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Hard and Soft Thresholding Based Genetic enthused Reactive Routing Protocol for Heterogeneous Sensor Network

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Abstract- Wireless Sensor Network has a wide area of applications but the main problem in WSN is its lifetime.To solve the issue of short lifetime of the WSN, hard and soft thresholding is infused with genetic algorithm. By using the genetic algorithm the energy consumption of the nodes is greatly reduced and the lifetime of the WSN also increases. By making use of hard thresholding (HT) and soft thresholding (ST) the network becomes a reactive network which saves the energy of the nodes during the data transmission also. Moreover the genetic algorithm has been used for clustering of the nodes and the thresholding has been used for the data transmission in the proposed protocol. The simulations of have shown increase in stability and the lifetime of the genetic algorithm (GA) based reactive protocol as compared to the genetic algorithm (GA) inspired protocol.

Keywords- *WSN, proactive network, reactive network, chromosomes, genetic algorithm, fitnes function, hard thresholding, soft thresholding, sensed value.*

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I. INTRODUCTION

In the current era technology has changed a lot from the wired one to the wireless. Now-a-day wireless sensors are used in almost each and every area that range from houses to the military.

WSN are used in wide range of applications like observing regions, scrutinizing the water quality, monitoring the proportion of air pollution, operational health observation and etc. WSN sustain many services.Small businesses can acquire many services by making the use of a wireless networks and some of them are as follows:

- Availability- One can access the resources of its network from any location within the range of wireless network.
- Flexibility- There is no necessity of the wired contacts and to stay tied to the desk.
- Effectiveness- Wireless connection to the Internet and to organizationsproperties provide provisions to the staff in getting their jobs done and enhance teamwork.
- Relaxed organization- Setup is quick and lucrative as there is no need to string the cables.
- Security- The developments in wireless networks has offered vital safeties.
- Inexpensive- The operational cost of wireless networks is fewer as there is no cabling cost involved.

These sensors have a wide area of applications as mentioned earlier but these are totally dependent upon their battery life which is quiet short lived. To elongate the life of wireless sensors a number of protocols have been designed, the most popular one being LEACH [1].

In a WSN there are large numbers of sensors that run on batteries. So, practically it is not possible to change all the batteries in the WSN. So, for this cause routing protocols are followed that somehow elongates the life of a WSN. The algorithms form several clusters of the whole network and assign each cluster with a cluster head (CH) and the data is transmitted from nodes to CHs and CHs to the base station (BS). This scheme saves the energy of the of the sensor nodes thus increasing network life.

The wireless sensor networks can be divided into two categories based upon their way of working:

i. *Proactive Network*

In proactive network [2] data transmission is done periodically. The nodes occasionallysense the surroundings and transfer the data which is of importance. Proactive networks are used in applications that require periodic data observing. Proactive protocols monitor peer connectivity occasionally to guarantee the accessibility of any path among lively nodes.

ii. *Reactive Network*

In reactive networks [2] the nodes respond instantaneously to abrupt changes in the sensed data. These are used basically for time trivial applications. Reactive protocols create paths only on some requests like to respond to any query and till that time the sensor nodes stay idle. Sensors forward the routing request to the base station through the neighboring nodes and the base station answer back over the inverse communication route. Because of the easiness and essential provision for data on requestthe reactive protocols area good choicein WSNs.

WSN can be heterogeneous or homogeneous on the basis of the initial energy of the sensor nodes. Hereheterogeneoussensor network is being used which consist two kinds of nodes normal ones and advanced one.The advanced nodes have more energy than the normal ones and here the advanced nodes are mainly selected as CHs. The lifetime of heterogeneous networks is longer than the homogeneous networks.

II. RELATED WORK

To deal with the lifetime issue routing protocols are followed. Some are proactive while some are reactive as mentioned above. The related protocols followed for the purpose of incresing lifespan of sensor networks are:

1. LEACH

LEACH is a proactive routing protocol. Among all the protocols developed for wireless sensor network the most basic one is LEACH [1] that consists of two phases namely, setup phase and steady phase.

In LEACH most nodes transmit data to cluster heads, and the cluster heads further send it to the base station. In setup phase, to become a cluster head in any particular round every node follows a random algorithm in whereasnodes that have been cluster heads cannot become cluster heads again for P number of rounds. So, each node has a 1/P probability of getting selected as a cluster head in each round.In the steady phase the cluster head creates a routine for all the nodes in its cluster to transfer data. When all sensed data reaches the base station the round ends and again the first phase starts and so on.

The major drawback of LEACH protocol is that the data may not reach the user on time and thus it is not useful for time critical applications.

2. GA Inspired Protocol

Genetic algorithm based protocol for wireless sensor network is also a proactive routing protocol that makes use of the genetic algorithm. The basic framework of the genetic algorithm [3] is:

i. *Initialization*- Produce irregular population of n chromosomes
ii. *Evaluation*- Estimate the fitness functions of each chromosome in the population that is prepared.
iii. *Selection*- Selection is done according to the fitness function of chromosomes. The foremost aim of selection is to prefer better solutions to worse ones.
iv. *Recombination*- Recombination merges fragments of two or more parent solutions to generate new and improved solutions.
v. *Mutation*- Despite the recombination runs on two or more parental chromosomes, mutation irregularly changes a solution.
vi. *Replacement*- The new population generated by the above steps is replaced with the original parental population.
vii. Steps 2–6 are repeated till an ending situation is encountered

In this protocol [4]the nodes are signified as bits of chromosomes as shown in figure 1. From these chromosomes, the fittest chromosomes are chosen to produce the next population. In GA-WSN, the cluster head nodes are indicated by 1's and the normal nodes are indicated by 0's.

S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0	0	0	1	0	0	0	0	1	0

Figure 1- Network Chromosome [5]

In this protocol, the cluster distance is the fitness function. The fitness of the nodes is checked on the basis of the sum of the distances between the nodes &cluster head and the distance between the cluster head andbase station which is known as the cluster distance [6].After the cluster heads are selected and cluster are formed than data transmission takes place. At the termination of every round the energy of all the nodes is updated.

3. HEER

HEER (Hybrid Energy Efficient Reactive) [7]is a reactive routing protocol which is for both homogeneous and heterogeneous WSNs. For the purpose of selecting cluster heads (CH) in HEER the initial and residual energies of the nodes are required.When cluster formation is done, the CH transfers two threshold values, i.e.hard threshold (HT) and soft threshold (ST).

In HEER, the nodes continuously sense the data from its surroundings and if a parameter among the set of attributes matches the HT value, the node will switchon its transmitter and transfersthe data. This decreases the number of transmissions. The Current Value (CV), on which first transmission occurs, is stored in an internal variable, Sensed Value (SV).

After the first transmission the nodes will again transfer the data in same cluster period only when CV differs from SV byan amount equal to or greater than ST, then it further decreasesthe number of transmissions.

HT[8] is a value for the detected attribute. It is the complete value of the attributesafter which the node will switch on its transmitter and send data to its CH.

ST [8] is the minute change in the detected attribute that activates the node to transmit data.

The hard threshold reduces the number of transmissions by allowing the nodes to transmit data only when the detected value is in the group of interest. The soft threshold also reduces the number of transmissions by eliminating the transmissions that may occur after a slight change in the detected values.HEER performs best for time critical applications in bothhomogeneous and heterogeneous environment.

It lessens the number of transmissions subsequentlyreducing the energy consumption and drastically increasing the constancy period and network lifespan.

III. PROPOSED GA BASED REACTIVE ROUTING ALGORITHM

In this proposed protocol we have combined both the genetic algorithm for clustering the nodes and the hard and soft thresholding values for the data transmission in the wireless sensor network. Both the protocols work in different phases. So following arethe various steps to attain the objective

Step I. Optimization

During the initialization of a heterogeneous sensor network, all the nodes whether advanced or normal are randomly placed. But in this proposed algorithm, optimization is doneby placing sink at the center and the advanced nodes are located at the far edges and the normal nodes are closer to the sink.

Here we have taken the WSN in the form of a square and divided it into 3 parts. First one is the inner part where sink is at center and normal nodes are placed randomly around the sink. The two outer parts consist of only advanced nodes as the energy dissipation of the farther nodes is greater than the others according to the following equations [10].

$$E_{TX}(k,d) = \begin{cases} kE_{elec} + kE_{fs}d^2 & d < d_o \\ kE_{elec} + kE_{mp}d^4 & d > d_o \end{cases}$$

WhereE_{elec} is the factor of electronics energy consumption, E_{fs} and E_{mp} are amplification coefficients of power amplifier andd_o distance between transmitter and receiver which is given as:

$$d_o = \sqrt{E_{fs}/E_{mp}}$$

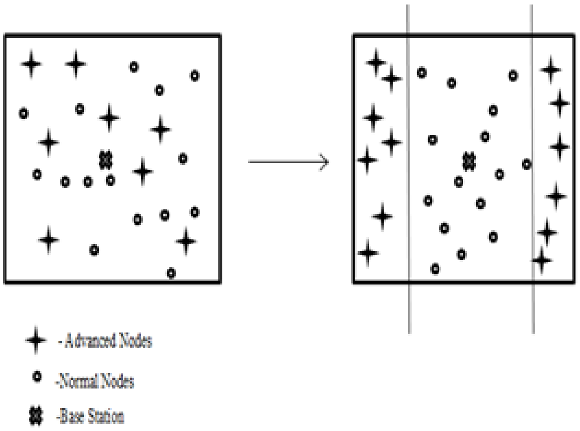

Figure 2- Network Optimization

Step II. Setup Phase: Genetic algorithm

In the setup phase of this protocol genetic algorithm has been followed for selecting the fittest nodes for long term execution of the network. Firstly the network will be initialized and based upon the fitness function the best nodes will become cluster heads and form uneven clusters in the network. The fitness function is calculated on the basis of energy as well as the distance from the sink. The fitness function is calculated as follows:

If Energy > 0;
For the rounds 1 to n;

$$Neighbour\_Dist = \sqrt{(x_2 - x_1)^2 + (y_2 - y)^2};$$

If Neighbour_Dist<=range;
Then Node is "Active";
Else Node is "Sleeping";

The active nodes are the CHs while the sleeping ones are the member nodes of those CHs. After selection of CHs, the base stations assign member nodes to all CHs and transmit the specifications of whole network to all the sensornodes.After this the clusters are organized thus completing the setup phase and beginning the transmission phase.

Step III. Steady Phase: Hard and Soft Thresholding

After the cluster formation two values are transferred to all the nodes that are hard threshold (HT) and soft threshold (ST). These two values govern the data transmission for every round.The first data transmission will occur only when the current detected value (CV) will be greater than or rather match the HT.

$$CV \geq HT$$

After first transmission the value of *CV* is stored in a variable sensed value(SV) while the nodes keep on sensing the surroundings. After this the next transmission will occur only if the difference of CV and SV exceed the soft threshold otherwise nodes will not transmit data and their energy will be saved.

$$CV - SV \geq ST$$

So this will reduce the transmission of inadequate data and lifespan will eventually increase.After the whole round is complete the energy of nodes is updated and the setup phase will again execute followed by steady phase and it goes on.

Step IV. Routing Update

As soon as both the steps are performed and the data reaches the base station one round is completed. So after completion of a round the energy of all the nodes is updated for the next round in which once again the CH selection is to be done. After updating of whole network step II and III are repeated until the entire nodes die and the system is terminated.

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IV. SIMULATION AND RESULTS

To evaluate the execution of genetic algorithm based reactive routing protocol MATLAB simulator has been used. The performance of the reactive protocol is checked on the basis of following parameters [9]:

- First node dead (R_{FD})
- Last node dead(R_{LD})
- Packets send to CH (P_{CH})
- Packets send to BS (P_{BS})

The first node dead represents the round in which the first node dies in other words it shows the stability of the network. The last node dead represents the number of round in which all the nodes of the network are dead that is the total lifetime of the network. The packets sent to CH and packets sent to BS parameters gives the number of packets of the sensed data sensed by the sensor nodes and sent to cluster heads and the base station respectively.

The parameters for the simulation are listed in table 1.

Parameter	Value
Network size	100x100
No. of nodes	100
Sink location	(50,50)
E_o	0.1J
E_{elec}	50nJ
E_{fs}	10pJ/bit/m2
E_{mp}	0.0013pJ/bit/m4

Table 1- Simulation Parameters [10]

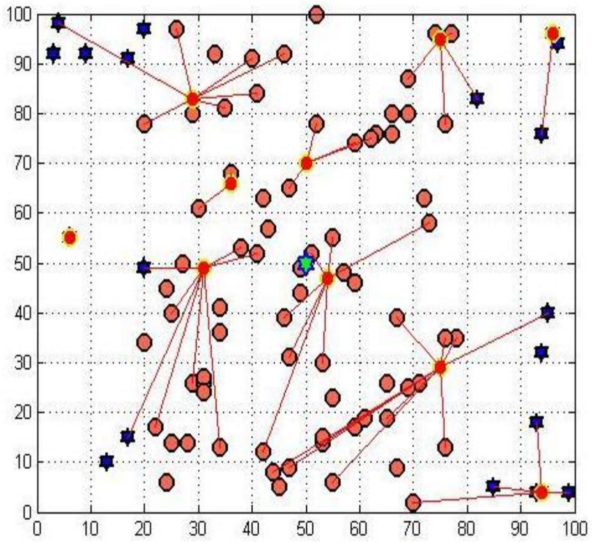

Figure 3- Wireless sensor network of 100 nodes

Figure 3 shows a WSN comprising of 100 nodes where some are advanced while some are normal.

The readings after simulation are observed in table 2.

R_{FD}	42
R_{LD}	253
P_{CH}	5687
P_{BS}	775

Table 2- Result when E_o= 0.01J

Some of the graphs which are observed after simulation include the energy graph, dead nodes graph, number of packets sent to CHs and BS graphs.

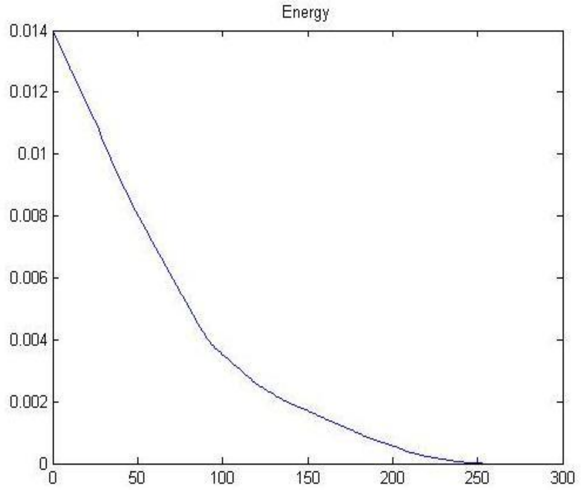

Figure 4- Energy graph

Figure 4 shows the energy graph, this graph represents the depletion of energy throughout the lifetime of the WSN. The x-axis represents number of rounds and the y-axis represents the energy.

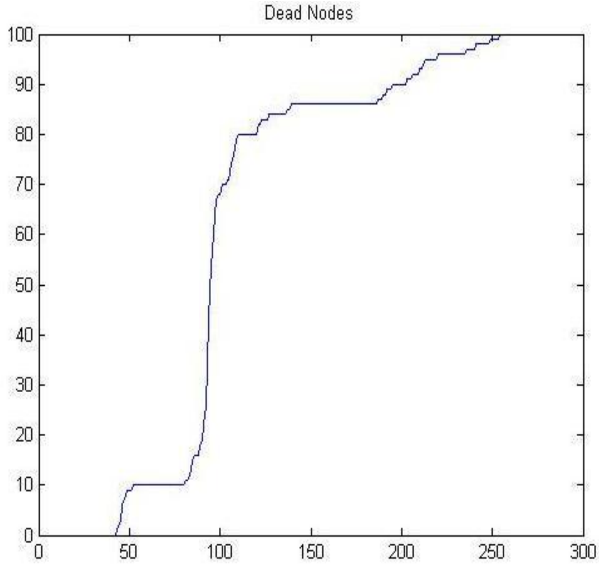

Figure 5- Number of dead nodes

Figure 5 shows dead nodes graph which include the nodes that died at different rounds. The x-axis represents the number of round and the y-axis represents the number of the nodes. From this graph we get to know the rounds in which the first node dies and the last nodes dies that is R_{FD} and R_{LD} respectively.

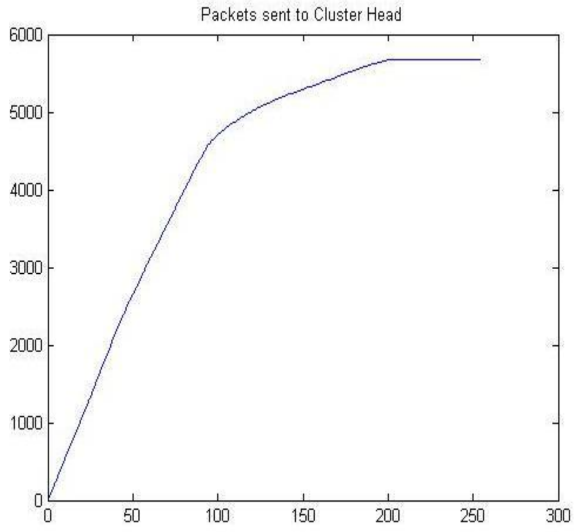

Figure 6- No. of packets sent to CHs

Figure 6 shows packets sent to cluster heads graph. This represents the number of packets sent by the member nodes to their respective cluster heads. The x-axis represents number of rounds and y-axis represents the number of packets.

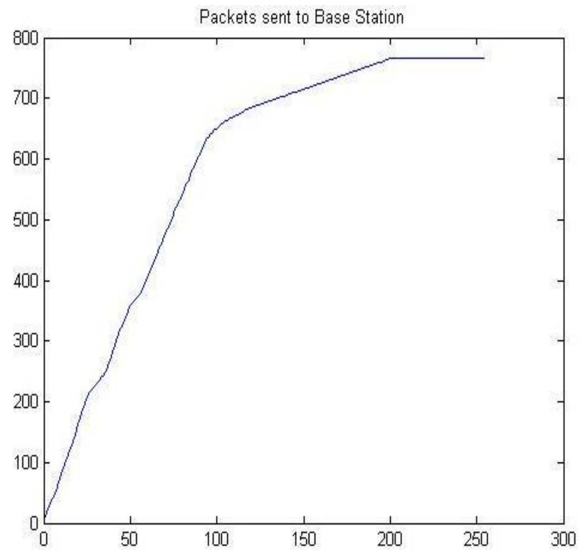

Figure 7- No. of packets sent to BS

Figure 7 shows packets sent to base station graph. This represents the number of packets sent by the cluster heads to the base station. The x-axis represents number of rounds and y-axis represents the number of packets.

V. COMPARISON

Comparison is drawn between the basic GA inspired protocol and the proposed GA based reactive routing algorithm (at E_o= 0.1J) on the basis of the above mentioned parameters i.e. R_{FD}, R_{LD}, P_{CH} and P_{BS}.

The graphs of the comparison are as follows:

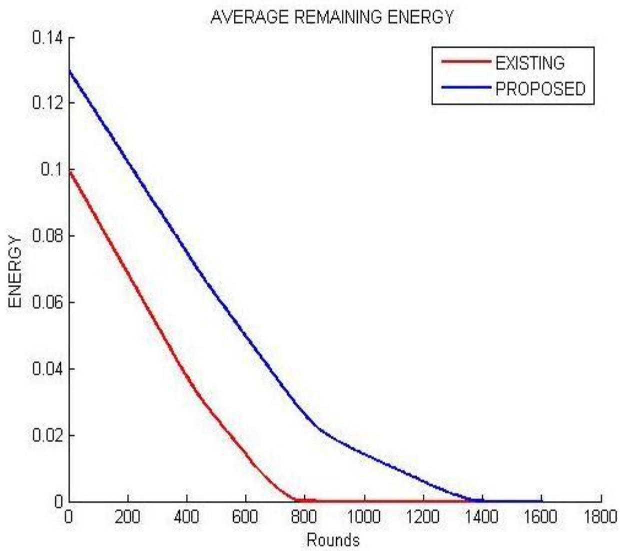

Figure 8- Comparison of Average remaining energy

Figure 8 shows the comparison of the average remaining energy between the existing and proposed algorithm. It is clear from the figure that the remaining energy is more in the case of proposed algorithm so the lifespan of the proposed algorithm is greater than the existing one.

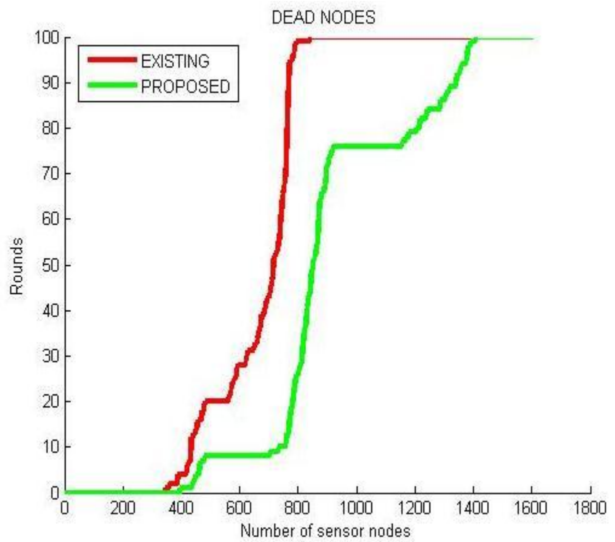

Figure 9- Comparison of No. of dead nodes

Figure 9 shows the comparison of the number of dead nodes. This figure represents the total number of rounds of the execution of both techniques and it is clearly visible that the proposed algorithm executes for longer than the existing protocol.

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2942 – 2948

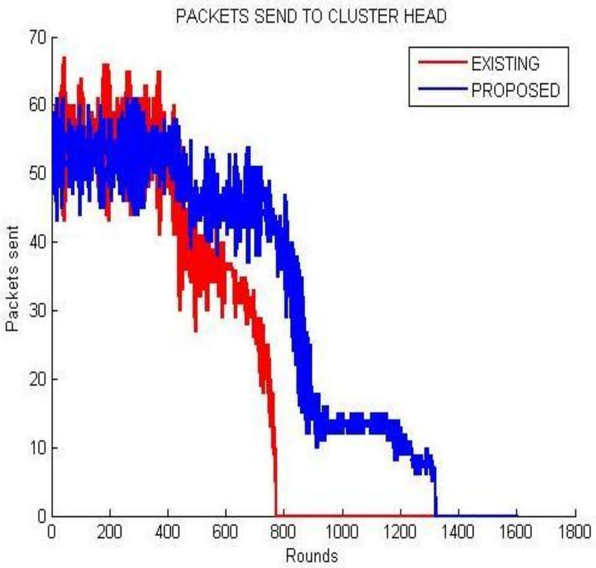

Figure 10- Comparison of no. of packets sent to CHs

Figure 10 is the comparison graph for the packets being send the cluster heads by their respective cluster member nodes.

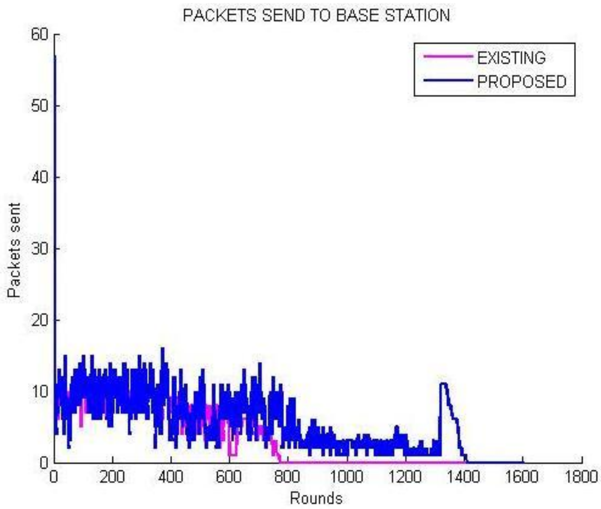

Figure 11- Comparison of no. of packets sent to BS

Figure 11 is the comparison graph for the packets being sent by the cluster heads to the base station or sink.

The results drawn after comparing the two protocols are as follows:

Parameters	Existing	Proposed
R_{FD}	358	395
R_{LD}	825	1408
P_{CH}	35777	47387
P_{BS}	3096	3818

Table 3- Results of comparison at E_o= 0.1J

There is a 10% increase in stability (R_{FD})and 70% increase in the lifetime (R_{LD}) of the genetic algorithm (GA) based reactive protocol as compared to the genetic algorithm (GA) inspired protocol. The performance has also increased as the packets sent to CHs and BS has also increased by 32% and 18% respectively.

VI. CONCLUSION AND FUTURE WORK

In this paper, we have combined both the genetic algorithm inspired protocol and the hard and soft thresholding to get a Genetic inspired reactive routing protocol. This protocol has shown improvement over the proactive protocols likethe genetic algorithm based protocol. The simulation results a have shown great improvement as the lifespan has been improved by 70%after following the reactive protocol.

In future, by using energy harvesting nodes [11]lifetime can be further elongated and additionally, the WSN executionwould never haltexcluding hardware faults and there will be an increasein its working capacity.

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