Optimization of Node placement and Clustering in Wireless sensor networks using Genetic Algorithm

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Abstract—Wireless sensor networks are having many applications in various industries therefore it is essential to improveits currently present parameters and protocols. The WSN steps includes deployment of nodes, clustering, network coverageand aggregationsof data. In this paper the concentration is on the nodes placement and clustering of WSN.The simulation and examination of GA based nodes placement and HEALisconductedfor evaluation of no. of movements and dist. travelled using NS2 and The simulations and analysis of the Genetic algorithm based clustering and LEACH based clustering is conducted for evaluation of energy spending and no. of alive nodes using NS2.

Keywords—Wireless sensor network (WSN), Genetic Algorithm (GA), Clustering, Cluster head, Low energy adaptive clustering hierarchy (LEACH), node placement

I. INTRODUCTION

The nodes placement plays anvitalrole in the optimization of sensor networks.The deployment of nodes on anobject field enhances the networkperformance.Figure 1 shows the nodes placement, for placement of nodes in network,there are threemain
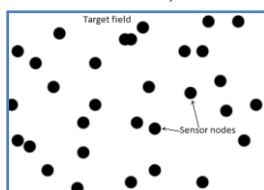

Fig.1: Nodes placement

categories as the grid placement, random placement and thestochastic node placement. The nodes additional energy for longer distance transmission, which is not energy effective.

Anothermain operational step of sensor networkis Clustering of the network. Clustering is method of arrangement of the nodes from the sensor network to form the groups which is termed as division cluster. CH role is to collect information from the nodes lo-cated in that cluster and send the information to the sink directly or via. The other clusters heads. The data broadcast to the sink from CH through other cluster head in such cases the optimized clustering drops load amongst sensor nodes effectively which outcomes in more lifetime and energy saving of the sensors in WSNs. Figure 2 demonstrates nodes clusteringin network. The enhanced security, less extra data are additional advantages of clustering.
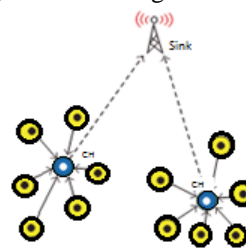

Fig.2:Clustering in sensor networks

II. RELATED WORK

In the various literature, the necessity of the optimization of the sensor networks is emphasized and GA is used.In [3], authorSertbasstudied the routing method with least energy consumption in WSN.The routing protocols with high energy saving (Gossiping, PEGASIS, LEACH, Director Diffusion and EESR) areexamined.In [6], author S. Hussain has offered the hierarchical clusters to decrease the energy expenditure requirements for networks. For informationcirculation in WSNs,GA is used to create energy effective clusters. The outputshowsthat the network lifetime can increase by using hierarchicalintelligent technique of clustering for several deployment of network. In [7], authorsusedthe dynamic technique of GAand studied the enrichment of lifespan and energy spending of network to decide the ideal clustering state. They have usedofferedequationwith the simple framework for improvementof lifespanalongside network coverage. Lastly, the projected algorithm is more efficient. In [8], author C.Sergiou analyzedand compared the performanceof four ways of nodesplacement on a network.Nodedeployment's simulation resultsindicates

the enhancedalgorithm performance. In [9], authors studied a GA centered technique and apply for a self-organize network. Fitness function is created considering the connectivity, compactness andenergy spending of network.

III. NODE PLACEMENT IN WSN

To make sure the network operates with the highest possible performance, the nodes deploy in the networkwith balanced energy expenditure of all nodes and withpreferred node placement protocol.

The Proposed Fitness Function:

fitness function formed on the extension of area under coverage is presentedbelow to obtain the optimum solution to cover wider area and maintain high efficiency of energy spending.The R is the radius centered ateach sensor[10]. The area of union is normalized by totalarea.

Fitness-function= $(min- f_{i,j})/(coverage_{i,j})$ (1)
The indicated fitness is taking into consideration coverage and energy is denoted.

HEAL:

Competentlycalculate and advance the area covered in WSNs. HEAL is consists of two steps. In the first step thehole identification and border detection is done. Thehole detection algorithm is less complex and used for different sizes of holes. The second stephole healing. It comprises twotasks; find hole healarea and nodes relocation. The only nodes which are near to hole are participating in healing action

GA based node placement:

Hole healing is takes place as the stages like Hole identify and detect border. In hole identification and healing:Every node of the network splits the area into four quadrants by keeping itself as center and checks for neighbors in each region. Node with single neighbor is considered as stuck node. The quad rule identify the stuck node which finds the hole by Hole detection algorithm for healing the found hole [2]

Find HC = $\{(X_{smin}+ X_{smax}) / 2, (Y_{smin}+ Y_{smax}) / 2\}$ (2)
Where, HC - Hole Center, Xsmin, Xsmax, Ysmin, Ysmax - Minimum and Maximum X and Y coordinates among stuck nodes

HA =3.14 * rSi * rSi

SA =3.14 * RSi * RSi

Required no. of nodes to cover the HHA = HA/SA

rSi - Hole radius (Longest dist. bet. two stuck nodes), RSi - Sensing radius of sensor Si, HA - Hole Area, SA - Sensor Area

Coverage is obtained in terms of dist. bet. nodes and the nodes that have less dist. indicates high overlapping area when compared to other nodes and it outcomes in less fitness nodes. By only moving less fitness nodes appropriate coverage and reduced energy expenditure can be achieved [1].
Fitness= Avg.Dist / [(Rc*Rc)-(Avg.dist*Avg.dist)](3)
Avg.distis theLength from moving node to centre of hole.Rc is theNode range communication

Simulation and evaluation results:
Software Requirements:
OS   : Ubuntu 15.04 LTS 64bit
Simulator   : NS 2.35
Language   : C++, TCL and AWK script

Simulation Model:

Simulator	Network Simulator 2
No. of nodes	200,250,300,350
Area	200m x 200m
Communication Range	24m
Sensing Range	12m
Interface Type	Phy/WirelessPhy
Mac Type	IEEE 802.11
Queue Type	Droptail/Priority Queue
Queue Length	50 Packets
Antenna Type	Omni Antenna
Propagation Type	TwoRayGround
Transport Agent	UDP
Application Agent	CBR
Simulation Time	50seconds

Hole identification and healing:

Initially sensor nodes are randomly deployed. To advance the coverage initial random node placement is adjusted through hole detection process. In the HEAL, the only nodes which are near to hole are participating in action of healing hole. However, in the GA approach the nodes having the low fitness will be moved to heal the hole.
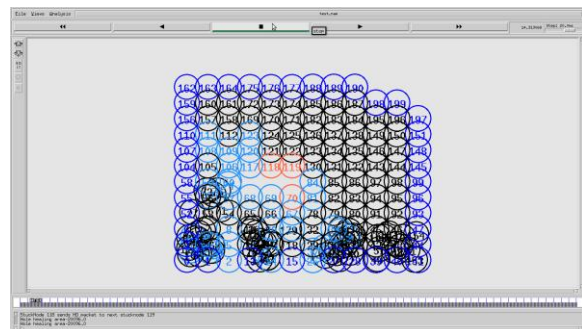

Fig.3:NAM- Hole identification and healing

A node which is not able to communicate at least any one direction in network then it is known as stuck nodes.Nodes located in the border of network are eliminated from stuck nodes. Those nodes are colored in blue.

Stuck nodes exchanges HD packet and lowest ID node is identified as Hole Manager. Hole Manager: 60 Nodes in dodger blue color belongs to HHA.

Hole Center: (80.0, 75.0)

Sensor Area: 452.15 m^2

HHA = 20096.0 m^2

Required no. of nodes to cover the HHA = 44

Available Nodes in HHA: 125

A population (chromosome) is produced using nodes located inside the area of hole healing. Every chromosome is created with no. of genes. Every gene denotes the node inside area of hole healing. Every gene is randomly initialized as 0 and 1. If the gene is initialized as 0 then it signifies it has to move to heal the hole.

The less fitness chromosome qualified for movement towards hole center. Fitness computation is performed in iterative manner till max iteration is reached. In each iteration best fitness value and its corresponding chromosome is found. New generation of chromosome is made in preceding iterations using the cross over and mutation process. These processes are performed by best chromosome found in previous iteration. Fitness is computed for newly generated chromosome and so on. Nodes found in the finally identified chromosome is moved towards hole center. Last three low fitness nodes are moved to the exact hole center. Last three low fitness nodes (38, 4, 115) are the nodes those leads to high overlapping. By moving those nodes, node placement is optimized in terms of reduced overlap and improved coverage.

Fitness for population after 6thgeneration:

Total Fitness for population 0=3.4683147548011761

Best Fitness=3.354653584670825 and population=1

Total Fitness for population 1=3.354653584670825

Best Fitness=3.354653584670825 and population=1

Total Fitness for population 2=3.692619586277659

Best Fitness=3.354653584670825 and population=1

Total Fitness for population 3=4.0704410618019118

Best Fitness=3.354653584670825 and population=1

Total Fitness for population 4=3.7129519584650001

Best Fitness=3.354653584670825 and population=1

Generation:6 Overall best Fitness=3.354653584670825 and population=1

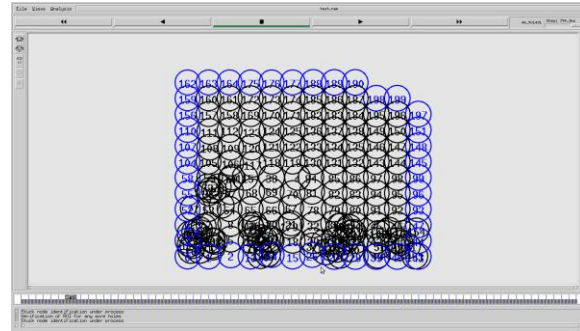low fitness nodes = 38, 4, 115

Fig.4:NAM- After hole healing no stuck nodes identified

After the healing process of existing hole, rediscovery of the stuck nodes is done. No node is stuck in the network at this time.

Performance metrics:

Total Distance Traveled: The total dist. traveled by the sensor nodes to optimize the node placement

No. of movements: It is the no. of movements carried out by a node to optimize the node placement

Performance Evaluation and results:

Comparison is made amongst the GA approach proposed here and existing HEAL protocol. Total Dist. traveled and No. of movements are assessed against no. of nodes. After the healing process of existing hole, rediscovery of stuck nodes is done. No node is stuck in the network at this time. Based onoutput using the graph tool in NS2 the result graphsare plotted.
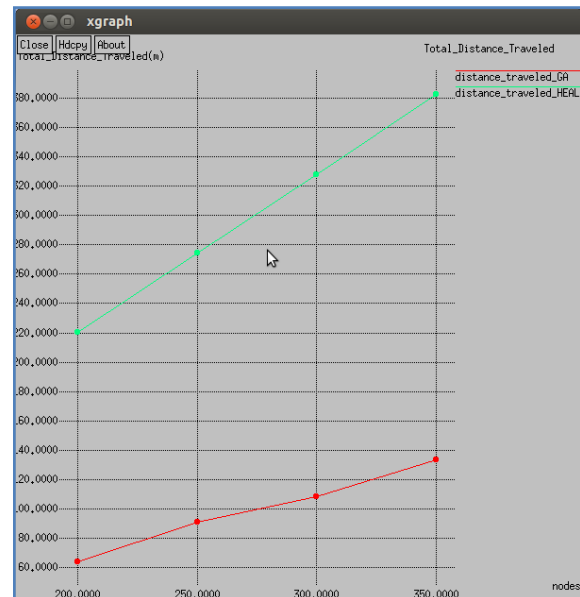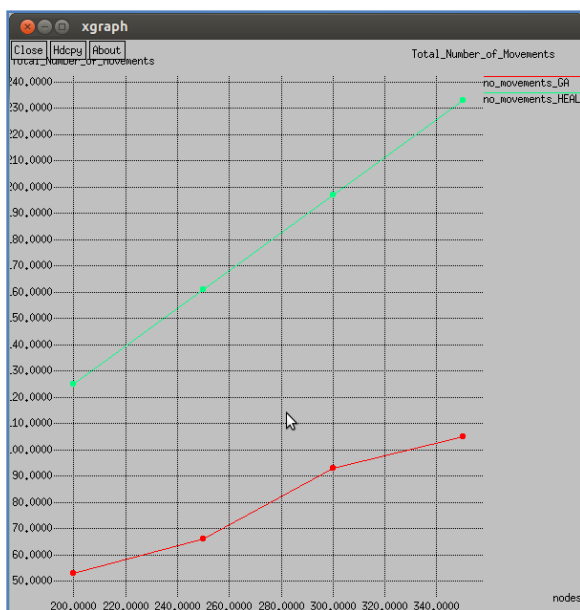

Fig.5:Total Distance Traveledvs No. of Nodes

Fig.6:No. of movementsvs Number of Nodes

IV. CLUSTERING IN WSN

To enhance the network's lifetime with leastenergy expenditure can be achieved by optimized clustering.The clustering focused applications are mainly for monitoringwith requirement of continuous data transmissionfrom sensors, therefore the cost reduction is essential for timely data message sending by routing protocols.

The Proposed Fitness Function:

Theformula [1] for getting the bestenergy spendingby using the morecoverage of the sensor is given below. In that, $(ei*T)\times(ej*T)$ denotes for the whole energy spending and $((Da \times \text{nodes})\times (Db \times \text{CHs}))$ denotes for entirelength bet. sensornodes and every cluster are multiplied by total lengthamongstCHs[1].

$$F(i) = (ei*T/Da*Nodes)*(ej*T/Db*CHs) \quad (4)$$

The intelligent suitability function F(i) is competent forranking chromosome. The ideal chromosome choice is doneconsidering passing generation to acquire the idealsolution[1].

LEACH based clustering:

The hierarchical approach is used in the LEACH protocol for clustering the network. TheCHdeals in each cluster. The collecting data sent by nodes, aggregation of data after collecting, and transmission of aggregated data to the BS are the duties of the CH.Generate TDMAschedule to allot a time slot to every cluster which is used for transmission of information is the keyactivity. The cluster participant node-

sacquire the schedule when the cluster headcirculates it.

GA based clustering:

Forthe lifespan enhancement of the networksand to lessen energy spending, the parameters of the GA were fixedas per the software services. If wereduce the length bet. participant nodes and relevant CH for this case every cluster might have one or more CHs, which is costlyconsidering the energy spending. If we chose more clusters we can avoid longer distances. Considering this, to accomplish average energy expenditure by every node, a ratio of entire energy consumed to the total distances of nodes was indicated. The intelligent suitability function F(i) is competent of ranking chromosome which is found by total energy consumption, distance among nodes and CHs.

$$\text{Fitness}=(1/DCHN)*(1/DCHBS) \quad (5)$$

Where, DCHNdenotes the dist. between sensors and CH and
DCHBSdenotes the dist. bet. CH and BS.

Simulation and evaluation results:

Software Requirements:

OS	: Ubuntu 15.04 LTS 64bit
Simulator	: NS 2.35
Language	: C++, TCL and AWK script

Simulation Model:

Simulator	Network Simulator 2
Number of nodes	50
Area	600m x 600m
Communication Range	200m
Interface Type	Phy/WirelessPhy
Mac Type	IEEE 802.11
Queue Type	Droptail/Priority Queue
Queue Length	50 Packets
Antenna Type	Omni Antenna
Propagation Type	TwoRayGround
Routing Protocol	LEACH, GA_Clustering
Transport Agent	UDP
Application Agent	LeachApp
Initial Energy	2 Joules
Simulation Time	300seconds

Cluster head selection:

In the LEACH the cluster heads are chosen based on all the sensors that generates the random no. less than the threshold. However, in the generic algorithm process for selecting the CH the process of crossover and mutation are applied. If no. of CHs are more or less then it result in extra energy spending.

Genetic algorithm is applied on the chromosomes. The best fitness chromosome is utilized in the clustering process. Each chromosome comprises of genes. Chromosome replicates the nodes in the network. Each gene in the chromosome replicates the state of the node. The optimized no. of CH can produce increased fitness.

Fitness for candidates in each generation:
Fitness=0.140888 generation=0 num_cluster=10 dchn=13539.540048 dchbs=5242.320978
Fitness=0.197813 generation=0 num_cluster=7 dchn=14474.075481 dchbs=3492.639065
Fitness=0.192114 generation=1 num_cluster=7 dchn=15506.475750 dchbs=3356.825089
Fitness=0.278206 generation=1 num_cluster=6 dchn=12044.474444 dchbs=2984.318051
Fitness=0.197492 generation=2 num_cluster=7 dchn=14529.934438 dchbs=3484.865549
Fitness=0.547502 generation=2 num_cluster=4 dchn=9205.368031 dchbs=1984.143102
Best fitness = 0.547502

Best fitness after 2nd generation:
candidates=6 population[1].gene[6]=1.000000
candidates=14 population[1].gene[14]=1.000000
candidates=16 population[1].gene[16]=1.000000
candidates=32 population[1].gene[32]=1.000000

The state of all the other nodes are 0. The node state is CH and non-CH corresponding to the value 1 and 0 respectively.Therefore the nodes 6, 14, 16, 32having state 1 are selected as CH as per Genetic algorithm.
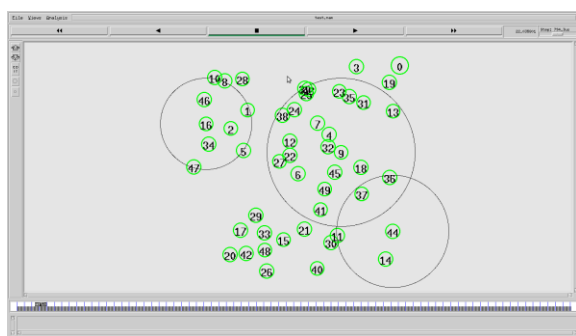

Fig.7:NAM- Data transmission in the network

Advertising by cluster head 32
Join Request:
27sending JOIN_REQ to 32, distance = 146.000000 ,
at time 13.263694 mac=32
22 sending JOIN_REQ to 32, distance = 112.000000 ,
at time 13.323019 mac=32

12 sending JOIN_REQ to 32, distance = 111.000000 ,
at time 13.448594 mac=32
Sending TDMA schedule:
32 sending TDMA schedule (ADV_SCH): 27 22 12 9 38 7 10 45 4 8 at time 14.341446
22 received ADV_SCH from 32 at 14.341685
Data Transmission to CH from sensors as per the received schedule:
Node 22 sending 1 data to CH 32 at 21.943685 | d = 112.000000
Node 27 sending 2 data to CH 32 at 31.981685 | d = 146.000000
Data Transmission from CH to BS:
Node 32 sending 1 data to BS at time 22.325801

Performance Metrics
Energy consumption: The total energy expenditure by sensor nodes.
No. of alive nodes: The total nodes remain alive in network.

Performance Evaluation and results:
Comparison is made in the proposed GA based approach and LEACH cluster-based protocol. Both are simulated based on simulation model and examined. Clustering and data transfer is repeated for each round and no. of alive nodes and energy consumed is measured in each round. Using the graph tool in NS2 the result graphsare plotted.
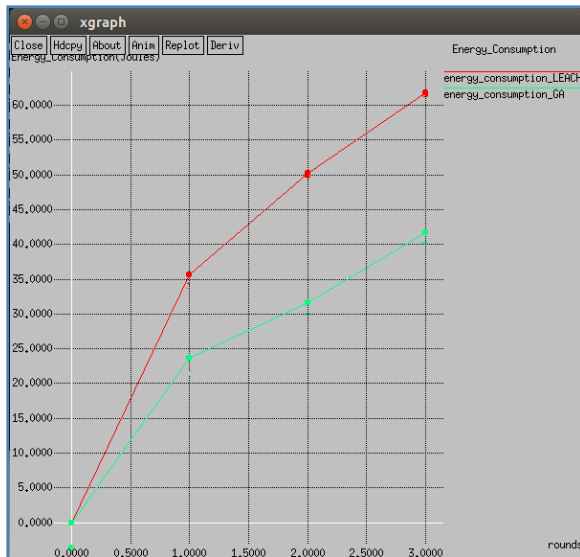

Fig.8:No. of alive nodesvs No. of rounds

Fig.9:Energy consumption vs No.of rounds

V. CONCLUSION

In Node placementdistance travelled and total no. of movements for optimized node placement are reduced in proposed GA approach when compared to HEAL, nodes deploymentis carried out in optimized manner based on fitness of the node that depends on the node dist. to hole centre and node coverage area whereas in the existing HEAL, the neighbour nodes are participate in hole healing and move towards hole centre. The reduced no. of movements and distance travelled result in less energy expenditure in network this in turn improves network lifetime.In Clustering, the proposed GA based clustering achieves reduced energy expenditure and increased no. of alive nodes when compared to LEACH, through the optimized no.

of CH selection. The optimized no. of CH can produce increased fitness. Choosing high fitness chromosome reduces energy spending and increases no. of alive nodes in GA based clustering.

REFERENCES

[1] Ali Norouzi and A. Halim Zaim, "*Genetic Algorithm Application in Optimization of Wireless sensor Networks*," Hindawi Publishing Corporation, The Scientific World Journal volume 2014, Article ID 286575, 15 pages, Feb 2014.

[2] Mustapha RedaSenouci, AbdelhamidMellouk and Khalid Assnoune, "*Localized Movement-Assisted Sensor Deployment Algorithm for Hole Detection and Healing*," IEEE Transactions on parallel and distributed systems, volume 25, no.5, May 2014.

[3] A. Norouzi, A. H. Zaim, and A. Sertbas, "*A comparative study based on power usage performance for routing protocols in WSN*," IEEE Inter- national Conference on Advances in Electrical, Electronics and Computer Engineering, Konya, Turkey, May 2013.

[4] A. Norouzi, F. S. Babamir, and A. H. Zaim, "*An interactive GA for mobile sensor networks*," Studies in Informatics and Control, vol. 22, no. 2, pp. 213–218, 2013.

[5] A. Norouzi, F. S. Babamir, and A. H. Zaim, "*A novel energy efficient routing protocol in WSN*," Journal of Wireless Sensor Network, vol. 3, no. 10, pp. 1–10, 2011.

[6] S. Hussain, A. Matin, and O. Islam, "*GA for hierarchical wireless sensor network*," Journal of Networks, vol. 2, no. 5, pp. 87–97, 2007.

[7] A. Norouzi, F. Babamir, and A. Zaim, "*A new clustering protocol for wireless sensor networks using GA approach*," Wireless Sensor Network, vol. 3, no. 11, pp. 362–370, 2011.

[8] C. Sergiou and V. Vassiliou, "*Chapter 1: efficient node placement for congestion control in WSN*," in Wireless Sensor Networks: Technology and Applications, InTech,2012

[9] A. P. Bhondekar, R. Vig, M. L. Singla, C. Ghanshyam, and P. Kapur, "GA based node placement methodology for WSN," in Proceedings of the International Multi Conference of Engineering and Computer Science (IMECS '09), vol. 1, pp. 106–112, Hong Kong, China, March 2009.

[10] A. Norouzi, F. S. Babamir, and A. H. Zaim, "A novel energy efficient routing protocol in wireless sensor networks," Journal of Wireless Sensor Network, vol. 3, no. 10,pp.1–10,2011