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Multi-Hop Clustering Approach for Energy Utilization in Wireless Sensor Network

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Abstract: ***Wireless sensor networks (WSNs) play an important role in our every phase of life. In WSN a smart sensors nodes deployed for a wide range of applications for monitoring and sensing the event. The amount of energy in every sensor node is fixed and limited. The battery (energy) is un-replaceable and not charged again therefore; energy efficiency is important design parameters for design any wireless sensor network. This paper is mainly focus on the clustering and proposed approach of routing for energy utilization of WSN. The proposed algorithm is mainly focus on maximization of energy in terms of round calculation. Clustering and design considerations are very important for minimize the energy consumption and prolong the life time of the WSN.***

Keywords: **sensor node, design factors, radio energy model, first and last node die.**

I. INTRODUCTION

Wireless sensor network is created and worked when the numbers of sensor nodes are used and deployed in the application area's or field. Nodes are deployed in multiple ways like manual deployment, one time manual, deterministic and random deployment [1]. WSN are designed to monitoring those areas where the natural phenomenon (event) and environmental changes (event) occur. It is also used in many applications such as military, battlefield, health, home and other commercial areas [2, 3]. WSN are designed by using the number of sensor nodes, with the capability to aggregate the information and data from other nodes and transfer the data with each other to communicate with end user. Each sensor nodes comprises various hardware parts. (In figure no. 1). Sensor nodes are varying in size and make according to application requirement. Sensor nodes are scattered in a WSN. These sensor nodes are connected to the sink node (base station) directly or via intermediate node which is the cluster node. A base station is fixed or mobile. Base station connects the WSN to the existing communications infrastructure or to the internet where a user can have access to the reported data [3]. Each sensor node typically consists of the sensing unit, central processing unit (CPU), power unit and communication unit. Every unit is also used sub parts, are assigned with different task [4].

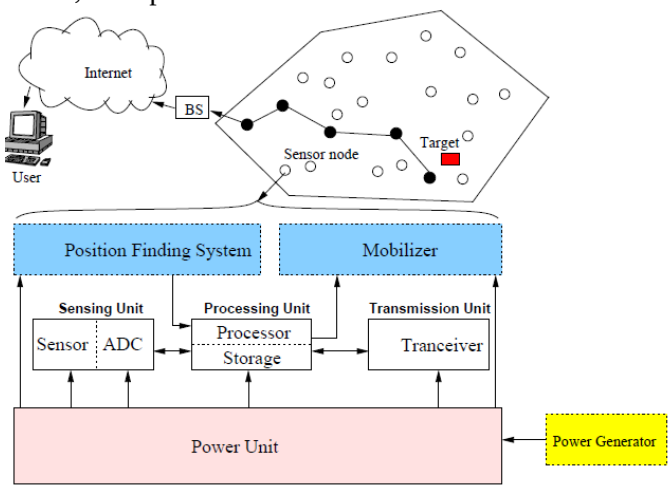

Fig 1: sensor node component and Network [3]

A. Application Areas of sensor network: wireless sensor networks are useful in various areas [5] for increase the reliability, efficiency and through put of various process and its related applications. Main areas where wireless sensor network (WSN) is used are Military, Health monitoring, Disaster monitoring, Habitat monitoring, industry and automotive, home network and environment monitoring [5].

B. Routing Challenges and Design Issues: various design issues are used in designing the routing protocol for a specific area and its related applications [6]. Routing protocols uses various design issue for successful routing the data between networks. The selection of design factors are based upon the application requirement and also on hardware and software which is used in wireless sensor network [6].

II. PROPOSED WORK

In this proposed work we mainly focus on the various model of communication for efficient utilization of sensor node energy. Various sensor networks use different kind of communication model for data delivery between sources to destination nodes. Sensor network used single hop communication and multi-hop communication model with clustering (basically heed). Proposed design network is based on heterogeneous nodes in which various nodes in the network having different node properties like hardware uses, communication range, data delivery speed, memory for data storage etc.. Nodes are mainly works for reactive network for improving the energy

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utilization in the sensing the event, data delivery, aggregation, storage and other phase. Proposed WSN design constraint is useful in those areas and application where the time limit or specific event value is required, for example in military battle field for security, temperature sensing in volcano areas, secure data delivery in network and different household applications like microwaves etc..

First order radio energy model is used for energy calculation of various nodes including cluster head and sink (base station node) node [7]. We have taken various design parameters of routing protocol and for simulation; design and output MATLAB Programming tool is used.

II. PROPOSED ALGORITHM

The proposed algorithms are based on the various routing model of wireless sensor network. In the existing routing techniques we have apply various design constraints of routing protocol [6, 8]. We have also use first order radio energy model for calculating the transmitting and receiving energy required in every sensor node for transferring and receiving the data from other nodes [8]. This proposed algorithm design parameters also apply with Heed protocol concept to compare its single hop functionality and result with multi-hop functionality. Proposed algorithm uses the setup phase and data delivery phase concept of single hop Heed model [9].

A. Algorithm for Network Deployment and Energy Computation

Set-Up phase for network deployment

Step 1: Take initial design parameters and assumption values of node, sensing network field and radio energy model.

Step 2: Random deployment of sensor nodes with the help of coordinate values(x axis, y axis) in define area.

Step 3: Deployment of the SINK node (base station) at fixed position (x=0, y=0) in the network area.

Step 4: find the sensor node within the transmission range of Base station (sink node).

Step 5: Find the total number of links between nodes in our network.

Above step 5 is required because we are applying single hop and multi-hop clustering approach, for this we have to decrease the number of links by keeping the same transmission range and connection of each node with base station

Step 6: In single hop clustering all the cluster head are connected to base station directly, Whereas in multi hop clustering, cluster head which is near to base station are connected to it and cluster head which is far away is connected to base station through other cluster head, which is worked as relay nodes also.

Step 7: Selection of Cluster Heads (CHs) firstly on the basis of their centralized position.

Step 8: Switching the transmission range of cluster head to 2X and X for the rest of the sensor nodes.

Step 9: Forming a distance matrix for each sensor node.

Step 10: Connecting all the CHs present within the transmission range of '2x' using the distance matrix.

Step 11: A CH is now responsible for discovering other cliques and sharing information within the clique.

Steady State Phase

Step 12: Use of more comprehensive first order radio model.

Step 13: Calculate energy utilization of each sensor node which includes transmission energy and receiving energy. It's give the total energy consumption to perform setup of node and network and data delivery between nodes.

Step 14: Calculate total number of rounds after which each node dies.

Step 15: Change of CH within a cluster if the first CH dies i.e. runs out of energy.

Step 16: Set-up phase for CH selection is repeated.

Step 17: Sensing occurs until the lifetime of the network.

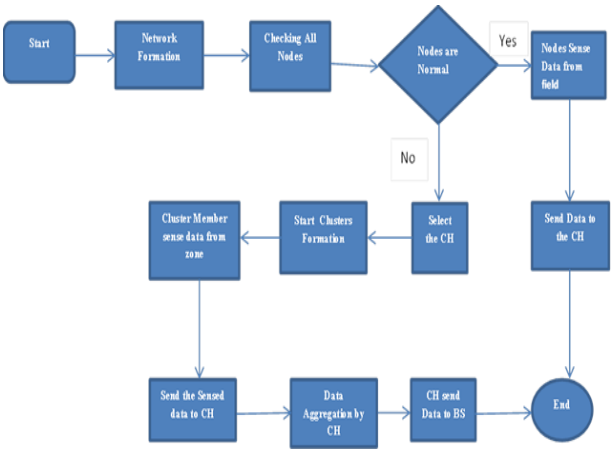

Fig 2: Flow graph of data movement

IV. FIRST ORDER RADIO ENERGY DISSIPATION MODEL

The following first order Radio Energy Model [10] is used by traditional protocol as well as by the proposed protocol.

In this radio energy model, the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics. Thus, to transmit *k*-bit message a distance *d*, the radio expends:

$E_{TX}(k, d) = E_{TX-elec}(k)$

$E_{TX}(k, d) = E_{elec}*k + Є_{amp}*k*d2$

$E_{TX}(k, d) = E_{elec}*k + \varepsilon*k*d^2 + E_{ecc} + E_{sensing} + E_{switching} + E_{da} + E_{switching}$

And to receive this message, the radio expands:

$E_{RX}(k) = E_{RX\text{-}elec}(k) + E_{processing} + E_{decyp}$

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$E_{RX}(k) = E_{elec} * k + E_{processing} + E_{decyp}$

Where,

E_{elec} = Energy dissipation for electronic device

$Є_{amp}$ = Energy dissipation for transmit amplifier for bits over the distance d

k = Packet size in node, k bit per sec transfer

d = Distance between node (sender to receiver)

E_{TX} =Transmitting energy of k bit packet.

E_{TX} =Receiving energy for K bit packet.

E_{ecc} = energy used for error checksum.

E_{sense} = energy used for sensing the data, event.

E_{da} = energy used for data aggregation.

E_{encyp} = energy used for data encryption.

E_{decyp} = energy used for data decryption.

The electronics energy (E_{elec}) depends on factors such as the digital coding, modulation, filtering, and spreading of the signal, whereas the amplifier (amp) energy depends on the distance to the receiver and the acceptable bit-error rate.

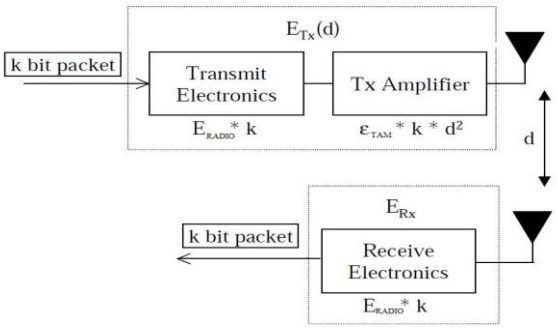

Fig 3: First order radio energy model

V. SIMULATION AND RESULT

Simulation for the proposed work is carried out with the help of some assumption and design parameters which is used for calculation the energy in routing the data between various nodes. For simulation of parameters we used MATLAB as a software tool for calculation of input parameters. it is also used as graphical user interface (GUI) to show the result in the graphical form. We need limited hardware and software requirement for generating simulation result.

A. Parameters used in Radio energy model

E_{elec}= Energy per bit = 50*(10) ^ (-9).

E_{amp}=Transmit Amplifier types for multipath loss = 0.0013*0.0000000000001.

k= number of bits to be transferred in a packet = 1000.

$E_{switching}$ = Energy used for switching =5*0.00000000001

$E_{switching\_reactive}$ = Switching Energy for reactive network = (120+20)*0.000000000001.

E_{ency_energy} = energy used for Data Encryption =5*0.000000000001.

E_{decy_energy} = Data Decryption Energy =5*0.000000000001

E_{da} = Data aggregation Energy =5*0.000000000001

E_{sense_energy} = 50*0.000000001;

n= Total Sensing Nodes = 11 or more (it depends on assumption and deployment).

CHs = Total cluster head (assumption) = 5, it depends on cluster creation algorithm and also total no of nodes and total network area size. Total base station (sink node) = 1, in some network it can varies.

Network coverage Area = 500x500 m^2 Approx.

B. Design Constraints Used in Data Delivery Model of WSN

In the propose work we mainly try to find out the energy utilization of sensor node when we used it with single hop and multi hop routing model. The existing routing model and algorithms takes some parameters values as an assumption for support the design factors [11]. Here we use various combinations of design factors which are used with assumption values and proposed algorithms.

Design issue (factors) used in Proposed work	
Node deployment	Random
Total no. of Nodes	Fixed (varies in model)
Routing approach	Hierarchical with Clustering
Scalability	Good
Node Type	Heterogeneous node
Data model	Hybrid (single-hop and multi-hop)
Mobility of sink location	Outside at (0,0)
Data aggregation	Possible
Power usage	Minimum
Security	Possible
Topology	Self organizing

Table 1: Design factors used in simulation

VI. SIMULATION OUTPUT

Simulation process is used various predefined concept, formulas and algorithms. In the simulation phase we have taken all previous define parameters, radio energy model, and various node values (energy, size and process capacity) and software programming language and tools.

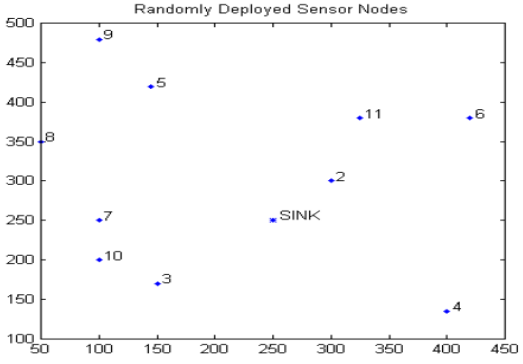

Fig.4: Random deployment of nodes

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In figure no. 4, it shows the random deployment of sensor nodes in heterogeneous network.

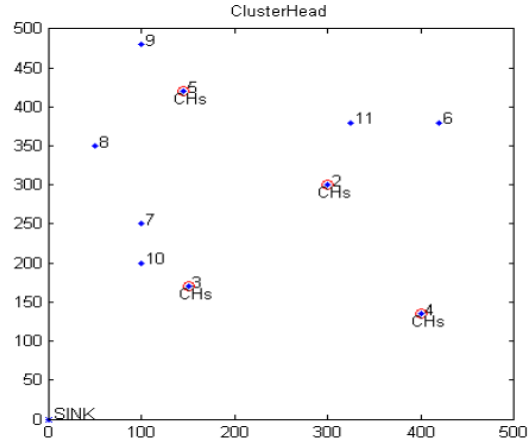

Fig 5 cluster head is selection

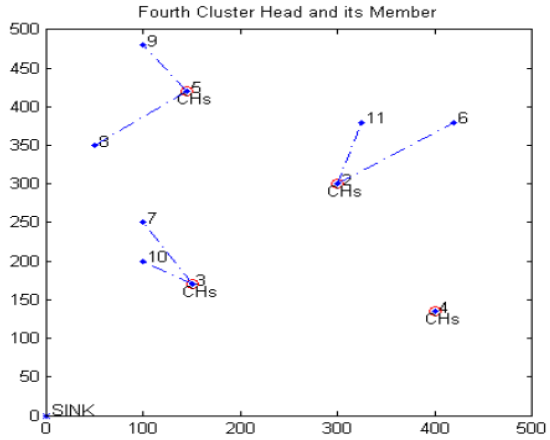

Fig.6: cluster formation

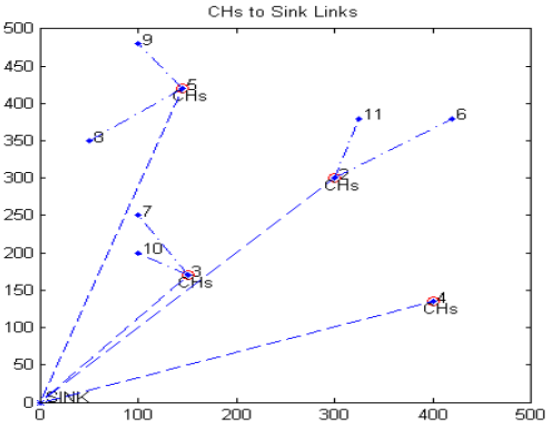

Fig.7: single-hop clustering

Figure No. 5,6 and 7 shows the clustering operation with existing nodes within network area. First the cluster head is selected according to threshold value of energy of node using HEED protocol. The other entire node transfers the data towards its near cluster head node. Finally all cluster head transfer the data to sink nodes.

Figure no.8 show the multi-hop clustering model with random node deployment in wireless sensor network. Multi-hop model is used for extend the range of node. It also used for long distance communication and also provide relay network within various cluster head nodes. All the cluster head node values transfer to base station through another cluster heads node and the cluster head which is near to base station collect the data from other cluster head. Near cluster head node is aggregate the data from other cluster head node and transfer it to sink node through which it is deliver to end user.

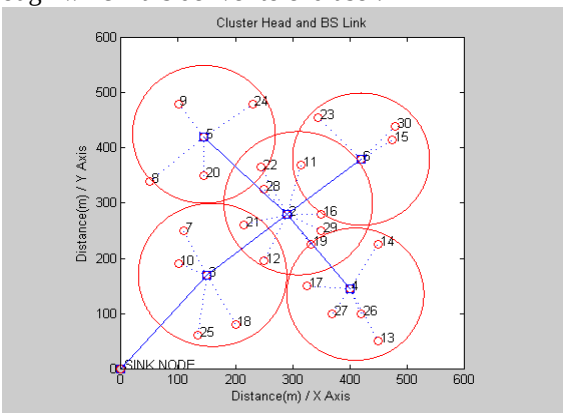

Fig.8: Multi-hop clustering

VII. RESULT ANALYSIS

Above fig. shows simulation of different routing protocol. It is also use full for understanding the path of routed data. Proposed network uses various parameter of routing protocol to find the total no. of rounds. Average no. of rounds in single hop clustering is 14004 whereas average no. of round in multi hop clustering is 18743 thus, by comparing both the model we can concludes that multi hop clustering gives the more reliable and energy efficient result.

VIII. CONCLUSION

In this paper, we propose an eveluation of energy efficient routing protocol for routing design constraints with existing routing model and protocols. single hop approach and multi hop approach is used with all nodes which is random deployed at selected area.

After the deployment of senor node, we can calculate the number of rounds in the clustering approach. If number of rounds is large than it means the more energy is utilized in the network for data sensing, storage and delivery with each other and towards base station.

In summary the number of rounds in the network will depends on

(1) No. of node used
(2) Random deployed of node in network area
(3) Total number of cluster Head selection.
(4) Transmission and receiving range of node.
(5) Initial energy of sensor nodes.
(6) Data aggregation
(7) Network type (reactive or proactive)

IX. FUTURE WORK

In the future work, we can apply quality of constraints factors like bandwidth utilization, delay, environmental

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factors in the network to check the efficiency at various conditions. comparison of various routing model and its energy utilization interms of number of rounds gives the fare idea about the usages of the proposed work.

Future Deployment of the network, for mobile nodes and dynamic network gives us real time result for a perticulat network and its node position.

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