Maximising Wireless sensor Network life time through cluster head selection using Hit sets

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Abstract

The main aim of this paper is to propose a solution to improve the life time of the network by reducing the no of active nodes that participate in communication. Life time of a WSN is improved through optimizing communication and minimizing energy usage. One way of optimizing communication is through cluster head selection. In this paper active nodes at an instance are identified using hit set. One among the active nodes is elected as cluster head by considering the degree of the node. Finally depending on the no of sleep nodes in the cluster the percentage of prolongation of the lifetime of the network is calculated

Keywords: *Cluster head, Hitset,, Residual energy, sensor components*

1. Introduction

A WSN also called as Intelligent Distributed sensor system which consists of small sensor nodes that act as information collectors and one or more processing centres connected via wireless links.A sensor node is resource constraint ie.limited energy,computation power(processor and memory),short communication range and low bandwidth.When deployed in hazardous environment it is almost impossible for a sensor to recharge.Hence prolonging of lifetime of network lifetime by efficient utilization of sensor nodes especially power savings has become an open area research in WSN.

The two basic tasks in WSN are computation and communication[3]. It is found in research that communication task consumes more energy that other tasks[1]. Hence optimizing the communication is the key to energy saving in WSN thereby network lifetime is prolonged.

The lifetime of the network is defined to be the time at which the first node runs out of its energy[2].Hence if it is desired to prolong the lifetime of the network.Two main options available are :topology control,by designing power aware routing algorithms. Among many routing algorithms, data aggregation based algorithms plays a keyrole for power saving while achieving information reliability[1].The key idea of data aggregation algorithm is, the data from various sensors is aggregated by a data centre(head nodes) and only head nodes communicate to sink node. Hence the energy is saved by minimizing the communication to only one head node.Election of head node becomes a crucial task for such algorithms. Many algorithms like LEACH[7],PEGASIS[7],K THEOREM[7],use their technique.

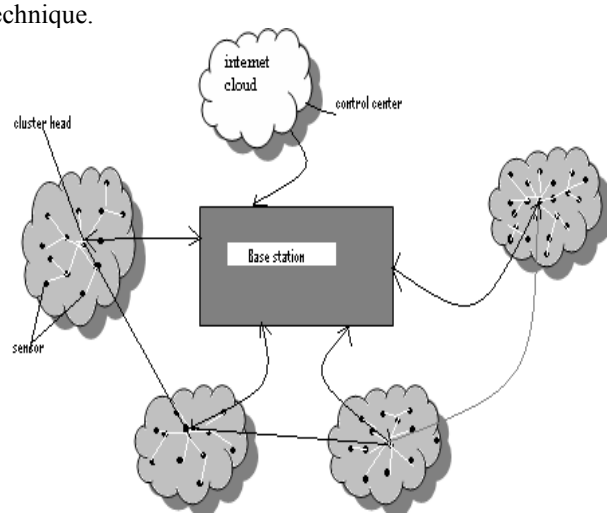

figure1.Cluster based wireless sensor network architecture

In this paper an approach is presented for maximising the lifetime of WSN through cluster head selection using hitsets.Hitset is a special case of setcover problem which covers minimum elements from all the sets.Since the main aim of this work is to reduce the number of communicating nodes,hit set concept gives the optimal solution for identifying minimum number of active nodes. The node attributes ,degree of the node and distance to base station will help in the final decision of the cluster head. It is found through analysis that by

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reducing the communication cost and sending as many nodes as possible to sleep mode, the network life time is prolonged.

The rest of the paper is organized as follows: Section II discusses about the basic definitions and assumptions .Section III outlines the procedure for election of cluster head. Section IV gives an illustrative example and theoretical analysis of the procedure. Section V gives the Conclusion and future work.

2. Basic definitions and assumptions:

The following are the assumptions of the algorithm.

1. The network is homogeneous
2. The nodes in the network are adhoc.
3. The algorithm is operational at time t.
4. The Clusters are already formed.

Basic Definitions:

Residual energy:

The lifetime of the networks is commonly taken to be the time at which the first node runs out of energy. This is actually determined by the residual energy levels and energy consumption rates of network nodes[2].

Since we assume that algorithm is operational at time t, the network nodes have variable residual energies. The energy is represented in three levels: high, medium, low. The nodes which have high and medium residual energy levels will form the topology at time t.

Hit set:

Given a set A={a1,a2,..an} a collection B1,B2,..Bm of subsets of A and a number k. There exists a Hit set H C=A of size k, such that $HUB_i \neq \emptyset$, $1 \leq i \leq m$ [6].

Given a graph G=(v,E) and a number K,we first define the set A in hitting set instance to be the V of nodes in the vertex cover instance. For each edge e_i = (ui,vi) C E, we define a set Bi = {ui,vi} in the hitting set instance.

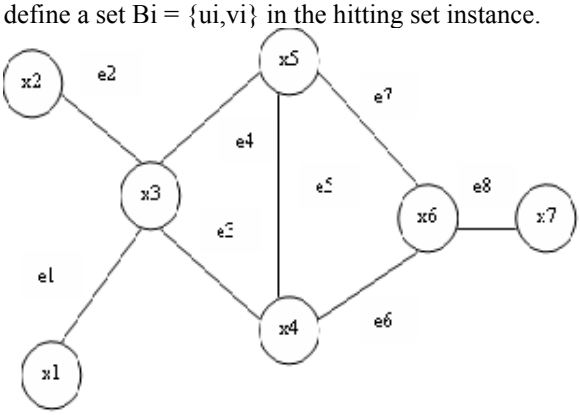

figure2. Sample network

From the construction , B1 ={X1,X3}, B2={X2,X3}, B3={X3,X4}, B4={X3,X5}, B5={X4,X5}, B6={X4,X6}, B7={X5,X6}, B8={X6,X7}. Hitting set is the vertex cover {X3,X5,X6} and the requirement of being a hitset holds.

Election of Cluster head:

Since it is the communuction task which consumes more energy of nodes, if all the sensors sends the information individually to the base station ,nodes will get drained quickly and hence network operable lifetime decreases. Hence cluster based communication in WSN has gained prominance in increasing the lifetime of the network. In cluster based communication,a cluster head is elected to gather information from all the sensors in a cluster and transmit it to the base station. Hence the election of cluster head plays a prominent role for efficient communication. In the proposed algorithm, cluster head is elected from each cluster hitting set[from previous step]. A node with the maximum connectivity covers maximum number of nodes in the cluster. So, we consider the node degree for finding the node with maximum connectivity. So,set of clusters in the network form a hyper set of nodes that which communicate with the base station.

If more than one node has the same degree, then the node with the less distance to the sink node has the higher probability to become a cluster head as the energy consumption is directly proportional to the square of distance to the sink node[3].

3. Procedure for election of cluster head

Step1:Consider the initial cluster assignment of sensor nodes in a network.

Step2:Identify the nodes based on the residual energy(high,medium) to form the current topology of the network.

Step3:Identify hitting set nodes from the below procedure for each cluster.

Step (a): Identify subsets covering each edge.

Step (b): Perform intersection operation on each set.

Step (c): Place the common element in the hit set.

Step (d): Continue step(b) and step(c) until all subsets are covered.

Step (e): The resulting set is hitting set

The nodes in the hitting set are the communicating nodes in the network.The remaining nonparticipating nodes in the current topology are sent to sleep mode.

Step 4:Identify the cluster head from each cluster. A set of cluster heads from each cluster forms a hyper set.

4. Illustrative Example and analysis:

In this paper we consider a wireless sensor network with 4 clusters c1,c2,c3,c4 respectively.Cluster1 consists a total of 15 nodes,cluster2 consists of 20 nodes,cluster3 consists of 25 nodes,cluster4 consists of 30 nodes. The example is worked out for cluster1 and the results are tabulated.

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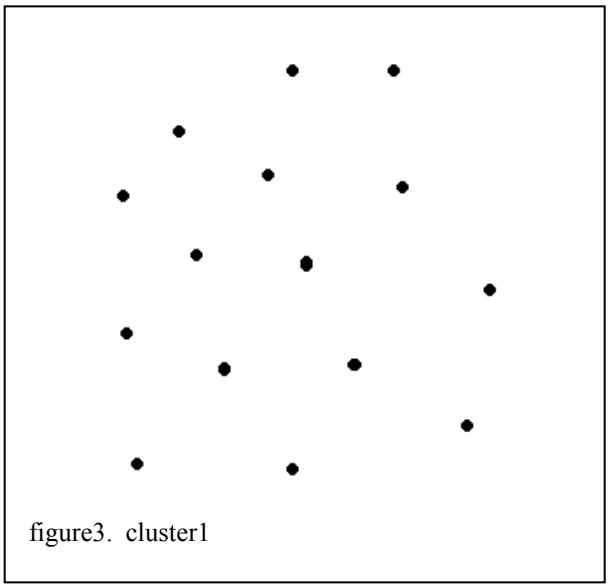

figure3. cluster1

Step1.

Clusters	Node-ID	Residual Energy	Decision
C1	1	high	Yes
C1	2	high	Yes
C1	3	med	Yes
C1	4	med	Yes
C1	5	med	Yes
C1	6	Low	No
C1	7	Low	No
C1	8	Low	No
C1	9	High	Yes
C1	10	Med	Yes
C1	11	Low	No
C1	12	High	Yes
C1	13	Low	No
C1	14	Med	Yes
C1	15	High	Yes

Table1.Node residual energies in cluster1

Step 2:
From the above table the following nodes are identified to form the toplogy based on the residual energy of the nodes.
The neighbourhood among the nodes in the topology is defined based on RSSI.

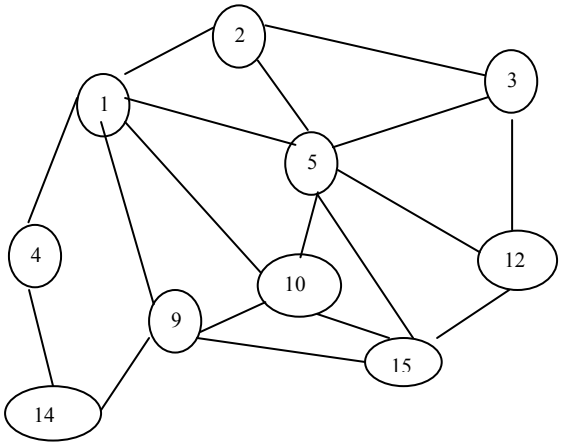

figure4. Network formed with minimum residual energies

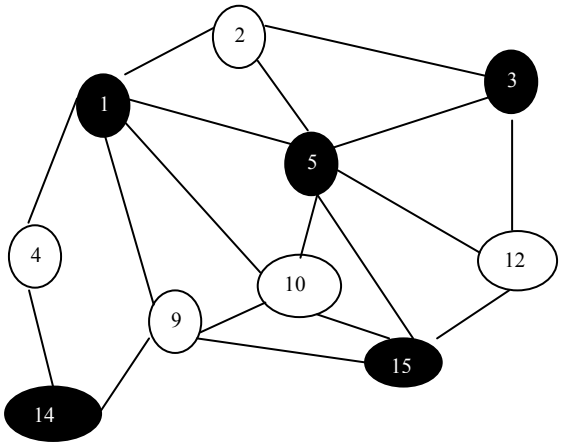

figure5. Hit set nodes in the given cluster

Step 3:
Hit set for the above network
H={1,3,5,14,15}
The remaining nodes are sent to sleep mode.
Step 4:
Identifying cluster head

Node-id	Degree of the node
1	5
3	3
5	6
14	2
15	4

Table2.Hit set nodes along with degree

Since node 5 is having the highest degree ,it is selected as cluster head.
Similarly the algorithm is applied for every cluster in the network and corresponding hit set, cluster head are

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identified. The set of all the cluster heads form Hyper set C.

Analysis:

In a Wireless Sensor network ,more energy savings is obtained by having as many sleeping nodes in the network as possible. Hence, in the above example maximum node reduction can be obtained based on residual energy and connectivity of the nodes.The following table gives the information of the node reduction ratio and prolongation of cluster lifetime for the above mentioned example.

Cluster	Total nodes	Sleeping nodes	Node-reduction ratio(%)	Prolongation of cluster life time
Cluster 1	15	10	67	3 times
Cluster 2	20	15	75	4 times
Cluster 3	25	20	80	5 times
Cluster 4	30	25	83	6 times

Table3.Node reduction ratio for the example WSN.

5. Conclusion

The objective of maximizing the lifetime of the wireless sensor network is achieved by making minimum number of nodes to participate in communication. In this paper a method for selecting the minimum number of participating nodes is discussed.An Initial set of active nodes are identified based on the residual energy. Further, the list of active nodes is reduced using hitset .The election of cluster head is done based on the connectivity of the selected nodes in the network.It is observed from the above analytical example that as the network is fully connected more number of nodes are sent to sleeping mode and hence high node reduction ratio and maximum network lifetime is achieved.

6. References

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