, Rakesh Kumar Saini ," Solution of Energy-Efficiency of sensor nodes in Wireless sensor Networks" International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 5, May 2013 .
5. Norah Tuah and Mahamod Ismail, "Extending Lifetime of Heterogenous Wireless Sensor Network using Relay Node Selection", ICoICT IEEE, pp. 17-21, 2013.
6. Olariu .S, "Information assurance in wireless sensor networks", Sensor network research group, Old Dominion University.
7. Pratyay K, Gupta SK, Jana PK. A novel evolutionary approach for load balanced clustering problem for wireless sensor networks. Swarm Evol Comput 2013;12:48–56.
8. Pooja Sindhu and Dr. Kanika Sharma, "Energy efficient Clustering using Genetic algorithm in Wireless Sensor Networks" International Journal of Science And Higher Engineering Research. ISSN: 2347-4890.
9. Shweta Sharma, Tarun Kumar ,"Energy Efficient Modified Cluster Routing Algorithm for Maximizing Stability Period of WSN",International Journal of Innovative Research in Computer and Communication Engineering, Vol. 3, Issue 9, September 2015.
10. Sweta Potthuri, T. Shankar , A. Rajesh," Lifetime Improvement in Wireless Sensor Networks using Hybrid Differential Evolution and Simulated Annealing (DESA)", Ain Shams Engineering Journal, 6 March 2016.
11. Youyun Ao, Hongqin Chi," Differential Evolution Using Opposite Point for Global Numerical Optimization" Journal of Intelligent Learning, Systems and Applications, February 2012,