Energy Efficient Routing and Swapping of Nodes in Wireless Sensor Networks

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Abstract

Wireless Sensor Network(WSN) are being used increasingly to detect events in fields of military, environmental and smooth transport flow, but the finite energy source of the nodes comes as the major hindrance. Transmitting and receiving information results in quick depletion of energy of nodes. In this paper a technique to recharge the batteries of nodes have been suggested with help of varying topologies. The nodes would be sorted in order of energy left and those would less energy would be moved away from the cluster head so that they would have to process less number of messages and could be recharged while working with less data.

Keywords: Wireless Sensor Network, routing, energy efficiency, cluster head

Introduction

Wireless Sensor Networks use thousands of sensors node to detect change in the environment they are working in, with limited battery, memory and processing power. Whenever an event is detected, all the sensor nodes in the cluster, communicates their message to the cluster head, the nodes in the vicinity of the cluster head have to process a lot of incoming message and forward it to the cluster head, so the nodes near the cluster head get discharged quickly[2][5]. If the nodes with less batteries are not replaced or recharged the node failure rate of the network increases which could result in breakage of the link between nodes and events in the network can go undetected.

Algorithms like tree based structure or grid based is used for routing message to the cluster head and both these techniques come with their respective pros and cons. In this paper a technique for energy efficient communication is proposed, which will work by balancing the load between the nodes while detecting the events in the environment.[3] Nodes which operate near the cluster head will be changed after their energy drops before a significant drop in energy. The energy of all the nodes near the cluster head would be calculated and one's with the energy levels above the threshold and minimum number of packets in the queue would be chosen to replace nodes near the cluster head in their respective cluster. After the nodes are swapped a new and efficient route would be established to route the information to the cluster heads. This way any node does not gets completely discharged and node failure does not occurs and nodes away from the cluster head can be recgarged while processing less information.[1][4]

Literature Review

N. Nake proposes a technique to preserve the energy of sensors by proposing a dynamic topology and establishing a route in which minimum cell headers have to participate. The coverage area of the wireless sensor network was divided into grids, and each grid has their respective cluster head and a centralized sink node which is free to move across the borders of the grids. Every participating node in the grid observes the environment regularly and communicates the data to their respective cluster head. The cluster heads communicate the data to the sink node, so the nearest cluster head to the sink node, utilizes the minimum energy to send the data collected.[2]

P. Dongarwar maintained energy efficient communication by using LeDiR(Least Disruptive Topology Repair) algorithm and SMTR(Select Most Trusted Routing) algorithm. They proposed a methodology which works by detecting all the active nodes and their respective energies; next all the nodes discover whether their neighboring nodes are dead or alive. If the node has failed then LeDiR algorithm is applied to find a suitable replacement and then SMTR algorithm is applied to find the best route. The data delivery rate of the network is increased so that nodes can send maximum data in minimum, so that nodes do not remain active for a long time thus saving the energy of nodes.[5]

S. Prabowo proposed a Distributed Energy efficient clustering for wireless sensor networks named EDsHEED (Enhanced Distributive Simplified Energy Efficient Distributed Clustering. In this there is a hierarchy of networking monitoring by using cluster heads (CH) as well a Super Cluster head (sCH). A broadcast probe is sent to all the active nodes in the network and those interested reply and become the respected heads. EDsHEED not only improve the energy consumption of the network but the lifetime of the network is also extended.[7]

K. Bhavitha worked on improving energy consumption by ensuring controlled access of the network, thus reducing collision. EECA (Energy Efficient Channel Accessing Protocol) is used to resuce the collision by deciding the manager of the network. Among all the nodes, the one which gets selected has the highest level of energy and minimum packets in the buffer for transmission. Once the manager gets selected it gives priority to the contending nodes to access the shared channel to send data. Once the current manager reaches the threshold, a new manager is elected.[4]

N. Sertbas proposed a energy efficient routing technique in which rather than selecting the path with the shortest distance, a new concept of edge weight is introduced to find the best route. The weight of the edge from node u to v is determined based on the power consumed in sending data over that edge. The decision of the best path revolves around the residual energy of nodes, neighbors of a node and the distance between the nodes.[3]

Proposed System

The proposed system will ensure that node failure does not occurs due to discharge of energy of nodes, because before the energy of the nodes, drops below the threshold, they would be swapped with the nodes which have more energy above the threshold and with minimum packets in their queue. The WSN network is divided into clusters and each cluster has a cluster head and all the data collected collaboratively by all the cluster heads.

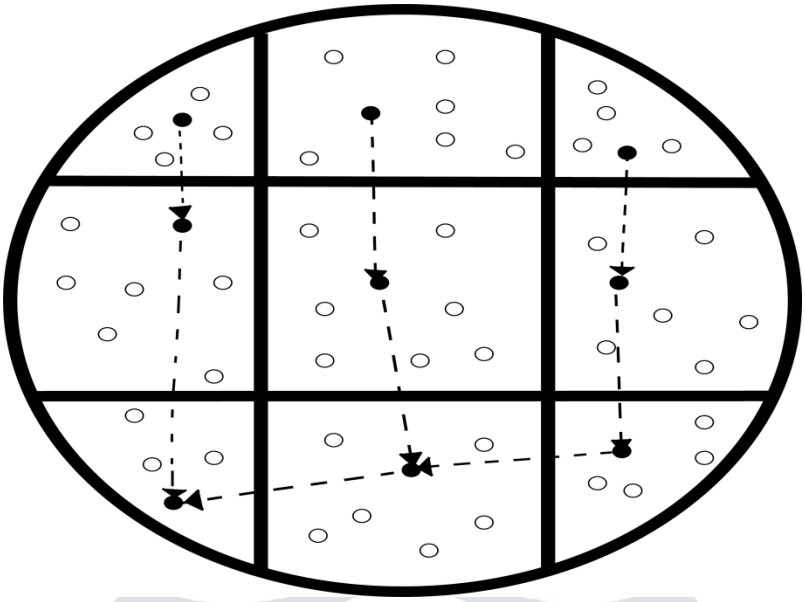

Fig.1:The clusters in the Wireless Sensor Network

All the nodes near the cluster head are checked for their respective energy, and their energy is compared with the threshold energy and all those nodes which have energy less than threshold value would be swapped. The neighboring nodes of the nodes are discovered by applying neighborhood discovery protocol, and their respective energies are compared with the threshold energy value of the networks. The contending nodes which qualify the threshold energy values would be further selected base on the number of messages that are queued in their respective buffers.

$$N_O = E < E_{thres}$$

And

$$N_N = E > E_{thres} \text{ and } M < M_{thres}$$

Where,

N_O = Old nodes which have to relocated

N_N = Nodes which have to be shifted near the cluster head

E= Energy of the nodes

E_{thres} = Threshold value of energy of nodes in the network

M = Number of message in the buffer of node

M_{thres} = threshold value of number of message in buffer

Based on above used formulas, all the contending nodes, are sorted in ascending order and the top ones in each cluster is swapped to take positions near the cluster head. The node discovery protocol also helps in discovering failed nodes, if the neighbor of any node has been detected to be not working or failed, the respective node will again run neighbor discovery protocol to find the next active neighbor. Once all the neighboring nodes have been detected and swapped, a new and efficient route would be established to send the data in minimum time so as not to drain the energy of the nodes, by using them for long time.

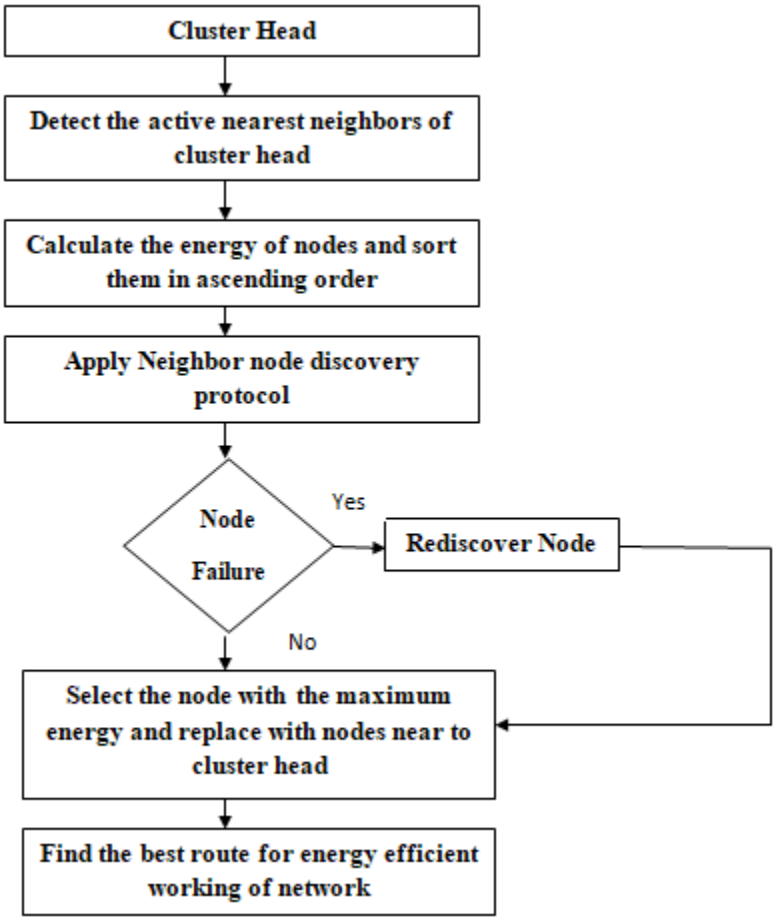

Fig. 2: Flow of the proposed system

The system continuously keeps on scanning the network and ensures:

- Periodically scans and collects information about the current energy levels of all the nodes in the network, and those with low energy levels are swapped with one with high energy level
- Recognizes the newly swapped node and checks for any malicious behavior, if the nodes shows any inappropriate behavior, it is removed from the network and the process is repeated again
- It also helps to check any node failure in the networks, and proceeds to remove them from the network

Algorithm

Input: E[i] and M[i] of all nodes

Output: Swapped nodes

1. For all i in E[i] do:
    a. Calculate $N_O = E < E_{thres}$ and $N_N = E > E_{thres}$
2. For all i Q[i] do:
    a. Calculate $M < M_{thres}$
    b. Swap N_O and N_N
3. Establish new route with swapped nodes
4. After route establishment, eliminate failed nodes
5. End

The next contention period in which new nodes would be searched, would be done regularly, and previously swapped nodes would also be added in pool after getting recharged

Conclusion

Wireless Sensor Networks use nodes to access their environment and communicate the information, but the nodes operation is limited to their restricted storage and battery power. To make the communication energy efficient, proposed system will swap the nodes which are low in energy with nodes which have energy more than the threshold value of the network. The new and efficient route established helps to communicate packets with balanced load on all nodes in network

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