Hybrid Sink Repositioning Mechanism For Wireless Sensor Network

D. P. Mishra[1], Ramesh Kumar[2]
Research Scholar CSVTU[1], Professor CSE, CSVTU[2]
Email: mishradprasad@gmail.com[1], rk_bitd@rediffmail.com[2]

Abstract- Wireless sensor networks are a collection of tiny resource-constrained sensors deployed in a dense mode in a specific area to interact and accomplish specified tasks; major challenge that affects the lifetime of wireless sensor network is uneven, unpredictable energy consumption by nodes, in this paper, we have proposed a Hybrid mechanism for the deployment and repositioning of the Optimal Number of Sinks in wireless sensor network to increase the lifetime of sensor network and nodes. Sink deployment can provide an optimal solution but its not always feasible since it requires precise knowledge of the monitored area for the proper and optimal repositioning of the sink, in order to maintain the residual energy of wireless sensor nodes that improve lifetime and performance of the network. Proposed hybrid sink re-positioning technique will overcome issues specific to energy holes. In our case, we have used both stationary and moving sinks to gather the data from the sensor nodes.

Index Terms-WSN, Sink Node, Mobile Sink, Energy hole, Network lifetime.

1. INTRODUCTION

Most of the earlier studies in WSNs focused on improving the overall network performance by considering the presence of a single stationary sink. The traditional approach of keeping a single sink is having a major drawback that degrades network performance. One such problem is called a single sink neighborhood problem, where the sensors within a one-hop distance from the sink have to relay the sensing data for the other sensors that cannot reach the sink directly. As a result, these sensors consume much more energy than the others do. Once they deplete their energy, the network will be partitioned and the sink will be disconnected from the rest of sensors even if those sensors are still operational with sufficient residual energy.

With the increase of network size, the single sink neighborhood problem becomes worse. The other is the network connectivity issue. It is compulsory that the network consisting of the sink and sensors should be connected. Otherwise, the data generated by the sensors in a fragment different from the fragment in which the sink is located cannot be collected. To address an issue specific to the single sink neighborhood, the sink multiplier strategy is utilized and demonstrated to improve various network performance including network lifetime[1], [2] average data delivery latency[3], and system throughput [4]. For improving the performance, multiple sinks are placed in the monitoring region. Lot more communication protocols have been proposed including other topology control [5], routing and clustering[6]. However, further, improvement can be achieved if we relocate the sinks in order to change over time the nodes located close to them. Thus, this can solve the energy hole problem and guarantee balanced energy consumption among the nodes.

2. RELATED WORK

Jun Luo et al [10] have investigated the problem of maximum lifetime data collection in WSNs by jointly considering sink mobility and routing. Continuous monitoring WSN nodes with accurate data generation rate were considered for accurate estimation. They also focused on the slow mobility approach and build a unified framework to cover most of the joint sink mobility and routing strategies. Kemal Akkaya et al.[11] have investigated the potential of sink repositioning for enhanced network performance in terms of energy, delay, and throughput. They addressed the issues related to when should the sink be relocated, where it would be moved to and how to handle its motion without a negative effect on data traffic. They have demonstrated two approaches that factor in the

traffic pattern for determining a new location of the sink for optimized communication energy and timeliness, respectively. Mohamed Younis et al [11] have investigated the potential of base-station repositioning for enhanced network performance. They addressed the issues related to when should the base-station be relocated, where it would be moved to and how to handle its motion without any effect on the data traffic. Presented approach tracks the distance from the closest hops to the base station and the traffic density through these hops. When a hop that forward high traffic is further than a threshold, the base-station qualifies the impact of the relocation on the network performance and moves if the overhead is justified.

2.1 Problem Identification

The approach, which is proposed in [12], is to place the Optimal Number of Sinks in Sensor Networks for Maximization of the lifetime. The main aim is to find the optimal number of sinks and their locations in a monitoring region for data gathering such that the network lifetime is maximized, subject to the constraint that each sink can only be placed at one of the given potential sink locations.

The following drawbacks are observed in this approach:

- In this scheme, the tree is constructed using the set of sink locations but node energy is not considered.
- There is no optimal searching solution when the sink is repositioned.

We propose n-Partitioned Minimum Depth Tree using the optimal search for placing optimum Number of Sinks in Sensor Networks for maximizing network lifetime. The first optimal number of sinks is determined using the optimal sink algorithm satisfying the h-hop constraint. Then n-Partitioned Minimum Depth Tree (n-PMDT) is constructed for positioning multiple sink nodes and setting up the routes.
The main advantage of this method is, the node lifetime in the construction of tree so the tree lifetime will be improved and we are placing the optimal number of sinks in sensor network for improving the network lifetime. Most important benefit overs here is computation will be ended in polynomial time.

3. METHODOLOGY

As soon as sink starts to move towards the next location in each step it will make the check for the sensor nodes who are one hop away from the sink node. If the sink is approachable then the last hop sensor nodes will adjust its transmission power so that the sink can receive the messages properly while moving to its next intermediate position. In an alternate situation if the sink goes out of the reach of sensor nodes, then it will look for a sensor node for relaying the data further. Overall, the designated or selected node must be in the range of the sink and the last hop sensor node as well it should have a sufficient amount of energy. The node with the highest energy is selected in case of multiple node availability. After this, the sink will update the routing table, broadcast it to the other sensors, and then proceed further to the next location.

3.1 Optimal Sink Positioning Algorithm

Using this optimal sink algorithm, the optimal numbers of sinks are selected to maximize the network lifetime. Let "S" - set of sinks and "ps" - the set of potential sinks. The set of potential sinks are derived from the set "S". In(ps) is the set of neighboring sensor nodes of sink s and Nh(ps) is the number of the hops from v to s no greater than h.

The collection of sets derived by the set S of potential sink location is C=Nh (ps) / ps ϵ S. Each sensor node reach one of the chosen sinks with no more than h hops and that is equivalent to finding a sub-collection ps ϵ S. Instead of using NP-complete, a greedy heuristic is employed then it provides approx solution to the problem with the approximation ratio of (logB), where $B = maxs \in S\_ \{|Nh(s)|\} \leq n$.
Consider a sensor CV is referred to be covered by a sink s if the number of hops from CV to S is no more than h; otherwise, CV is uncovered by s. If the sink is uncovered means it is not covered by the sink s.

1. Start
2. Sn = set of sink
3. V = set of sinks covered by Sn
4. ps = 0 // Initially all sensors in SV are uncovered
5. while S ≠ 0
6. {
7. If (Sn ∩ Nh(ps) = max)
8. Select a set Nh(ps) ϵ Sn
9. Ps ← Ps ∩ Sn
10. Sn ← ps ∩ Sn – Nh (Sn)
11. C ← C – { Nh (Sn)}
12. }
13. Return Ps
14. End

3.2 Algorithm: Optimal Sink Algorithm

As per algorithm, initially, all sensors in CV are uncovered and PS is set to empty. Iteration is done by while loop and each time it compares the sensors in the set with the covered sensors in the list.

3.3 Example of Optimal Sink Algorithm

Consider the example given in Figure 1. S is the set and it contains all the nodes (having high and low energy). ps is the set contains potential sets. In the optimal sink algorithm, initially, PS is set to empty. The algorithm selects a node that is having higher energy by carrying out an iteration process

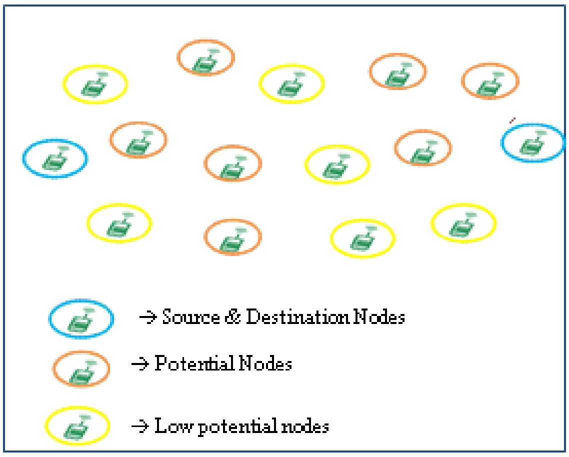

Figure 1. Example of optimal sink algorithm

If the number of hops from CV to S is not more than hop count then sink covered the sensor. If the hop count is the same those are nodes covered by the sink, otherwise, those set to be uncovered nodes. All covered nodes come into the ps set.

3.4 N-Partitioned Minimum Depth Tree

n-Partitioned Minimum Depth Tree (n-PMDT) is designed for a sensor network which has multiple sink nodes and a Minimum Depth Tree (MDT) is a tree constructed, that MDT minimizes the cost from each vertex. In n-PMDT, n means the number of sink node and it divides the sensor network into k disjoint partitions.

The n-PMDT algorithm is applied on k sink nodes and for every possible combination of k sink node. The set of sink nodes, which maximize Vmin, is chosen. Vmin is the minimum volume produced at a sensor node.

n-PMDT algorithm

1. Start
2. Define
3. For ($\sum_{i=1}^{k} Ci \neq 0$)
4. {
   For each sensor node in the list
   {
   For each sink node
   {
   The shortest path is calculated for each sensor node to the sink node.
   }
5. Choose the sink node as a root of the MDT which has the shortest path among all paths to several links
6. }
7. Calculate the Vmin for each partitioned MDT using the equation (2)
8. Select the minimal Vmin as a n -PMDT Vmin
9. }
10. Choose the best set of sink nodes which maximizes n-PMDT Vmin
11. End

In the n-PMDT algorithm, the shortest path is calculated for each sensor node to the sink node in the list. For example, if there are n sensor nodes and k sink nodes. The n-PMDT algorithm runs approximately n_{Ck} times to get the best set of sink nodes. Cnk First calculates the number of children for each sensor node in MDT and then calculate the link cost to the parent. The total data volume produced at each sensor node can be calculated from the following [13]

$$\text{Vnode} = \frac{Ei}{Nc*Pr+(NC+1)*PTchild}$$

Where –
Ei- Initial Energy of the sensor node
NC – no of Children
Pr - Receiving power consumption per bit
Pt – transmitting power consumption
Vnode – Total volume produced at the sensor node

The n-PMDT algorithm solves the shortest path problem from each sensor node to a sink node. There are multiple sink nodes in the sensor network, so a sensor node calculates the shortest path to each sink node. Then, the sensor node selects one sink node as a root of the MDT, which has the shortest path among the paths to several sink nodes. This process is repeated for every sensor node in the sensor network. In the given example shown in Figure 2. MDT is formed using potential sink nodes. The potential sink nodes are selected using the Optimal Sink Algorithm.

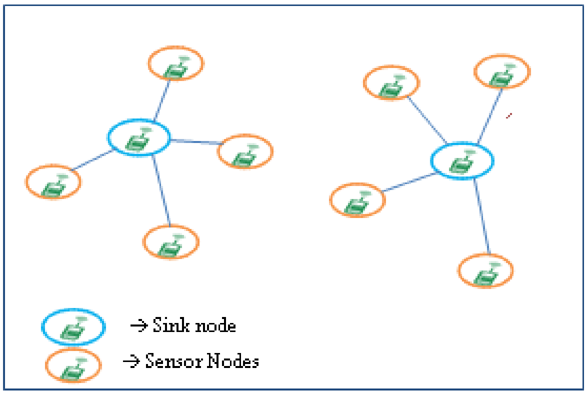

Figure 2. n-PMDT Algorithm

An n-Partitioned Minimum Depth Tree (n-PMDT) is constructed for positioning multiple sink nodes and setting up the routes. In the n-PMDT algorithm, the shortest path is calculated for each sensor node to the sink node in the list.
Sensor calculates the shortest path to each sink node, and selects one sink node as a root of the MDT, having the shortest path among the paths to several sink nodes this process is adopted throughout the network
After determining the optimal number of sink positions and routing, it would select the best sink reposition by optimum search method. In optimum search, local search approach is used to obtain the optimal solution; it forgot about the current sinks positions and solve the optimal multi-sinks position problem in a network

3.5 Sink repositioning algorithm

For the sink, repositioning the calculation of the distance of each node from the sink node is used, later on, the optimal location for the sink is calculated. The longest distance node from sink consumes more energy to transmit packet than the nearest node, longest distance node get depleted its energy before all other nodes which lead to energy hole problem[14]. For verifying the effect of repositioning total power, tx power of the node for the previous and next sink positions is evaluated and compared. Later on the gain in terms of power transmission is checked and if it is more than a threshold value then only the sink will be moved to a next position[15] or its optimum position otherwise it remains at the previous location and if further, the overhead is justified then only the sink will finally move to the next position.. It means as sink node moves to the central position, the distance of the last hop node from the sink node is decreases and energy consumption decreases[16].The flow of the sink repositioning algorithm is shown in figure 3.

1. Select sink node S from WSN kept in boundary X, Y Position.
2. Randomly deploy sink node S in the (X, Y) position.
3. Tabulate distance D between each node and sink node using the Euclidean distance formula.
   Dist(x,y) = $\sqrt{(x1-y1)^2+(ya-y2)^2}$
4. Tabulate Energy consumption Etx of each node to transmit and receive the packet based on distance from the sink node by using energy consumption formula [8].
   Etx (k, d) = Eelec × k + ε_{amp} × k × d^n
5. Tabulate average position for Sink node in the transmission boundaries (X, Y).
   AvgX = (Sumx(Dist)/number of node
   AvgY = (Sumy(Dist)/number of node
   New position for Sink node is (avgX, avgY)
6. Reposition the sink node to the new calculated position for sink node (avgX, avgY) in the transmission boundaries.
7. Repeat step **no.3** and step **no.4** respectively.
8. Distance and energy consumption of each node is compared before and after sink repositioning

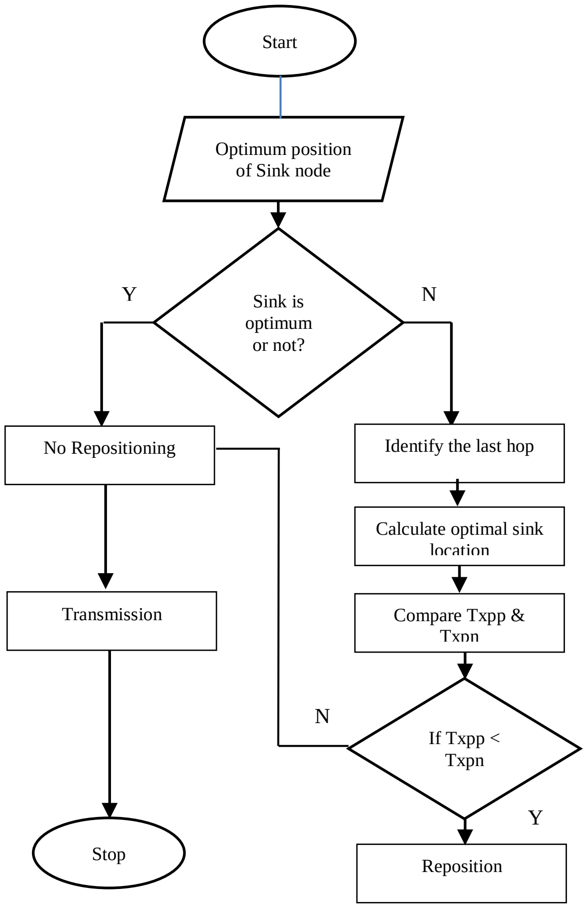

Figure 3. Flowchart of Sink repositioning algorithm

4. RESULT AND ANALYSIS

For simulating the proposed architecture NS2(Network Simulator-2) [17], is used. In the simulation, the mobile nodes move in a 500-meter x 500-meter region for 50 seconds of simulation time. Sensor nodes are kept at the same transmission range of 250 meters traffic used is Constant Bit Rate (CBR)[18]. The simulation settings and parameters are summarized in Table No.1.

TABLE -1 Simulation Parameters

No. of Nodes	20,40,60,80 and
Area	500 * 500
MAC	IEEE 802.11
Transmission	250m
Simulation Time	50 Sec
Traffic Source	CBR
Packet Size	512
Initial Energy	20.1 J
Transmission	0.6660
Receiving Power	0.035
Rate	50 Kb

4.1 Performance Metrics

The proposed Hybrid Multiple Sink Repositioning and Relocation (HMSPR) is compared with the n-PMDT technique and performance is analyzed based on.

- *Packet Delivery Ratio:* Ratio of received packets vs send packets.
- *Packet Drop:* Avg packets dropped in transmission.
- *Residual Energy:* Energy available with the nodes.
- *Delay:* Time is taken to transmit the data packet.

4.2 Analysis based on Nodes:

For analysis, we have done the utilization of a varying number of nodes and it would vary from 20,40,60,80 and 100

Figure 4. Shows the delay of HMSPR and n-PMDT for the different scenario the delay in our proposed approach is somehow similar to n-PMDT approach.

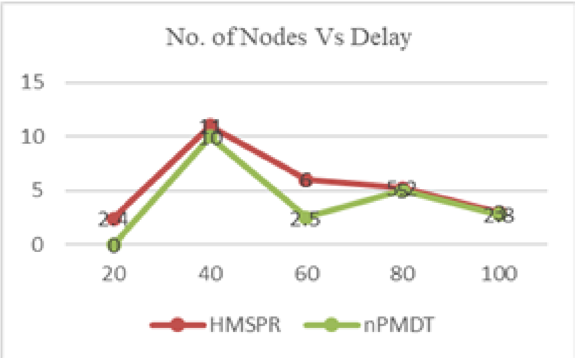

Figure 4. No. of Node vs Delay

Figure 5. Shows that the delay in the proposed HMSPR is 18% less than n-PMDT techniques.

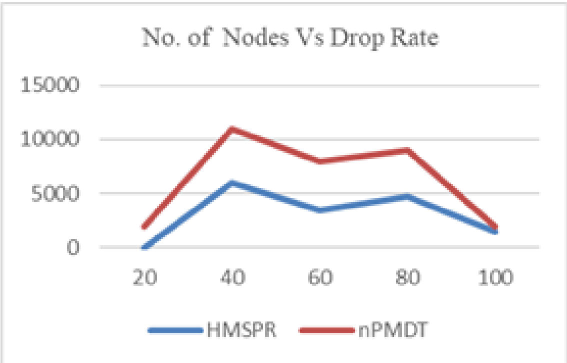

Figure 5. Node vs Delay

Figure 6. Shows the graph of Node vs Residual Energy that clearly indicates that residual energy level (energy of node after transmission) is comparatively better in HMSPR.

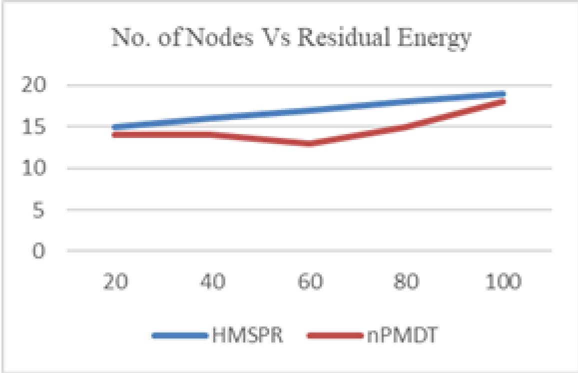

Figure 6. Node vs Residual Energy

5. CONCLUSION

We proposed n-Partitioned Minimum Depth Tree using the optimal search in Placing Optimal Number of Sinks in Sensor Networks for improving the Network Lifetime, it would finalize the optimal number of sink node by optimal sink algorithm. Then n-Partitioned Minimum Depth Tree (n-PMDT) is constructed for positioning multiple sink nodes and setting up the routes, once an optimal number of sink positions and routing is finalized then best sink repositioning is selected by optimum search method. Sink movement is based on intelligent movement and optimal position of nodes. The major advantage of this method is an optimal tree preparation on the basis of the lifetime of nodes. The proposed method is significantly improving the lifetime of the node, overall the network life and performance will be improved.

REFERENCES

[1] Y. Hu, Y. Xue, Q. Li, F. Liu, G. Y. Keung, and B. Li, "The sink node placement and performance implication in mobile sensor networks," *Mob. Networks Appl.*, 2009.

[2] O. Dousse and P. Thiran, "Latency of Wireless Sensor Networks with Uncoordinated Power Saving Mechanisms," pp. 109–120, 2004.

[3] A. Perrig and J. Stankovic, "Mobile Systems Security WSN security threats," vol. 47, no. June, pp. 53–57, 2004.

[4] M. Elappila, S. Chinara, and D. R. Parhi, "Survivable Path Routing in WSN for IoT applications," *Pervasive Mob. Comput.*, vol. 43, pp. 49–63, 2018.

[5] L. Tawalbeh, S. Hashish, and H. Tawalbeh, "Quality of Service requirements and Challenges in Generic WSN Infrastructures," *Procedia Comput. Sci.*, vol. 109, pp. 1116–1121, 2017.

[6] A. Akbari, A. Dana, A. Khademzadeh, and N. Beikmahdavi, "Fault Detection and Recovery in Wireless Sensor Network Using Clustering," *Int. J. Wirel. Mob. Networks*, vol. 3, no. 1, pp. 130–138, 2011.

[7] Y. B. Türkoğulları, N. Aras, İ. Kuban Altınel, and C. Ersoy, "An efficient heuristic for placement, scheduling and routing in wireless sensor networks," *Ad Hoc Networks*, 2010.

[8] W. Hu, C. T. Chou, S. Jha, and N. Bulusu, "Deploying long-lived and cost-effective hybrid sensor networks," *Ad Hoc Networks*, vol. 4, no. 6, pp. 749–767, 2006.

[9] V. Incze, D. O. V Ass, and R. O. V Ida, "Adaptive Sink Mobility in Event-Driven Densely Deployed Wireless Sensor Networks," pp. 1–35, 2006.

[10] H. Luo, J. Luo, Y. Liu, and S. K. Das, "Adaptive Data Fusion for Energy Efficient Routing in Wireless Sensor Networks †," pp. 1–34.

[11] M. Younis and K. Akkaya, "Strategies and techniques for node placement in wireless sensor networks : A survey," vol. 6, pp. 621–655, 2008.

[12] H. Song, S. Zhu, and G. Cao, "Attack-resilient time synchronization for wireless sensor networks," vol. 5, pp. 112–125, 2007.

[13] H. Kim, Y. Seok, N. Choi, Y. Choi, and T. Kwon, "Optimal Multi-sink Positioning and Energy-efficient Routing in Wireless Sensor Networks."

[14] D. Tian and N. D. Georganas, "Connectivity maintenance and coverage preservation in wireless sensor networks," *Can. Conf. Electr. Comput. Eng.*, vol. 2, pp. 1097–1100, 2004.

[15] K. Akkaya, M. Younis, and M. Bangad, "Sink repositioning for enhanced performance in wireless sensor networks," *Comput. Networks*, 2005.

[16] S. Guo and O. Yang, "QoS-aware minimum energy multicast tree construction in wireless ad hoc networks," *Ad Hoc Networks*, vol. 2, no. 3, pp. 217–229, 2004.

[17] S. Wu and K. S. Candan, "Power-aware single- and multipath geographic routing in sensor networks," *Ad Hoc Networks*, vol. 5, no. 7, pp. 974–997, 2007.

[18] R. Zheng and R. Kravets, "On-demand power management for ad hoc networks," *Ad Hoc Networks*, vol. 3, no. 1, pp. 51–68, 2005.