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A Novel Approach for Two-Stage Cluster Head Selection Protocol for Wireless Sensor Network

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Abstract

The Wireless Sensor Network (WSN) and the deployment techniques guarantee the monitoring events in the deployment area. However most of these techniques do not meet the criteria to maximize the lifetime of the network with the deployment of minimum number of nodes to satisfy the connectivity and coverage of the network area. To ensure balanced energy consumption in heterogeneous sensor network, different algorithms are used for the deployment and clustering of sensor nodes. The cluster heads are cooperatively transmitted data to the base station. This ability of performing task is depends on the existingresidual energy of the sensornodes.The aim is to enhance the network lifetime by adjusting the energy consumption inside the zonal area. The proposed protocol is used for partition the network into the levels with incresing number cluster heads at each level enhanced network lifetime. The simulation result shows proposed protocol achieves better stability period, reduces overhead and improve the overall lifetime of the network.

Keywords- *Wireless sensor network, Node deployment, Coverage and connectivity, Network lifetime.*

I. INTRODUCTION

Wireless sensor network consist of a various small sensor nodes working in collaboration to gather the data from its environment and send the detected data to the Base Station (BS).The advancement of WSN technology is inspired by various military application such as enemy tracking, battlefield surveillance. Presently these technologies are utilizing in many areas for example, military, natural, and scientific applications [1]. The sensor network architecture is shown in the Fig.1.

Fig.1. Architecture of wireless sensor network

In view of explicit criteria, the nodes are assembled into clusters. Cluster head (CH) is that node among the nodes of a cluster which arranges the assignments of rest of the cluster individuals (CMs). Either the nodes themselves choose the CH or the CH is pre-characterized by the planner, in view of appropriate parameters. Clustering reduce the network life time and scalable and also consume less battery power. Cluster head and cluster member both scheduled properly that is the reason to consume less power. Number of packet delay depends on the CH's performance.

In the cluster oriented network topology use tow type of communication intra-cluster and inter-cluster. Intra cluster communication work inside the cluster either single node or multi node communication. Inter cluster communication each CH (cluster head) send the packet to the base station (BS) either directly or through multiple CH. In the single node sending packet it becomes impractical to big network. To reduce this problem multi-hop communication more necessary to save battery power and improve network life time [2]. In the hierarchical network there is uneven consumption of energy between the Cluster Heads(CHs) and Cluster Member(CMs). But in the multi-hop communication energy of battery saves among the CHs.

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In the single-hop communication CHs each sensor search their neighbor cluster head(CH) in the network and transmit the data to the CH. Where in the multi-hop sending data for data transmission creates hotspots network. CHs present close to the base station (BS) drains large energy in short time. The reason is that for heavy traffic that problem turn on the hot-spot problem [3].

Mostly clustering techniques creates even size clusters. The intra-cluster correspondence is of uniform measure in even size clusters of the network. Due to the restricted transmission ability of the sensor nodes, a sink node is deployed in the network called "sink hub" which collects the data from other sensors in the cluster and follows a multi-hop data transmission model. In its data transmission phase, cluster head goes in hand-off modes to convey signal information from source to destination. The overhead of cluster communication, the cluster transmits to the base station is troubled with high hand-off traffic and will flush the bucket much faster than the far away cluster heads. This scenario arise problem area issue and reduce network lifetime. To overcome the issue of problem area, unequal cluster forming strategy is proposed in the paper. An uneven size cluster of nodes in the system where the size of a cluster increases with corresponds to base station movement. The idea behind making small clusters close to base station (BS) is to protect some vitality between cluster correspondences. The Unequal size clustering system maintains a strategic distance from problem issued area however it brings a few more issues in the system. It is fruitful in accomplishing uniform vital scattering among CHs of the network yet not between cluster individual nodes and cluster heads.

The paper is divided into Section I Introduction to the paper. Section II design issues and related work. Sectional proposed Two Stage Cluster Head Cluster Selectionprotocol is discussed. Section IV The performance of the scheme is evaluated by providing simulation results. Section V includes the conclusion.

II. DESIGN ISSUES AND RELATED WORK

Various researches have been carried out to extend theprevious works that had investigated hierarchical clustering techniques in WSN with different perspectives [4].In WSN, clustering is an energy efficient protocol to utilize the energy of sensor nodes to report the sensed data to the sink node.In this paper,we have defined a model of layered protocols where a network is formed with few clusters of wireless sensors. A unique sensor node is assigned in each cluster called "Cluster Head". The main responsibility of cluster head is to manage the sensors in the cluster by handling the data transmission events among all sensors in the cluster. The network region is divided in hierarchical partitions called cluster layers. In each individual cluster, nodes are gathered into cluster by a cluster head which has the capability to route data from one cluster to next adjacent cluster heads or directly to the base station, Information flows from lower cluster layer to a higher cluster layer. Even the data if it hops from one sensor node to another, on the other hand the hops from one layer to another covers longer distance and it transmits the data faster to the Base Station(BS). Clustering provides necessary improvement capabilities in the cluster heads.In this paper,we are examining some important hierarchal based routing protocol for WSNs.

Geographic Adaptive Fidelity (GAF): GAF is a energy based routing protocol basically proposed for MANETs, yet it might be utilized for WSNs in same way since it favours energy protection. The scheme of GAF is inspired by energy state which considers energy consuming because of the gathering and sending of packets and additionally sit out of gear (or tuning in) period at whatever point the radio of a sensor is on to detect the nearness of arriving packets.GAF is an energy efficient routing protocol. GAF turns off unnecessary sensors and maintains consistent flow of routing fidelity (an uninterrupted connection only between communicating sensors).In GAF sensor region is partitioned into square shape grids and each individual sensor efficiently utilizes its geographic position data received by GPS or other area of the sensor network, so that it can connect with a specific grid area in which it locates. This kind of association is followed by GAF to observe the sensors which are equal from the viewpoint of packet sending [5]

GEAR- Geographic and vitality mindful directing (GEAR)[6], calculation utilizes the geographic data while scattering inquiries to suitable districts. Scattering data to a geographic locale is extremely helpful crude in numerous area mindful frameworks and particularly sensor systems. Rigging utilizes

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vitality mindful and topographically educated neighbour determination heuristic to highway a parcel towards the objective area as opposed to flooding the inquiry or bundle to the entire system. Despite what might be expected, the intrigue is overwhelmed in entire system in coordinated dispersion. Along these lines GEAR monitors more vitality when contrasted with the coordinated dissemination. Apparatus does not require the requirement for an area database and accept the static sensor hub in the system field. It is expected that every hub is appended with a GPS gadget to get its present area in the system and furthermore accepted that every hub realizes its residual vitality level, and its neighbour's area and remaining vitality level through a basic neighbouring convention. The connection in the convention is thought to be bi-directional. In GEAR, every hub has two kinds of cost parameter [6].

LACBR- Location aware cluster based routing in WSN**.**It uses three stages in remote sensor systems. In the main stage, the area data of every sensor node is registered by utilizing the restriction calculation, for example, Trilateration, Triangulation and so forth; the sensor nodes are bunchedin the second stage to limit the leftover vitality and boost the system execution then the Group head is chosen dependent on the base separation between the group hub's and the centroid; in the third stage, Directing happens between the bunch head and the bunch individuals and furthermore between the bunch head and the base station [7]

ZBRP- It isBased on two bad-to-the-bone components, clustering and network configuration space, this paper proposes (ZBRP) for remote sensor systems. The key point of ZBRP is to enhance sensor network lifetime by limiting all odd energy utilization by applying some constrained rule to reduce the overhead on sensor nodes in the network.ZBRP provides a mechanism to make bunches of even size with less control overhead on the nodes by utilizing their data. It deploys random back-off clocks to select the bunch heads in every node data transmitted around the network field. It provides a fundamental and reasonable multi-hop data transmission model .ZBPR achieves problem free sensors connected with consistent energy utilization among the group heads[8].

PEAS- The node themselves regulate their sleeping period and this help in maintaining the wakeup rate constant. The decision of sleep and wake is done on the basis of the information gathered from the environment. This information is in terms of the location and state of the sensor nodes. Thus the variables maintained by PEAS protocol are: the Time taken to receive a message (T) and the number of messages received (N). PEAS is a robust protocol which help in increasing the coverage ratio of the network [9].

Energy Efficient Homogenous Clustering Algorithm for WSN in remote sensor network is categorized Homogeneous clustering algorithm to save node energy and increase network lifetime. Homogeneous deployment of sensor nodes in the cluster guarantees to enhance the lifetime of the network . A novel CH is choosen by considering the residual energy of available group heads and nearest distance of the node [18][19][20].The homogeneous approach guarantees that every node in the cluster will become a cluster head or an individual node from the groups in the cluster of remote sensor network.The proposed principles of grouping set ,the individual nodes of the clusters are consistantly communicate. In this manner the network life expectancy increases, moreover, in the proposed protocol CH's communicate only with group development data but not with every sensor node.In this way , it strengths the life time of the sensor network.The major significance of this technique is to build the system life cycle by establishing a homogeneous deployment of nodes in the groups of the clusters so that it must not much accepting or sending overhead to a cluster head[9][16].

EECH- This protocol works in heterogeneous network system .EECH is divided in three hierarchical levels with the help of three varieties of sensor nodes called 1.The normal node, 2.The advance node and 3.The super node. In sight of their energy levels and cluster head selection strategy is similar to LEACH protocol. The super node equippedwith more energy than the advance node .Similarly, advance node is equipped withadditional energy than the normal node. The network lifetime is more than SEP protocol because of utilization of three level hierarchies.Due to its irregular organization of nodes, it is subsequently emerge with area coverage issue in the network [10].

RBHR -In RBHR (Region based Hybrid routing) sensor nodes send their data packet to the cluster head through source routing only and each cluster head further transmit data to base station with

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single hop routing. In RBHR single hop routing guarantees significant energy utilization but lifetime and stability period of the network is restricted exponentially [11][17].

2.1 Energy Model

The free space model used in WSN makes an assumption for attenuation of a propagation signal. The model is represented as:

$P_R = P_0 / d^2$

Where P_R : The received signal power
d : The distance
T_X :The transmitter
R_X: The receiver.

In the free space radio model, the distance between transmitter T_x and receiver $R_x$is used to compute inverse square function for measuring the power of received signal .The free space consist (d^2 power loss) while in multi-hop routing or forwarding (d^4 power loss) controlmodel mechanism is used and they are based on the distance between transmitter T_x and receiver R_x.
If the required distance computed is smaller than the threshold value,then the free space model is selected and if it is greater or equal than the threshold value then multipath model is used. The preferred approach model is called first order energy model. This model is named as first order radio energy model and this model helps to calculate the energy utilization of data packets in sending and receiving operations.
Energy departed from 'L' bit size packet for transmission and the distance'd' is shown in Figure2.

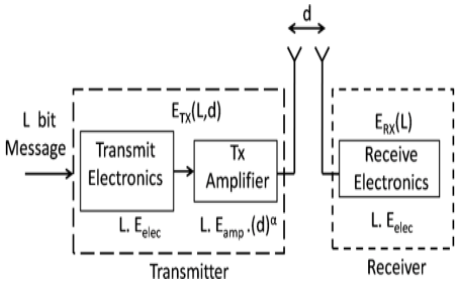

Fig.2. Radio model

Energy (*Elec*) is the energy used for sending /receiving thedataper bit.

Therefore if node transmitted 'L' bit packet then energy utilize while in transmission is

$$E_{TX}(L, d) = E_{elec}.L + E_{amp}(L, d) \quad (1)$$

$$E_{TX}(L, d) = L.E_{elec.} + L.\epsilon_{fs}.d^2 \text{ if } d < d_0 \quad (2)$$

$$L. E_{elec.} + L. \epsilon_{fs}.d^4 \text{ if } d \geq d0$$

Here threshold

$$d_O = \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}}. \quad (3)$$

To receive the '*L'* bit size packet, the radio expend energy

$$E_{RX}(L) = E_{elec.}L. \quad (4)$$

Here *Eelec* is the energy lost/ bit, ϵ_{fs} is the free space coefficient, E_{amp} is the multi-path coefficient,*L* is the transmitted data in bit form, *d* is the original transmission distance and $d_0$is the threshold value of distance[12][13][14][15] [16].

PROPOSED METHODOLGY

The Two Stage Cluster Head Selection protocol is proposed**.** The aim of the protocol is to enhance the lifetime of the network by efficient utilization of energy consumption inside the zone as well in the cluster. The protocol has two stages. The first phase is known as set-up phase .In the first phase

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network area is partitioned into different level of regions . The second is the steady phase in which all nodes reply to get associated CHs and finally message is sent to base station.

We distributed the network of (100X100) m^2,(200X200) m^2,(300X300) m^2 area having 100,500,1000 and 1500 nodes. The network area is partitioned into equal size grids constructed on the basis of theirlongitudinal distance to the Base Station(BS).The no of cluster increases the nodes residual energy. The Chs selection is performed two factors1.Maximum node energy and 2. Minimum distance from BS. The two-level clustering hierarchy is used for data transmission to the base station. Similarly for (200*200) $m^2$and (300*300) m^2area same numbers of nodes are distributed for the data transmission to the base station.

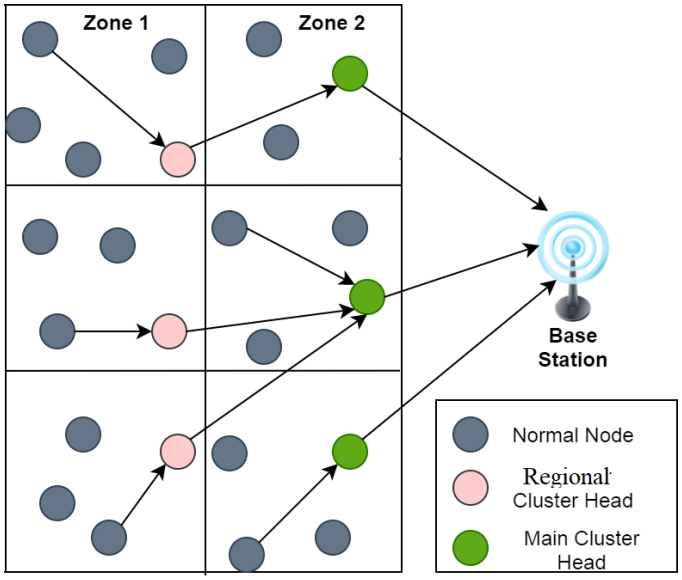

Fig.3. Region Division of Network

First Phase – Setup Phase (Network Partition Phase)

Declaration
TCh= Cluster Head Threshold
Ch = Cluster Head
ACh = Auxiliary Cluster Head

CH SELECTION
Start
Step 1: For node (i) in the cluster.
Step 2: ComputeTCh
Step 3: Sort TCh to get maximum TCh as cluster head.
Step 4: If TCh>ChThr
Then
Communicate
Step 5: Do Until Regional Ch
Send data to the next level cluster head and aggregate the data.
Step 6: Until Regional Cluster Head value < Threshold of the Main Cluster head
Goto Step 7
Step 7: Data send to Main Cluster Head and aggregate the data and finally send to the base station.
End.
End.

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These are following assumptions that are assumed for the WSN model of the proposed protocol:

1. The sensors are placed in random order in the target area.

2. Thesensors areheterogeneous in nature.

3. Multi-hop technique is used to transmit data between the two sensors.

4. The deployment is free from radio background noise or any interference.

5. The data aggregation and data confining is performed by the Cluster heads of each clustersin the network.

6. Cluster heads furthertransmit the received data towardsBase station.

7. Base Station contains knowledge of the location information of sensors and ID's of all the nodes in the network.

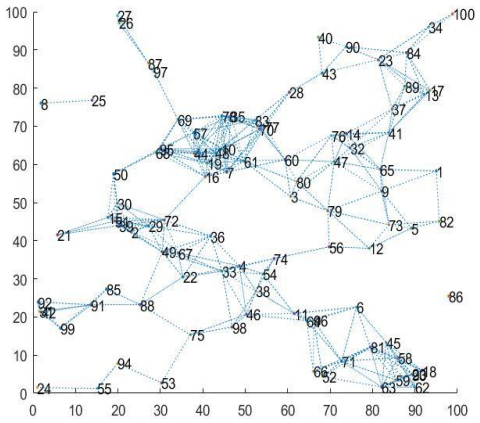

Fig.4. Wireless sensor network of 100 nodes

The hundred sensor nodes in the network size of (100*100)m^2 area are randomly deployed. The Base Station(BS) is located randomly at coordinates of (300,50) on X and Y axis in the network. Once the nodes deployment is finished the nodes are free to decide cluster head or cluster member. The threshold value is used for the selection of a cluster head. In the WSN all the network generate a random number of 0 and 1 for the selection of CH. The node which has maximum threshold will be CH itself and it will broadcast messages to all node which are surrounded it. The other normal nodes can receive messages from the rest of CHs. These nodes can compute the distance to Ch based on receive message and signal strength. The nodes having shortest distance can join by sending the request message and IDs. Once the Ch receives the request of other nodes then CH identified the members of the cluster. They exchange the message between normal nodes and CH.CHs broadcast acknowledgment to all associated nodes. In a cluster ,data transmissions from sensor nodes to theCH assigned using time slots. All CHs transmit aggregated data to the Main cluster head and finally trasmitted to the base station.

Second Phase (Steady Phase)

Algorithm

proposed approach
Initialization B.S.–Base Station, N.N.-NeighbourNodes,n-Node,T(n)-Threshold value of node ,C.H.-Cluster Head, Rd-Random Generation , T (R_d),CM-Cluster Member,B_C-Broadcast

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Step 1: Start
Step 2: for 1=1: level do
Step 3: Rd =random (0,1)
Step 4: if T(n)>T(Rd)
Then C.H. =n;
Step 5: For j = 1 to nodes do broadcast
{
Step 6:(B_C) Message Broadcast to all NN
Step 7:NN of CH send their ID
Step 8: NN joinscluster
Step 9: CM broadcast message
}
Step 10: end of current round and begin next round from Step 1.

SIMULATION RESULTS

The simulation parameters in the Table.1 are used for the proposed protocol.

Table 1. Simulation Parameter

Pararmetre	**Value**
Sensor Field	100*100 m^2 200*200 m^2 300*300 m^2
Nodes	100 -- 1500
Energy of nodes(Initial)	0.5 J
E_{elec}	50 nJ / bit
E_{fs}	10 pJ / bit / m^2
E_{amp}	0.0013 pJ / bit / m^4

Analsyis of Node and Packet Size

The simulation results are performed in the Matlab for the 100*100m^2,200*200m^2,300*300m^2 area having packet size 1024 bits ,2048 bits and 4096 bits to evaluate the network lifetime .The lifetime of network is computed in terms of rounds.

The simulation results for 100 nodes for 100*100m^2 area is shown in Fig.5.

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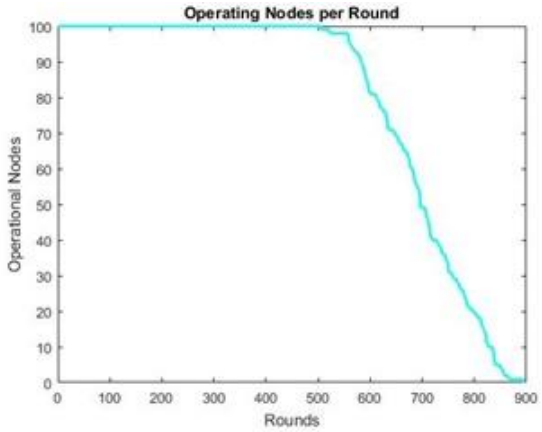

Fig.5 Lifetime of network having packet size 1024 bits for 100*100m^{2}area

The above simulation result show that maximum lifetime of network is 893 rounds.

Similarly lifetime is evaluated for the 100*100m^{2}area for the packet size 2048 bits and 4096 bits is shown in the Table No II.It found the lifetimeof nerwork increses on incresing the number of nodes with fized packet size.

Table No.2 Lifetime of n/w for different packet sizes

Size of Packet in bits	No de 100	Node 500	No de 1000	Nod e 1500
1024 bits	893	1100	116 0	1199
2048 bits	464	559	585	600
4096 bits	229	270	285	300

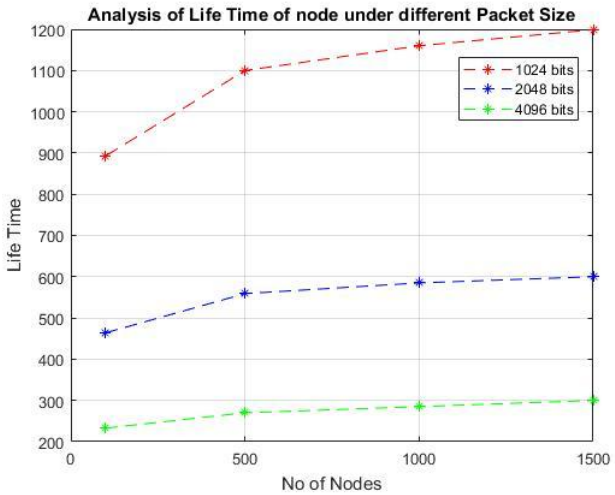

Fig.6.Analysis of Lifetime of node under different packet size

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The above simulation results indicate that on increasing the number of sensor nodes with fixed packet size the lifetime of network enhances .The maximum lifetime for the packet size 1024 bits is 1199 rounds,similarly for 2048 bits is 600 rounds and 4096 bits is 330 rounds.

Table No.3 Lifetime of n/w under different network area

Size of Packet in bits	No de 100	Nod e 500	Nod e 1000	Nod e 1500
$100m^2$	893	1100	1160	1199
200 m^2	1081	1681	2037	2241
$300m^2$	1212	2244	3147	4113

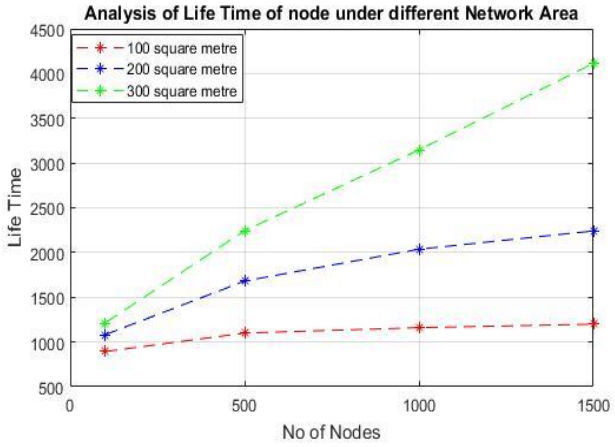

Fig.7.Analaysis of Lifetime of node under different network area

The above simulation shows that on increasingarea the lifetime of network enhances .The maximum lifetime for the 100 m^2area having is 1199 rounds, similarly for 200 m^2 area is 2241 rounds andfor $300m^2$ area is 4113 rounds.

The lifetime of the network is an important feature for a wireless sensor network. In a wireless sensor network, network connectivity is based on aliveness of nodes as well as forwarding of the nodes. From the result, it is observed that the lifetime of the network increases with an increasing number of nodes.

In case of secondscenario, thenumbers of nodes are increased with fixed area size i.e {100*100m^2}, {200*200 m^2 } and {300*300 m^2}. From the above scenario the communication ranges are variable when there is less adjacency among the nodes with respect to the communication ranges. To increase the communication ranges the chance of selecting CHs among the nodes increases there for more balanced the network using proposed protocol. When the communication range increases (100*100) $m^2$to (300*300) m^2more nodes are connected to the base station and increases the network lifetime of the network.

CONCLUSION

The design of routing protocols for WSN must take into considerations not only the minimization of the length of the route but also the maximization of the network lifetime. In the desired approach data is sent through different level hierarchy architecture by optimum and efficient CH selection process in the zone that maximizes the number of rounds and improves network life.To reduce the unnecessary

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energy of sensor node in WSN ,the proposed protocol has two phase, 1. Set up phase and 2. Steady-state phase.The energy utilization of protocol is calculated and it shows enhancement in the network lifetime**.**

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