Secure Wireless Network Connectivity with Energy Aware Multipath Routing

A. Lalitha[1] P. Sasikumar[2]
[1]PG Scholar [2]Associate Professor
[1,2]Department of Computer Engineering
[1,2]Selvam College of Technology, Namakkal

Abstract— In wireless sensor networks the sender and receiver should sharing the message with secure and timely manner. Each node communicates through an intermediate node which is moving over the network. The nature of an intermediate or relay node should produce the throughput performance on entire network. We consider transmission of a confidential message from a source to a destination in a decentralized wireless network in the presence of randomly distributed packet droppers. In a WSN, sensor hubs convey sensed information once again to the sink through multihopping. The sensor hubs close to the sink will for the most part expend more battery force than others; therefore, these hubs will rapidly empty out their battery vitality and abbreviate the system lifetime of the WSN. Proposed an Energy-Aware Sink Relocation Method (EASR), which adopts the energy-aware direction- routing method for message relay. Due to the battery resource constraint, it is a critical issue to save energy in wireless sensor networks, particularly in large sensor networks. Possible solution is to deploy multiple sink nodes simultaneously. Propose a protocol called MRMS (Multipath Routing in large scale sensor networks with Multiple Sink nodes) which incorporates multiple sink nodes, a new path cost metric for improving path selection, dynamic cluster maintenance and path switching to improve energy efficiency. MRMS is shown to increase the lifetime of sensor nodes substantially compared to other algorithms based on a series of simulation experiments.

Key words: Throughput, Battery Resource, Multiple Sink, Path Selection, Cluster Maintenance, Path Switching

I. INTRODUCTION

In wireless sensor networks (WSN), sensors send data packets to sink nodes through multi-hop wireless links. As the size of the network increases, the sensors near the sink nodes will dissipate energy faster than other sensors as they need to forward a larger number of messages, and prolonging the lifetime of whole network becomes a critical problem. One promising approach is to deploy multiple sink nodes in WSN, since it can decrease the energy consumption of sensors and improve the scalability of the networks.

A. *Multipath Routing*

MRMS includes three parts: topology discovery, cluster maintenance and path switching next rotate the cluster head within a cluster and change delivery node between clusters to balance energy consumption in the cluster maintenance process. Finally, when some of the sensors in the original primary path have dissipated too much energy, re-select the primary path to connect to an alternate sink node. Simulation shows that MRMS can improve energy efficiency significantly.

The main contributions in our paper are as follows: First, introduce a new path cost metric which is based on the distance between two neighbor nodes, hop count to sink node and the residual energy of sensor node. This metric is very useful in path selection and improving energy efficiency. Secondly our scheme uses stateless clusters in which all the ordinary sensors in the cluster maintain only the previous hop and corresponding sink. This means the cluster head does not need to maintain information on its children in its cluster, which simplifies cluster maintenance considerably. Finally, we introduce mechanisms for path switching when the energy of the sensors in original primary path has dropped below a certain level. This allows us to distribute energy consumption more evenly among the sensor nodes in the network

B. *Sink Relocating Scheme*

Propose a sink relocating scheme to guide the sink when and where to move to. Some mathematical performance analyses are given to demonstrate that the proposed sink relocating scheme can prolong the network lifetime of a WSN.

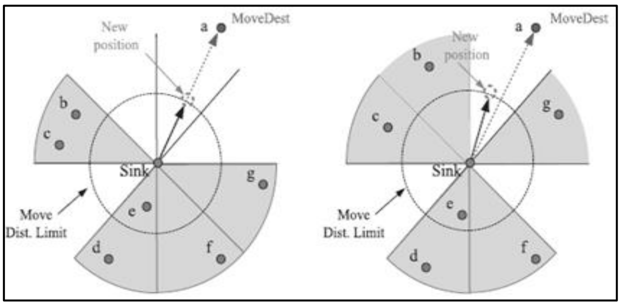
C. *Sink Relocation and Related*

In general, WSNs can be classified into two categories, stationary and relocatable WSNs, depending on whether the nodes are capable of moving or not. When a stationary WSN is deployed in a sensing field, each sensor node locates at a fixed position to perform round-and-round of sensing and message reporting/relaying tasks until a sensor node (or a portion of the sensor nodes) drain out their battery energy; then the WSN dies. For the category of relocatable WSNs, sensor nodes or the sink are capable of moving. As the total energy level of a region drops down to a low level state or there are some sensing holes or communication holes in the region due to some sensor nodes draining out their battery energy, then some mobile sensors can relocate their locations and move into this region to relieve the above problem.

II. RELATED WORK

Joint sink Mobility and Routing strategy (JMR) for data collection in a WSN. The JMR uses a circular trajectory at the periphery of the WSN. Note that the circular trajectory is a predetermined trajectory for the sink relocation. The sink will use a constant velocity to circle the trajectory. Proposed A multiple sink relocation scheme with multiple pre-determined hexagon trajectories Each trajectory has a mobile sink constantly relocating itself along the hexagon path. As a sink passes through a sensor node, then the sensor can relay the sensed data to the mobile sink. This category of sink relocation scheme is easy to implement and the sensor node can easily predict the sink’s position due to the fact that its moving velocity is constant and the trajectory is predetermined. However, this category of relocation scheme does not adapt to taking the current residual battery energy of sensor nodes into consideration, which is important information, and it might give better performance results for relocation methods.

In the other category of sink relocation, the autonomous sink movement scheme, the sink will constantly collect nearby sensor nodes' related information (such as the residual battery energy) and then, based on this information, plan when to move and where to move to.



(a) (b)

Fig. 5: A portion of the sink relocating policies

In the following, introduce two sink relocation schemes of this category. Proposed a mobile sink relocation scheme to drive the sink to the next position by taking the conditions of nearby nodes' residual battery energy. The method firstly partitions the nearby sensing region of the sink into 8 fanshaped sectors. The sensor node with the maximum residual battery energy is called the MoveDest The sector containing the MoveDest is called the Dest sector. If the residual battery energy of a sensor node is below a given threshold, then this node is called a quasi-Hotspot A sector containing at least one quasi-Hotspot is called a miry sector otherwise, it is called a clean sector.

The next new relocating position of the sink will be primal based on the intersection point between the line from the current position of the sink to the Move Dest and the border of the given transmission range (Move Dist. Limit) [see Fig. 5(a)].

Then, based on the possible state (miry or clean) outcomes of the two neighboring sectors of the Dest sector, the new sink relocating position will be slightly minor adjusted accordingly.

The proposed method provides 6 adjusting plans based on all of the possible outcomes. For example, as shown in Fig. 5(a), the two neighboring sectors of the Dest sector are both clean, then the sink will relocate itself to the new position as stated above and there is no need for it to be adjusted. In the other case of both of the neighboring sectors of the Dest sector being miry then the new relocating position of the sink will be the intersection between the border of the transmission range with the center line of the Dest sector.

Proposed two autonomous sink movement schemes, the One-step and the Multi-step moving schemes. The methods firstly compute a position for the destination of moving, which can be determined by the total residual battery energy of the sensor nodes. When a moving destination is determined, the One-step moving scheme will drive the sink to directly move to the destination despite the distance. For the Multi-step moving scheme, the sink will relocate its position iteratively from one intermediate moving destination to the other, and the distance of each relocating step will be limited to the transmission range of the sink.

III. SYSTEM MODEL

First state our major assumptions. Assume there are multiple sink nodes in the wireless sensor networks, each of which has an infinite amount of energy. Every sensor, whose location is randomly distributed, has the same initial energy and radio range. Both the sensor nodes and the sink nodes are stationary. A perfect MAC layer and error-free communication links are assumed, but no communication is possible once the energy of a sensor node has been depleted. A transceiver exhibits first order radio model characteristics in free space i.e. energy spent in transmitting a bit over a distance d is proportional to d2.

A wireless sensor networks (WSN) is modeled as a graph G(V, E), as show in Figure 11, where V is the set of all sensor nodes and all sink nodes, E is the set of all links.

$$V = V_{sink} \cup V_{sensor},\ E = \{(i,j) \mid i,j \in V\}$$

Every sensor's initial energy is E_{init} and its residual energy is E_{RE}. The path is defined as $\{V_1, V_2, \ldots\ldots, V_i, V_j, \ldots\ldots, S\}$, $V_i, V_j \in V_{sensor}$, $S \in V_{sink}$; the cost is defined as the cost of one link $<V_i, V_j>$.

$$Cost_{ij} = \alpha * d^2 + \beta$$

Now define the path cost as follows:

$$\text{path cost} = \Sigma cost_{ij} * E_{RE}^{\gamma}$$

Where α is the energy/bit consumed by the transmitter electronics, β is energy/bit consumed by the transmitting and receiving signal operation overhead for amplifying, and d is the distance between two sensor nodes. γ is the coefficient of residual energy and it is a none-zero negative value. From formula (1) and (2), it is clear that the longer the transmitting distance or the larger the overhead, the higher the cost. So the increase in the hop count between the sensor nodes and sink node will increase path cost. In addition, if the residual energy for each sensor decreases, the path cost will also increase. Hence, after a path has been used excessively, the residual energy of the sensors in the path will decrease, driving up the path cost and triggering the path-switching process. The role of the path cost metric in energy-efficient routing will be shown in greater detail in a later section. There are three phases in MRMS: topology discovery, cluster maintenance and path switching.

A. *MRMS Topology Discovery*

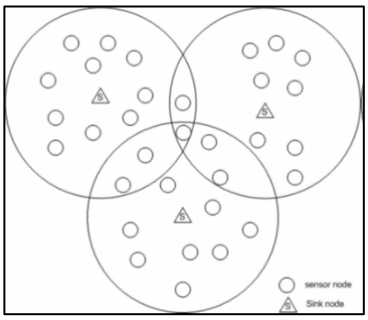


Fig. 6: (a) Sensor and sink nodes before topology discovery

MRMS topology discovery is derived from the three-color algorithm used in TopDisc, but with a number of significant differences. Firstly, MRMS must save the paths from different sinks, so that when the primary path is not reachable or if the residual energy of the sensors along the path fall below a certain threshold, another path will be selected. Secondly, during the cluster construction, it can construct an optimal or sub-optimal path to any sink node which is based on the path cost metric. Thirdly, the cluster is stateless and each cluster can be considered as a single node.

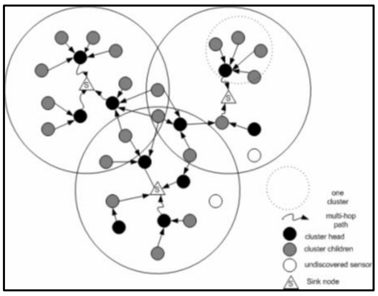


Fig. 6: (b) Sensor and sink nodes after topology discovery

B. The MRMS Topology Discovery Algorithm

/*WHITE: Undiscovered node
*BLACK: Cluster Head node
*GREY: Discovered by one black node
*/

1) If node is sink Then

Topology discovery is finished and return;

2) If node is sensor and it is still WHITE

– If previous node color is BLACK Then
– Change the node's color to GREY;

3) If node is sensor and it is still WHITE If previous node color is BLACK Then Change the node's color to GREY;

$minPathCost \leftarrow path\_cost_{old} + cost_{ij} * E_{RE}^{\gamma}$

Save the previous node as the route to its cluster head.

Broadcast the topology discovery message again with some delay; where the delay is inversely proportional to the distance which between itself and the previous node.

If previous node color is GREY Then Delay some time, with the delay inversely proportional to the distance which between itself and the previous node.

After delay, if node is still WHITE, change its color to BLACK Mark this node as cluster head,

hopCount ← hopCount +1; /* note each cluster is considered one hop count here */

$minPathCost \leftarrow path\_cost_{old} + cost_{ij} * E_{RE}^{\gamma}$

Save the corresponding information as its primary path in its route table;

Broadcast the topology discovery message again

Else if ((node color is GREY and its previous node is BLACK) OR (node color is BLACK))

AND (new sink is not in RouteTable) Then

If $path\_cost_{old} + cost_{ij} * E_{RE}^{\gamma} < minPathCost$ Then

$minPathCost \leftarrow path\_cost_{old} + cost_{ij} * E_{RE}^{\gamma}$

Change the primary path to the new sink; save the original path as its alternative path

Broadcast the new topology discovery request again

Else

Discard the topology discovery request.

C. Cluster Maintenance

There are two major processes within cluster maintenance: energy monitoring and cluster reconstruction. The residual energy of the sensors is monitored and when it falls below some threshold, cluster reconstruction is initiated. In cluster reconstruction, if the Cluster Header's (CH) residual energy is below some threshold, it will select new children whose residual energy is the maximum in this cluster to take over. On the other hand, if the delivery node's residual energy is below the threshold, the CH will select a new delivery node whose path cost is the minimum.

D. Cluster Reconstruction

– When the energy of the current CH has dropped below a certain threshold, the current CH broadcasts a message to poll the residual energy level of all its children. When a sensor receives this message, it will report the current residual energy to its CH.
– The current CH selects the child with the maximum residual energy as the new CH; the new CH changes the radio range to 2R and broadcasts probing the new delivery node message to all neighbors
– The sensor node receives the probing message, it will do the following.

If its sink node is the same as that of the original cluster and hopCount < hopCount of original cluster Then Report its current battery residual energy and its path cost to original sink.

– After the new CH receives the reply information,

If path_costold + costij * EREγ < minPathCost Then
minPathCost ← path_costold + costij * EREγ

Change the primary path to corresponding information

If all new calculated path_costnew is larger than η * path_costold Then

Initiate path-switching by sending a new probing message to probe the path to another sink /*

– After the new CH broadcast has selected the new delivery node in its primary path, it will broadcast the new information to all children in the old cluster.
– All of children in old cluster change its previous hop to the NEW CH in its primary path.

E. Path Switching

The main function of the third phase, path switching, is to switch path to another sink when the primary path to some sink is not usable any more. After a primary path has been in use for an extended period of time, the energy level of the sensors along this path will dissipate faster than other sensor nodes, and some nodes may run out of energy altogether leaving the path unusable. By switching paths, energy consumption is distributed more equitably.

IV. EXPERIMENT RESULTS

There is a gap between a simplified model and a realistic situation, it will help to proceed with the theoretical analysis. In the following, use this model (the grid network) to demonstrate that the proposed sink relocation can prolong the network lifetime of the WSN. When an event (abnormal event reporting or sensed data gathering) occurs at a grid node u, then an informed message will be transmitted from u to the grid area which contains the sink s (for ease of discussion, also uses to represent the respective grid node) along path Pus. Note that, the routing path can be predetermined by some routing protocol.

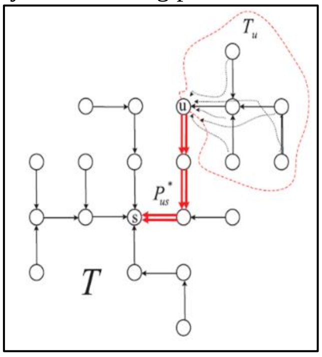


Fig.10. An illustration of the message routing

In this paper, use the MCP method to determine the routing path in the grid network, which has been discussed. Use Gg = (V, E) to denote the grid network and T to denote the collection of all maximum capacity routing path Pus us with respect to each grid node u.

From an probability point of view, for long-term event processing, the energy consumption with respect to a grid node u will be proportional to the number of nodes in subtree Tu ⊂ T, where Tu denote the subtree rooted at node u in T [see Fig. 10]. This is because any sensor node v ∈ Tu, which wants to submit a message to the sink has to pass through node u. And assume that the chance of submitting a message to the sink of each sensor node is equal to a constant value. Thus, the energy consumption of a node u is proportional to the number of sensor nodes in Tu (i.e., |Tu|). Based on this assumption, give the following definitions for estimating the network lifetime of a WSN. A re locatable sink is another approach for prolonging network lifetime by avoiding staying at a certain location for too long which may harm the lifetime of nearby sensor nodes.

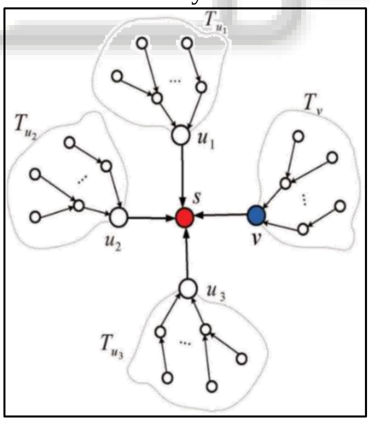


Fig. 11: Illustration of the message routing

This approach can not only relieve the burden of the hot-spot, but can also integrate the energy-aware routing to enhance the performance of the prolonging network lifetime. An Energy-Aware Sink Relocation Method (EASR), which adopts the energy-aware routing MCP as the underlying routing method for message relaying. EASR can prolong the network lifetime of a WSN.

V. Conclusion

The main objective of our simulation is to evaluate the energy efficiency and the lifetime of sensor networks. Mean Energy Consumption of one packet indicates the energy consumption of transmitting a packet to sink successfully. Average hop count to sink is useful since the larger the number of hops a packet has to traverse before it reaches the sink, the higher the aggregate energy consumption. The higher the delivery ratio, the higher the reliability of the network. The packet delivery ratio is also a good indirect measure of the lifetime of the network. Furthermore, to plan on exploring the effect of a lossy MAC layer on the MRMS, as well as how to construct node-disjoint multi paths for multiple sink nodes. Multipath routing protocols improve the load balancing and quality of service in WSN and also provide reliable communication. The multipath routing technique which has demonstrated its efficiency to improve wireless sensor performance is efficiently used to find alternate paths between sources and sink.

References

[1] Dong .M, Ota .K ,Liu .A, et al. "Joint Optimization of Lifetime and Transport Delay under Reliability Constraint Wireless Sensor Networks," IEEE Transactions on Parallel and Distributed Systems, vol. 27, no. 1, pp. 225-236, 2016.
[2] He .S, Chen .J, Jiang .F, et al. "Energy provisioning in wireless rechargeable sensor networks," IEEE transactions on mobile computing, vol. 12, no. 10, pp. 1931-1942, 2013.
[3] He .S, Chen .J, Li .X, et al. "Mobility and intruder prior information improving the barrier coverage of sparse sensor networks," IEEE transactions on mobile computing, vol. 13, no. 6, pp.1268-1282, 2015.
[4] Hu .Y, Dong .M, Ota .K, et al. "Mobile Target Detection in Wireless Sensor Networks with Adjustable Sensing Frequency, "IEEE System Journal, Doi: 10.1109/JSYST.2014.2308391, 2014.
[5] Liu .X, Dong .M, Ota .K, Hung .P, Liu.A. "Service Pricing Decision in Cyber-Physical Systems: Insights from Game Theory," IEEE Transactions on Services Computing, vol. 9, no. 2, pp. 186-198, 2016.
[6] Liu .A, Dong .M, Ota .K, et al." PHACK：An Efficient Scheme for Selective Forwarding Attack Detecting in WSNs," Sensors, vol. 15, no. 12, pp. 30942-30963, 2015.
[7] Liu .A, Jin .X, Cui .G, Chen .Z, "Deployment guidelines for achieving maximum lifetime and avoiding energy holes in sensor network, ―Information Sciences, vol. 230, pp.197-226, 2013.
[8] Long .J, Liu .A, Dong .M, et al. "An energy-efficient and sink-location privacy enhanced scheme for WSNs through ring based routing," Journal of Parallel and Distributed Computing, vol. 81, pp. 47-65, 2015.
[9] Jayarajan, K & Sabari, A 2016, 'Multi Variant Mitigation Model for Improvement of Security in Wireless ADHOC Network Threats using Flow Based Time Variant Approach', Asian Journal of Research in Social Sciences and Humanities, vol. 6, Special Conference Issue September, pp. 91-106.
[10] Jayarajan, K & Sabari, A 2016, 'Route Inference Theory for Mitigation of Network Threats in Wireless Sensor Networks', Transylvanian Review, vol. 24, no. 10.
[11] Seo S.H., Won .J, Sultana .S, et al. "Effective key management in dynamic wireless sensor networks,"

IEEE Transactions on Information Forensics and Security, vol. 10, no. 2, pp. 371-383, 2014.

[12] Shen .S, Li .H, Han .R, et al. "Differential game-based strategies for preventing malware propagation in wireless sensor networks," IEEE Transactions on Information Forensics and Security, vol.9, no. 11, pp. 1962-1973, 2014.

[13] Monaco .U, Cuomo .F, Melodia .T, Ricciato.F,and Borghini .M, "Understanding optimal data gathering in the energy and latency domains of a wireless sensor network," Comput. Netw., vol. 50, no.18, pp. 3564–3584, Dec. 2006.

[14] Mousavi .H, Nayyeri .A, Yazani .N, and Lucas .C, "Energy conserving movement-assisted deployment of adhoc sensor networks," IEEE Commun. Lett., vol. 10,no. 4, pp. 269–271, Apr. 2006.

[15] Sara .S .G and Sridharan .D, "Routing in mobile wireless sensor network: A survey,"Telecommun. Syst., Aug. 2013.

[16] Shah .C .R and Rabaey .J, "Energy aware routing for low energy ad hoc sensor networks," in Proc. IEEE Wireless Commun. Netw. Conf., vol. 1. Mar. 2002, pp.350–355.

[17] Saravanan, T. "An Efficient Multi Channel Query Scheduling In Wireless Sensor Networks." International Journal of Computer Science and Network Security (IJCSNS) 14.2 (2014): 71.

[18] Wang .L .G, Cao .H .G, Porta .L .T, and Zhang .S .W, "Sensor relocation in mobile sensor networks," in Proc. IEEE Inf. Commun. Conf., vol. 4. Mar. 2005, pp.2302–2312.