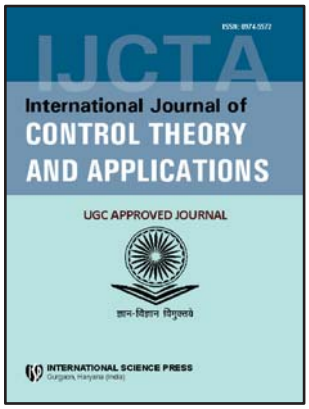

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Optimum Routing of Data through Cluster Head in Wireless Sensor Network

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Abstract: To transmit data involving more number of nodes in wireless sensor network (WSN), the path identification always plays a vital role for data transmission from sensor node to the sink. To reduce the time required in identifying a path we propose a cluster formation and choosing a path between sink and the cluster heads of various clusters. The cluster head after receiving the packet redirects the data to the global sink. Instead of transmitting the data to all the nodes in the network only cluster head and the intermediate nodes is chosen for the data transmission. The intermediate node and cluster head alone is sufficient for efficient communication in WSN, thereby reducing the traffic in the network and avoids congestion and saves the energy of the node involved in the WSN. The Cluster head is chosen based on its energy level and the cluster head is iteratively chosen among the various nodes in the cluster to ensure every node actively participate without any selfishness.

Keywords: *Sensor, cluster, Congestion, Energy, nodes.*

1. INTRODUCTION

In the Wireless sensor network (WSN) the data transmission among the sensor nodes causes the entire network to be flooded with data. Most of the routing protocol first transmit the data to the entire possible route and then identifies the shortest path in the network. This causes almost the entire node to participate in the communication for path identification even though it is not the intended receiver. This causes the loss of energy of the various sensor nodes for receiving the data and forwarding it to the nearby node. Also wherever a link or path in the network is broken then to identify the new path again the same procedure is carried out. As is it a sensor network the probability of change in the network topology is more when a sensor node drains out and the procedure of route discovery will often has to be implemented. This will often involve all the sensor nodes in the network which will often flood the network with data and the overall efficiency of the network in terms of the bandwidth and energy will degrade drastically. To avoid the unwanted flooding we suggest the formation of the cluster and then choosing the cluster head in the nodes of the cluster. After the formation of the cluster head, the sensed data is transmitted between the cluster head to the global sink. When the distance between the cluster head and

the global sink is more, then the sensed data from cluster head is transmitted through the various clusters and then reaches the global sink. For the data transmission in the WSN, the sensor node first sends the data to its cluster head; the cluster head forwards the data to the various cluster heads in the network and finally the data reaches the global sink. This procedure help in overcoming the unwanted traffic in the network and hence the resource like bandwidth is used effectively in the WSN. The cluster head often updates its table as the network is a dynamic network. Whenever in WSN the cluster head energy drops below the threshold value, a new cluster head is chosen and the details of cluster head is communicated with the nearby cluster heads.

Most of the routing protocol finds the shortest path and updates the route of the shortest path in the routing table. Whenever a link is failed or whenever node energy drains out, the search of a new route is carried out and that route is updated in the routing table. In this paper to eliminate the previous method the group of node called as the cluster is formed and the node in the cluster head which has the highest energy level is chosen as the cluster head. To choose a node to be a cluster head the main criteria a node has to satisfy is its energy level should be above the threshold level. To ensure that every node in the cluster is participating in the data transmission each node in the cluster is given a chance of being cluster head. This is achieved by assigning a node to be a cluster head when the previous nodes energy drops below the threshold value.

The cluster head updates the table whenever a node joins or leaves the cluster. With this information the data transmission across the entire network is carried out with ease. In the previous method only the route discovery is updated in the table but in the proposed WSN the details of the node involved in updated. So in our proposed method instead of the route updating the details of the node in the clusters is updated. So whenever a node needs to transmit the data it directly sends the data to the cluster head. The latency caused in the previous method is also overcome in our proposed method. So overall the performance of the network is significantly improved. The delay in data transmission is reduced, the bandwidth is used effectively, and the energy of the various nodes participating in the WSN is saved. Even the formation of the new cluster head is done instantaneously by comparing its energy level to the threshold value and there is no disturbance in the network reformation.

2. RELATED WORKS

For collection of data in a WSN a mobile node named Sencar is proposed, which goes through the location of the various sensor nodes and collects the data in a multi hop procedure [1] [2]. The advantage of using the Sencar for data collection is the bottleneck problem is getting eliminated. When each individual sensor node transmits the sensed data simultaneously to the global sink, then the data at the sink wait in a queue. When the data in the queue is more than the buffer size, then the data send will be lost. As in the case of WSN, the energy constrain of the sensor node plays a major role, an optimum solution for transmission of data is important. The Sencar method of data collection eliminated these problems, but for sensitive application when the sensed value has to reach the sink immediately this method cannot be implemented. To minimize the energy spent by the sensor node, the sensor node in the sensing field is made active based on the demand [3]. For some application where the environmental condition remains the same, instead of gathering the data from all the nodes, only the data is collected from the selective node. The remaining node in the field is turned off to save the energy of the sensor nodes. The protocol provides the coverage area of the required area alone and if required the coverage area can be scaled. For the environmental condition which varies randomly the sensors over the entire coverage area remains active. This method helps in saving the energy by careful monitoring the environmental condition and selectively making the sensor node to be active over the region of coverage.

The Various parameter should be considered to get the best optimization in WSN namely path identification, path length, energy of the sensor node and eliminating the collusive node [4]. The collusive node in the sensor network pose a great threat as the resource like the energy spent for the data transmission goes in vain. These collusive nodes also flood the network with unwanted data transmission. The collusive nodes which degrade the performance of the WSN can be eliminated by the cryptography techniques. For the application involving

operation related to industrial automation, the light weight header can be used. As using the light weight header will ensure the traffic and the energy spent will be less. For the application which involves very secure operation like one in military operation, a high level encryption and cryptography scheme is used [5]. So based on the application of interest the choice of header weight is chosen.

In WSN, energy harvesting method is used; the energy needed for the sensor node is calculated before the transmission of the sensed data [6]. Since the energy transmission is estimated, it has to ensure that the error should be minimum, so the mean square error is observed over a period of time and its average value is calculated and the best solution is derived out. The energy required by the sensor node is derived from the renewal resources such as solar power or wind power. The power generated by the renewal source should be above the energy level required by the sensing node for sensing and transmitting the data. The energy harvesting method is suitable in the location where the possibility of renewal energy is available. For the location of sensor in dense forest region it is not possible to implement the energy harvesting method.

In certain industrial application the routing of the data has to be collected from two different sensors, as in some control application two sensed data are required [7]. So to monitor a certain event and collect the data simultaneously both the event has to be synchronized. For this purpose a controller is used enabled with a timer, based on the timer the data is simultaneously received from the two sensors. The sensed value is given as an input to the controller and based on the sensed value a corrective action is taken if requires. The practical issues are delay caused in execution of the program and the communication delay. The correlation between the nearby sensor nodes is analyzed and the similarity in the data transmitted by the sensor node helps in eliminating the redundant information [8]. The WSN is classified based on the arrangement into two types one in flat WSN and another is hierarchical WSN. In a flat WSN the nearby node communicates with each other and with the received information the node comes to a decision about the suspicious node in the network. The final decision about suspicious node is made after receiving a message from the majority of the sensor node. The transmission of the sensed data individually to the global sink consumes more energy by the network. But the hierarchical model is best suitable for the saving the energy in the WSN.

The routing of the data in the WSN has to be done by choosing a path which provides a better packet delivery ratio [9]. The collection of data and routing it properly to the sink help in effectively utilizing the network resource like bandwidth and minimizing the packet loss. The nodes are classified into two type's namely high priority and low priority nodes. The path chosen with the high priority nodes which has a high packet delivery ratio compared to the path chosen for node with low priority nodes. Whenever a path is with low priority node formed the algorithm quickly does the assessment to find the path involving node with higher priority.

3. DATA TRANSMISSION THROUGH VARIOUS CLUSTERS

For a large sensing area more number of sensor nodes has to be implemented. When each and every sensor starts transmitting the sensed data then network will be loaded with a heavy traffic. Also the path discovery will become tedious as a path has to be found from each sensor node to the global sink. And whenever a link is failed due to draining out of relay node then path finding will be a major problem. For some sensitive application the delay created in the WSN will degrade the overall performance of the network. To overcome this group of sensor node are combined together to form a cluster [10] [11]. For every cluster a cluster head is selected, which maintains a table about the sensing node involved in its cluster. The sensor node instead of transmitting the data to the global sink which is at a far distance transmits the data to the cluster head. The cluster uses a time division multiple access technique to collect the data from all the sensor nodes in its cluster [12]. After collecting the data the cluster head transmit the data only to the other clusters through the intermediate nodes and reaches the global sink. Sine in our proposed algorithm only the cluster head are involved in the data transmission the path identification technique is simpler compared to the previous technique. The technique of formation of the cluster is first discussed, followed by iteratively changing the cluster head is discussed and route modification whenever a cluster head change occurs is discussed. The diagram shown in the figure 1 indicates how the sensed data is transmitted from the Sensor node A to the global sink through the various clusters.

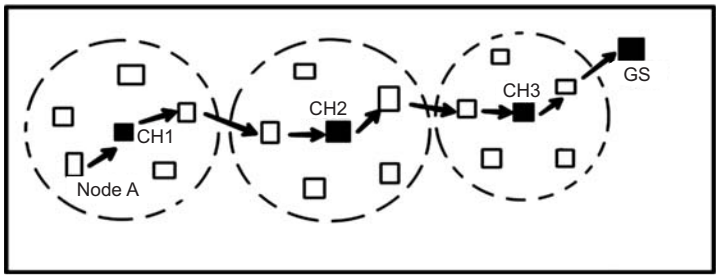

Figure 1: Sensed Data from Node A routed Through Various Cluster Heads (CH) to Global Sink

4. IDENTIFYING CLUSTER HEAD

The flowchart shown below in figure 2 describes the step involved from cluster head creation and updating of the cluster head table.

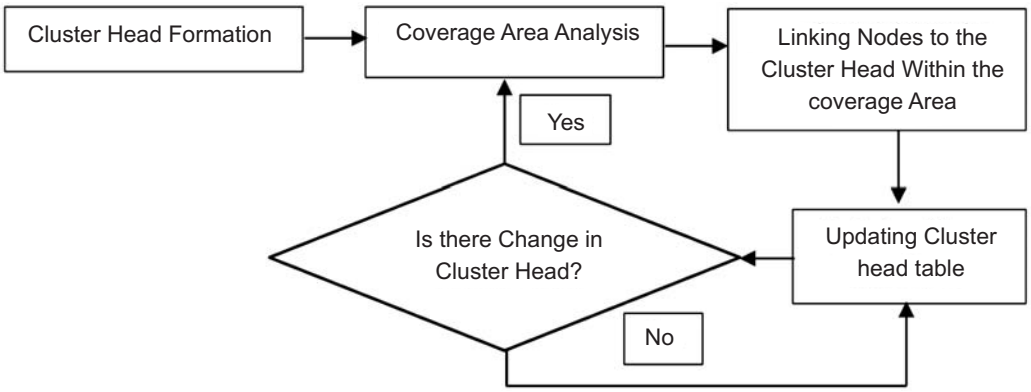

Figure 2: Steps in Analyzing Coverage Area and Linking Mobile Nodes

The steps in formation of the cluster are;

1. Identifying the node with energy level above the threshold
2. Analyzing the coverage area of the cluster head and linking the nodes to the cluster head
3. Creating and updating the table about the details of the node involved in the cluster.

4.1. Identifying the node with energy level above the threshold

For the WSN which involves a more number of nodes the size of the network increases with increases in the number of participant that is sensor nodes. With increase in the network size the overhead associate with the data transmission also increases. For deploying efficient WSN, the overload is to be as low as possible. To make this a possible the number of node involved in the communication is to be minimized. When lesser number of nodes participates in a network lesser energy is spent for the transmission and the reception of the data. This can be achieved by choosing a node to be a cluster head. The main purpose of the cluster head is to relay the data through various cluster head to the global sink. So always the cluster head will be involved in the communication. So the node which is chosen as the cluster head should have an energy level supporting this requirement. The process starts by choosing a node with sufficient energy above the threshold energy level. The overall area it divided into subarea and for the each sub area a cluster head is chosen by comparing it node energy with the threshold energy level. Initially the threshold value is chosen to be 50 % of the maximum energy level of the sensor node.

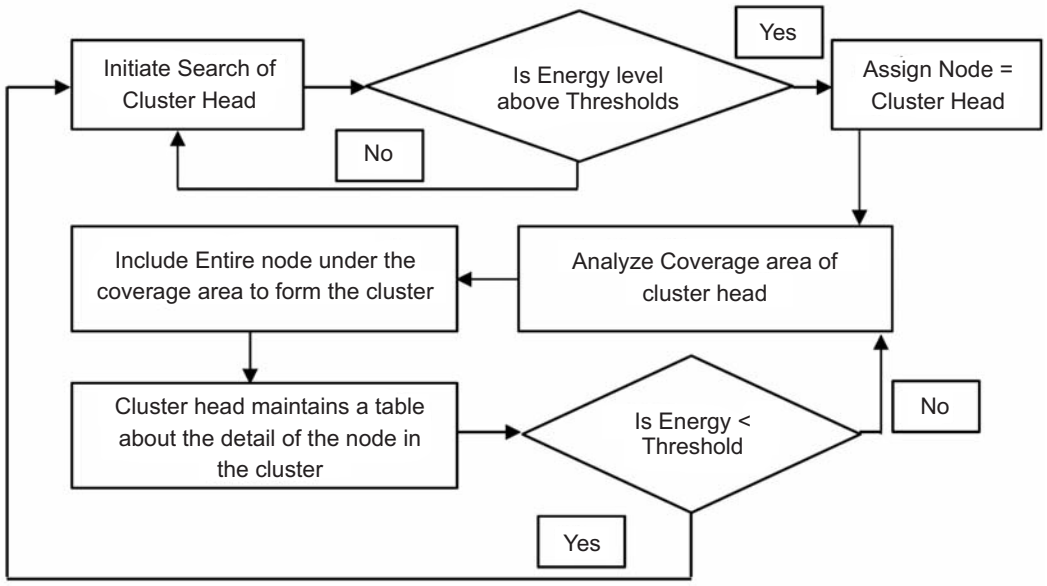

Figure 3: Flow Chart for Identifying the Cluster Head

The above figure 3 clearly shows that the node with energy level above the threshold is chosen as the cluster head as long as its energy level is above the threshold. The main advantage of the formation of the cluster head is that the data transmission is will carried out between the various cluster head alone. The cluster head in turn transmit the data to the global sink through various cluster head. Since only the cluster heads and the sensor nodes are involved in the transmission the unwanted flooding of the data is avoided in the network. Otherwise a sensor node will transmit the data to the entire node and the data will reach the global sink through multi hop communication resulting in deploying the energy of the entire sensor node involved in the communication. It is found clearly that the other node which is not intended receiver also receives the data, which is totally unnecessary. So our proposed method helps in reducing the traffic.

4.2 Analyzing the coverage area of the cluster head and linking the nodes to the cluster head

After choosing a node to be a cluster head, the next objective lies in forming a cluster. The cluster is formed by linking the node to the cluster head which lies within the coverage area of the cluster head [13]. After linking the sensor nodes with the cluster head the cluster formation is complete. Now sensor node which wants to transmit the data will directly transmit the data to the cluster head instead of searching of a route. This eliminates the delay caused in the previous methods. The antenna used by the mobile nodes involved in WSN is Omni directional antenna. Thereby the coverage area of the antenna will be over entire 360 degree.

When a node lies between two cluster head, the node selects any one cluster head which is at a shorter distance from it. Let the location of the node be ($n1$, $n2$), where $n1$ and $n2$ represents the x and y coordinate of the node. Let the location of the cluster head one be (ch1,ch2) and location of the cluster head two be (ch3,ch4). The node joins the cluster 1 when it satisfies the condition

$$d(\text{Ch1, N}) \; < \; d(\text{Ch2, N}) \tag{1}$$

$$\sqrt{(n1-\text{ch1})^2+(n2-\text{ch2})^2} \; < \; \sqrt{(n1-\text{ch3})^2+(n2-\text{ch3})^2} \tag{2}$$

Where d(Ch1, N) is the distance between node and the cluster head node and d (Ch2, N) is the distance between node and the cluster head two. If the condition fails then the node joins the cluster 2 and sends the sensed data to the cluster head 2. The figure 4 shown below indicates the coverage area of cluster linking the nodes under its coverage.

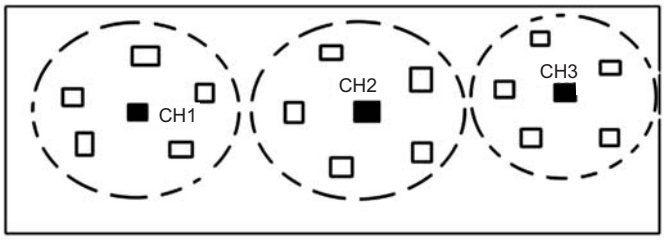

Figure 4: Cluster Head (CH) Linking the Nodes under its Coverage Area

4.3. Creating and updating the table about the details of the node involved in the cluster

Once a cluster is formed and the mobile nodes are linked to the cluster then the cluster table is created. The cluster head table consists of the details of the sensor nodes which has joined the cluster. This table helps the cluster head to check and collect the sensed data from the all nodes within the cluster. So whenever a new sensor node joins the cluster then that particular node is updated in the table. Similarly whenever a node leaves the cluster the details of the node is removed or deleted from the table. The details of the sensor node in a table will also be removed when the energy of the node completely drains out. Also when a new cluster head is created the cluster head table is updated. Since the formation of the cluster occurs over the entire region of coverage all the sensor nodes in the network will be linked to any one of the cluster head in the clusters. Any node involved in WSN will have its details in the any one cluster head table. Also the network is avoided with unwanted loading and hence our proposed method reduces the conjunction in the network. The cluster head act as a local sink by collecting and transmitting the data under its cluster.

5. CHANGING CLUSTER HEAD ITERATIVELY

After the formation of the cluster, the cluster head receives the data from the sensor node and forwards the data to the global sink through the intermediate clusters. Since the cluster head has to collect and transmit the data, the power level of the cluster head decreases. When the energy level of the cluster head completely drains out then not only the cluster head is inactive but all the sensor nodes in the cluster also become inactive as there will not be any node to collect the data from them. To overcome this energy of the cluster head is monitored and whenever the energy level is below the threshold then the search of new cluster head is carried out and a new cluster head if formed. Now the new cluster head will take the role of collecting the data from its clusters and forwarding it to the global sink. To avoid any selfishness all the node in a cluster is given a chance to be a cluster head. Only after ensuring all the nodes in the cluster is taken in charge of cluster head, then the threshold value is decreased further. This process is carried out iteratively so as to ensure a particular sensor node draining out quickly and getting isolated from the WSN is eliminated [14]. The equation 3 mentioned below indicates the remaining energy of the node after forwarding the sensed data.

$$En = Ei - (Et + Er) \quad (3)$$

$$En = Ei - Es \quad (4)$$

Where E*n* is the remaining energy of the node, E*i* is the initial energy of the node and E*s* is the energy spent in transmitting (E*t*) and receiving (E*r*) the sensed data. When the E*n* < E*thr*, Where E*thr* is the threshold energy, then the search of the new cluster head is carried out. Since the data is collected by the cluster head and then forwarded to the global sink through the various cluster head the cost of the energy aggregated in forwarding the sensed data is given by

$$Ef = \text{hop}(n, g) * E(\text{Packet Size}, d) \quad (5)$$

Where hop (*n*, *g*) represent the number of hop count between the sensor node and the global sink. Here the packet size indicates the aggregated packet from various sensor nodes and d is the radio range of the sensor used in the WSN.

Algorithm for Change in cluster head and Life time calculation:

Step 1: Setting the timer

Step 2: Assigning the Energy of cluster E*n* = E*i* – (E*t* + E*r*)

Step 3: When E*n* < E*thr*, Go to step 6

Step 4: Else the same node remain as Cluster Head

Step 5: Go to step 3

Step 6: Search for new cluster head

Step 7: Repeat step 3 to 6, till all nodes is chosen as cluster head

Step 8: Decrement the threshold value, increment the round count and repeat the above procedure

Step 9: Count if E*n* = 0

Step 10: When all nodes energy = 0, Stop the timer

Step 11: Lifetime of entire sensor node = Assign timer value

Step 12: Display the total number of rounds.

6. ROUTE MODIFICATION

Whenever a cluster head is changed following the drop in its energy level below the threshold, then the following steps are taken.

1. The New Cluster Head should intimate the other cluster heads.
2. Analyzing the coverage area of the new cluster.
3. Linking the sensor node to its cluster and updating the cluster head table.

The route is always carried out between the various cluster heads as stated before. So whenever the energy level of the cluster head drops below the threshold level, a new cluster head is chosen and from then onwards the data getting routed to the previous cluster head is forwarded to the new cluster head. So whenever there is change in the cluster head, the intimation is given to all remaining cluster and the new route is formed. Since a minor modification is done in the new route the overall performance is not affected in our proposed work when compared to the existing method.

7. PERFORMANCE EVALUATION

The simulation was carried out using the open source software NS2. The result obtained in our proposed work is compared with the methods such as direct diffusion and Low energy adaptive cluster based routing (LEACH).

Table 1
Simulation Parameters

Parameters	*Values*
Dimensions	1500*1500 m square
Number of Sensor Nodes	350
Number of Global Sink	1
MAC Protocol	IEEE802.11 DCF
Antenna Type	Omni Directional
Antenna Range	100 m
Initial Power	10 W
Transmitting and Receiving Power	42mW and 29mW respectively
Packet Size	64 bytes

The parameters such as packet delivery ratio, deadline miss ratio and the life time of the sensor node are compared with the existing methods. The result shows our proposed method performance well and saves lot of resource in WSN. The table 1 above shows the detail of the simulation parameter used in the proposed method. The graph shown in the figure 5 below shows the comparison of the packet delivery ratio with respect to the distance from the global sink. The packet delivery ratio is the ratio of the number of packet successfully received to the total number of packet send. From the figure below it is evident that as the distance increases the packet delivery ratio decreases as the chances of the packet getting lost is more. But since in our proposed method the path is formed between the various cluster head, the packet loss is less and the proposed method provides a better packet delivery ratio.

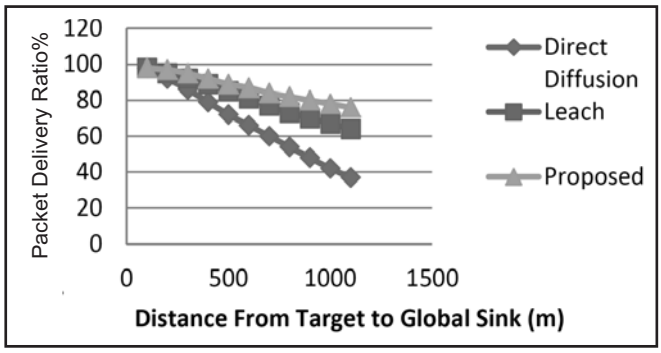

Figure 5: Packet Delivery ratio (%) vs. Distance from Target to Global Sink (*m*)

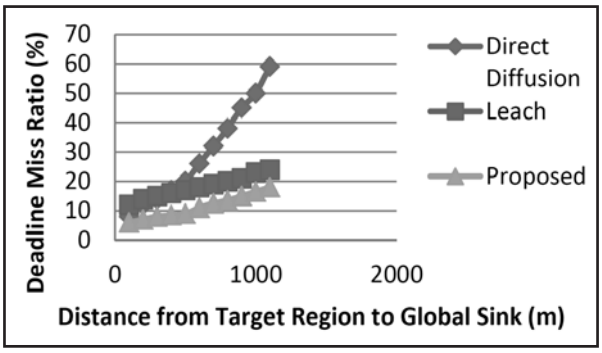

Figure 6: Deadline Miss Ratio (%) vs. Distance from global Sink (*m*)

The next parameter is the dead line miss ratio. Every packet has to reach the destination within a stipulated period of time otherwise the data is discarded. Since a path is formed between the various cluster head and the global sink the sensed data reaches the sink through the path created. So the proposed method shows a very less target miss ratio compared to the existing methods as shown in the above figure 6. The time over which the sensor remains live is the life time of the sensor. In the direct diffusion method the energy of the sensor node drains out quickly as each sensor node transmit the data directly to the global sink. Since a path is created in our propose work the sensor node stays live for more duration when compared with the Leach as shown in the figure 7 below.

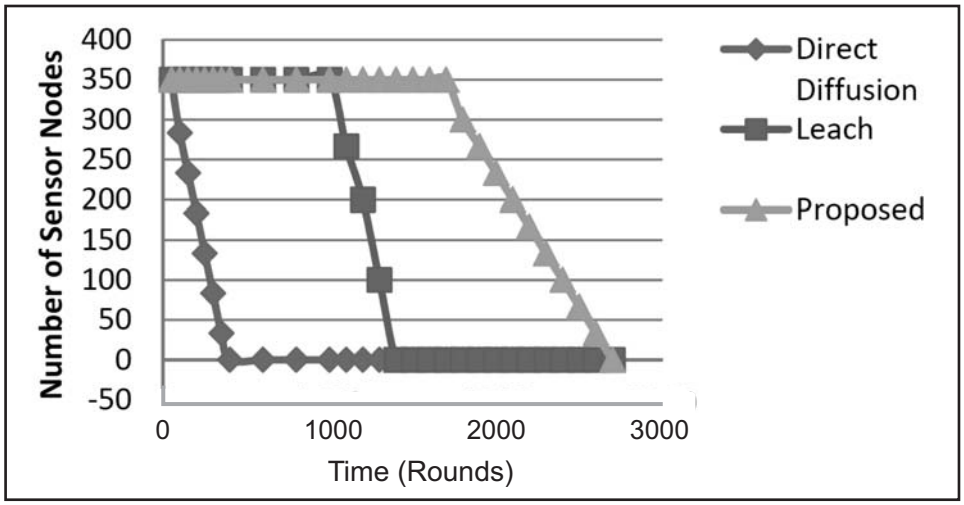

Figure 7: Sensor Node Life vs. Time (Rounds)

8. CONCLUSION

We have created a path between the various cluster head to the global sink, which helps the data transmission to reach the global sink without much constrains. Whenever the route is modified the new route creation does not disturb the WSN. The sensed data is relayed over the various cluster head and finally reaches the global sink. By this method of routing the data, it is evident from our result that the proposed method help in increasing the life time of the sensor network and minimizing the packet loss and improving in the deadline miss ratio.

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