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SFM: An Energy Efficient Algorithm based on Reducing Control Messages in Wireless Sensor Networks

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Abstract—
Wireless Sensor Networks are an active research area used in various applications. It is widely used in monitoring environment. Periodic sink location update traffics cannot predict the current sink location in the deployed area. Then the path prediction in wireless environment is not suitable. The algorithm here is used to reduce the control message overhead named as sinktrail-s and to improve the energy efficiently we use flat multihop routing algorithm. It is named as Sinktrail-S with Flat Multihop (SFM) routing algorithm. The algorithm is designed to provide sufficient flexibility in the movement of mobile sink in the sensor deployed area. The protocol does not need any location prediction strategy or any satellite devices to determine the location. It improves the energy efficiently. Both practical and theoretical results demonstrate the energy efficiency and reduction of control message overhead.
Keywords— Wireless sensor networks, mobile sink, sensor node, data forwarding, location update, deployed area, logical coordinate.

I. INTRODUCTION

Wireless Sensor Networks (WSN's) is used in various applications to detect the events. It is used for Forest fire detection, pollution monitoring, Agriculture etc., The Sensor nodes are statistically placed or mobile sensor devices are available according to the application. The data collection is based on various routing algorithms such as tree or cluster network and the data forwarding, on energy efficient route and error free route and dead end free route.

The Mobile Sink is a device with radio equipped containing transceivers to forward and receive data. It is mainly an animal or vehicle or a human (user) with radio device. That is moved along the sensor deployed field to gather data and communicate with sensor nodes. It is not an energy aware device. Sensor node is an energy aware device.

Data gathering using mobile sink is a challenging process. Predicting the location means the sink cannot freely move in the deployed area. Periodic update leads the traffic detouring large data packets (originally targeted at previous location and the sink now moves to a new location causes detouring the data packets) and leads to a loss of energy. The path prediction is another strategy and it is not suitable in wireless sensor networks because the network uses various topologies and it varies in time. Scheduling the mobile sink path in advance improves the performance of the entire network but it is not suited under certain constrained area.

The Mobile Element Scheduling (MES) proposed the protocols that achieve efficient data collection to the controlled sink [12], it may not be able to adapt to constraint area, and it follows field boundaries. It is particularly used in pollution level monitoring based on predictable and controlled manner. It is not suited for farmland because the movement of sink spoils the crops.

Without scheduling the mobile sink path the sink trail protocol [16] is proposed, here the location prediction strategy is not used and it is dynamically adapt to various situation (self- adaptive). Typically the SODD protocols namely, Directed Diffusion [15], GRAB [9], sink trail [16]. SODD protocol frequently announces its location throughout the network and it is used to find the location of the sink but the control message overhead increases, flooding the network and increase the energy consumption but the sink trail protocol somewhat reduces the energy consumption. It provides flexible movement in the deployed area. Data forwarding plays a vital role in the wireless sensor network. It is a challengeable to minimize the data gathering time. Finding shortest route to forward the data is energy efficient. Relay the data to the closest neighbour that forward the data to the sink.

In this paper, we propose Sink trail-s and advanced sink trail-s is SFM, sink trail-s is a self-adaptive and it reducing the control message overhead in the network. Without the assistance of any GPS devices or location finding strategy, the control messages are broadcasted throughout the network to find the location of the sink. It is mainly based on the hop count distances, find the destination vector and the source distance find the shortest distance and also the energy efficient route to forward the data to the sink based on SFM. Sink trail-s reduces the control message overhead and SFM algorithm improves the lifetime of the network.

The key features of the paper are:

1. The logical coordinate is used to update the trail reference. Without the use of any satellite and location prediction strategy. It is widely suited.
2. Then the SFM algorithm is designed to forward the data to energy efficient route.
3. Sink trail-s reduces the overhead and SFM algorithm used to lengthen the lifetime of the network.

The rest of the paper is organized as follows. Section II presents related work. Sink Trail-S protocol design is discussed in Section III. Section IV discusses the Sink Trail-S with Flat Multi-Hop Algorithm (SFM). Section V shows the simulation results. Finally the paper is concluded.

II. RELATED WORK

In the past few years there is a substantial development in the wireless sensor networks. The most challenging part of this approach is to handle effectively the control message overheads introduced by a sink's movement throughout the network. So, first is broadcasting a mobile sink's current location to the whole network is the most natural solution to track a moving mobile sink without the assistance of any location prediction strategy. This type of approach is sink oriented data dissemination (SODD) and some early research efforts, e.g., [5], [8], [15], [16] have demonstrated its effectiveness in collecting a small amount of data from the network. Several mechanisms have been suggested to reduce control messages. Beacon Vector Routing (BVR), assigns coordinates to nodes based on the vector of hop count distances to a small set of beacons, and then defines a distance metric on these coordinates. BVR routes packets greedily, forwarding to the next hop that is the closest (according to this beacon vector distance metric) to the destination. Directed Diffusion [8] is data-centric in that all communication is for named data. The networks were application aware that enables to achieve energy savings by selecting good paths and by caching and processing data in-networks. One or more human operators pose that any node in the network, questions of the form: finding how many pedestrians are observed in the geographical region X or by finding in which directions the vehicle in the region Y is moving. K. Fodor and A. Vida´cs proposed that [8] multi-hop communication is essential where nodes relay information packets between the source nodes and the sink(s). Because of the low-cost tiny devices the operation of the network is highly energy sensitive. The lifetime of the network largely depends on the energy of the sensor nodes neighboring the sink(s) that relay all messages on the last hop. The TTDD protocol, proposed in [15], constructed a two-tier data dissemination structure in advance to enable fast data forwarding. Park et al. [10] proposed DRMOS that divides sensors into "wake-up" zones to save energy. Fodor and Vida´cs [4] lowered communication overheads by routes are updated only when topology changes. Moreover, these papers either assume that mobile sinks move at a fixed velocity and fixed direction, or follow a fixed moving pattern, which largely confines their application. The SinkTrail protocol with message suppression minimizes that reduces the control message overhead and improve the lifetime of the sensor node. Another solution is finding shortest route to forward the data.

Second called as Mobile Element Scheduling (MES) algorithms [12], [13], considered controlled mobile sink mobility and planning the mobile sink's path in advance to improve the performance. The author [12] proposed that in the case of wireless sensor networks, mobile elements are deliberately built into the system to improve the lifetime of the network, and act as mechanical carriers of data. The mobile element, which is controlled, visits the nodes to collect their data before their buffers are full. The sensor network is equipped with a mobile element (acting as a base station) that does the job of the data gathering.

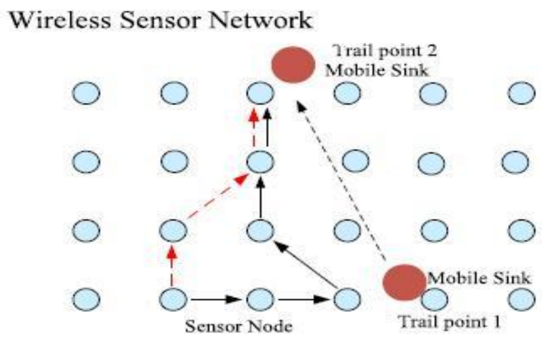

Fig1. MES versus sink trail. The black lines indicates the Scheduled path it needs 5 hop count and red lines indicates the sink trail it needs 3 hop count to reach the sink in trail point 2.

Once the mobile element visits a sensor node, it transfers the data to its own memory and the sensor's memory is freed. A problem is may not adapt to constrained areas. Deadlines are dynamically updated. Unlike MES algorithms, SinkTrail, with almost no constraint on the moving path of mobile sinks, achieves much more flexibility to adapt to dynamically changing field situations and reduce overheads. SinkTrail uses sink location prediction and selects data reporting routes in a greedy forwarding. In [9], Keally et al. Sidewinder continuously predicts the current sink location based on distributed knowledge of sink mobility among nodes in a multi-hop routing process. Moreover, the continuous sink estimation is adjusted to perform with resource-constrained wireless sensors. The Sequential Monte Carlo (SMC) theory is integrated into Sidewinder to handle intensive topology changes in mobile sensor networks. SMC Prediction module enables Sidewinder to forward data close to a mobile sink, the Limited Flooding module ensures that data finally reaches the sink. When a forwarding node is a one-hop neighbor of the sink node, data packets received are passed to the Limited Flooding module, which broadcasts them to all the node's two-hop neighbors, ensuring the data reaches the sink even if the sink has moved out of range of the forwarder. Moreover, SinkTrail does not rely on the assumption of location-aware sensor nodes, which could be impractical for some real-world applications.

The routing protocol of SinkTrail is inspired by recent research on virtual coordinate routing [3], [5], Rao et al. proposed a greedy algorithm for data reporting using logical coordinates rather than geographic coordinates. Fonseca et al. [5] presented vector form virtual coordinates, in which each element in the vector represented the hop count to a node. SinkTrail adopts this vector representation and uses past locations of the mobile sink as virtual landmarks Sink trail is associated with the mobile sink's "footprints" left behind the moving path of the sink that used to construct the logical coordinate. The vector form coordinates, called trail references, are used to guide data reporting without knowing the physical locations, speed and moving pattern of the mobile sink. It provides sufficient flexibility. It is dynamically adapted to various situations.

III. SINK TRAIL-S PROTOCOL DESIGN

The mobile sink moves throughout the network with uniform speed. It stops in some place and broadcast the control messages throughout the network i.e. the location of the sink in the sensor deployed area. The place where it stops is the Trail point and the message that is broadcasted is the Trail Messages. The Trail messages contain the message sequence number and the hop count. That is received by the sink. For a particular period of time it stop and broadcast the control messages throughout the network by broadcast to its neighbor sensor node that to its neighbor sensor node. The control message contains the message sequence number and the hop count. Then the sink move to the next trail point and increment the message sequence number and broadcast.

ALGORITHM 1: SINK MOVEMENT
1: ----------Initially------------
2: message.sequenceNo is 0
3: message.hopCount is 0
4:-----------For every move----------
5: **while** the process is not yet completed do
6: when move to next position
7: message.sequenceNo+1
8: wait for some time to broadcast
9: end **while**

The Logical Coordinate is constructed to identify the sink location when it is moved in the sensor deployed area. It maintains an array with initial value of [-1,-1….,-1]. Each node maintains this array according to the number of mobile sink. When the control message get received it shift the array left by one position and increment the hop count and save it on the left most position of the array according to the mobile sink id when there is a multiple mobile sink. And the sensor node again broadcast the trail message to its one hop neighbour by increment the hop count and broadcast it. For the same message sequence number different hop count can be received by the sensor at that time it compare the hop count (saved and received hop count) and save the smallest hop count and rebroadcast it.

Finally the mobile sink reach the destination and the destination is find out based on the hop count received by the sensor node and the hop count is termed as vector representation. The destination is calculated based on the distance. Then the data forwarding process greedily select the shortest path to forward the data to the sink.

ALGORITHM 2: SINK TRAIL-S
1: maintain mobile sink id individually
2: new message.sequenceNo
3: compare the hop count
4: **if** the hop count is same
5: Save and not rebroadcast it.
6: **else**
7: Shift the trail ref array left by one position
8: Increment the hop count and save it.
9: Increment the hop count and rebroadcast it
10: **else if** the same message.sequenceNo means
11: Compare the save and received hop count.
12: save the shortest hop count
13: rebroadcast it
14: **else**
15: discard the message
16: **else if** old message.sequenceNo means
17: Simply discard it
18: **end if**
19: --------Initialization----------

20: message.sequenceNo is 0
21: message.hopcount is 0

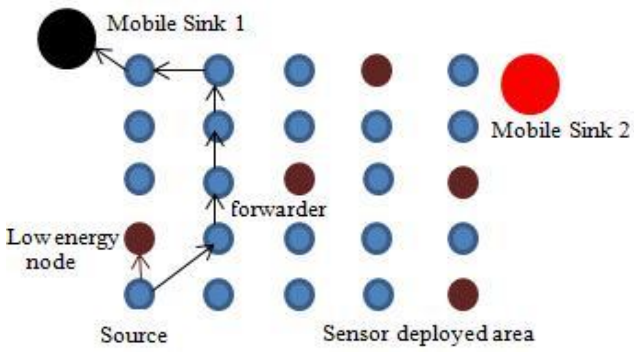

Fig2. SFM Algorithm. Source node forward data to mobile sink 1. The shortest distance leads to low energy node and it needs only 5 hop counts to reach the sink. But it selects the energy efficient forwarder to forward the data to sink 1 it needs 6 hop counts and the overall network life time gets improved.

Sink Trail-S is reduces the control message overhead. The main advantage of having this algorithm is:

1. Same hop count for consecutive message sequence number it avoid rebroadcasting to its neighbour node.
2. It avoids meaningless updates when the node finishes data forwarding.
3. It reduces control message overhead.

ALGORITHM 3: DATA FORWARDING

1. exchange the trail ref array with neighbour node in the network
2. Find the distance between the source node and sink
3. find the closest mobile sink
4. **if** mobile sink within a range
5. forward directly
6. **else** find the forwarder to forward the data to the sink already calculated.

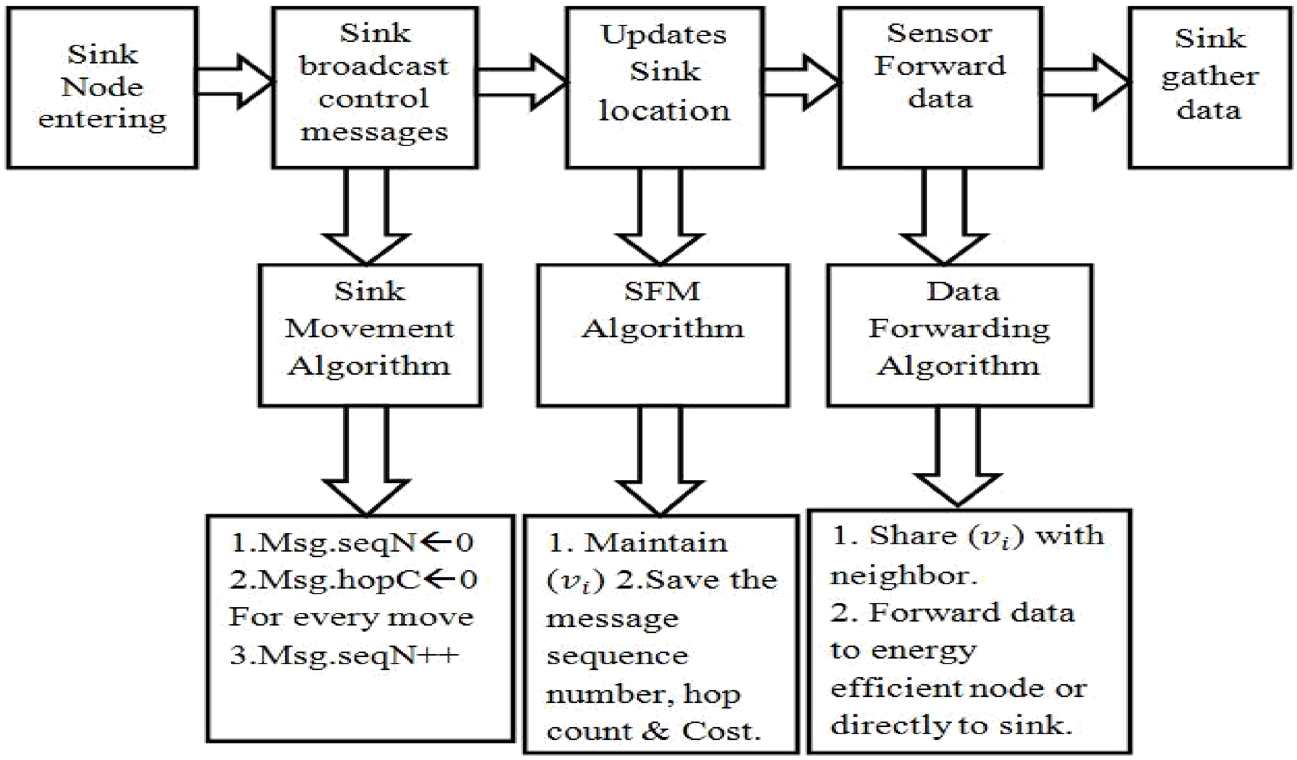

Fig 3. System Architecture of SFM

IV. SFM PROTOCOL DESIGN

It is an improved version of Sink Trail-S. The difference is that: The sink trail-s protocol is designed to have multiple mobile sink. Initially the mobile sink enters into the sensor deployed area and start broadcasting its current location through the entire network based on the sink strategy algorithm. Next the sensor updates the sink location by means of trail reference i.e. it maintains the hop count distance and the cost consumed by the node or the summation of the link cost is maintained. Then finally the data forwarding all the entire techniques are discussed in the architecture shown below. The source node selects the destination mobile sink to forward the data. The Data Forwarding is done by Data forwarding algorithm. The forwarder is an energy efficient node. Thus SFM simply follows the sink trail-s and a little change in calculating the trail reference by choosing the energy efficient route. The trail reference update algorithm used to calculate not only the sink location by means of hop count (coordinate points), it also used to construct the routing table that maintains the cost of the node to forward the data to the sink by choosing the efficient forwarder. Finding the summation of link cost used to determine the efficient route path [1].

An approach to balance the energy consumption is discussed in [7], combination of direct and multi-hop transmission. It is used for concrete routing protocols.

Training the sensor network by "how to forward the data" in [14] and it construct the virtual tree abstract but it raises security related issues. In [6] the methods are Integer linear program used to determine the location of sink and Flow based routing protocol used to find the efficient route. And partition the large network into sub network. Position based algorithm is discussed in [11] that do not assume fixed or connected topology and maintains minimum energy links and dynamically updates.

ALGORITHM 4: SFM

```
while Data gathering process is not over do
/*——Receive a trail message——*/
if new mobile sink ID then
    Create v_i_mID;
    Create λ_mID;
else
/*——Message from a known sink——*/
if msg.seqN > λ then
    λ ← msg.seqN;
    if e_i^dv = msg.hopC + 1 ; then
        Discard the message.
    else
    Shift v_i to left by one position;
    e_i^dv ← msg.hopC + 1;
    cost ← int_eng - trans_eng;
    msg.hopC ← msg.hopC +1;
    Rebroadcast message;
    end if
    else if msg.seqN =λ then
    Compare e_i^dv with (msg.hopC + 1);
    if > (msg.hopC+ 1) && cost >= (received_cost + cost) && ( e_i^dv – msg.hopC+1) <= threshold value then
            e_i^dv ← msg.hopC + 1;
            cost ← cost+received_cost;
            msg.hopC ← msg.hopC +1;
            Rebroadcast message;
    else
            Discard the message;
   end if
else if msg.seqN < λ then
     Discard the message;
end if
end while
/*——Initialization——*/
For j = 1; . . . ; dv  e_i^j ← -1;
λ ← -1
cost ← 0
```

v_i represents the trail reference update and λ represents the message sequence number and e_i^{dv} denotes the left most position in the trail reference array. Cost denotes the energy consumption of the node and the cost is initialized to zero initially. Link cost is determined by finding the summation of the cost in the entire path. The threshold value is the one that is the acceptable number says for example 2 or 1 according to the application i.e. the difference of the received and the saved hop count.

V. SIMULATION RESULTS

The simulation results shows the performance obtained in the sinktrail-s and its existing technique named as sinktrail. The simulation result shows the energy consumption and the reduction of control message overhead. The result shows the effectiveness of message suppression. And sinktrail is an existing version of sinktrail-s and SFM technique. The figure illustrates various simulation results with its performance.

The figure 4 shows the overhead obtained, it is compared with the sinktrail and the sinktrail-s. It shows that the overhead obtained by the sinktrail-s is reduced when compared to the overhead obtained by the sink trail. Thus the energy of the node gets improved. And hence the transmission overhead also gets decreased.

Next the figure 5 shows the energy consumption for the existing sinktrail and the proposed sinktrail-s. It shows that the energy consumed by the sinktrail-s is minimized when it is compared to the energy consumed by using the sink trail protocol. Thus the energy of the node and network gets improved.

The figure 6 shows that the control message overhead is reduced in SFM, when it is compared with the existing sink trail-s and the proposed Sink trail-S with flat multi-hop (SFM). In figure 7 the average energy consumed by all nodes in the deployed area it also shows that the SFM is better than sink trail-s. In figure 4, 5, 6 and 7, the x axis represents the number of trail points in the network and the y axis represents the overhead obtained and energy consumed by the node.

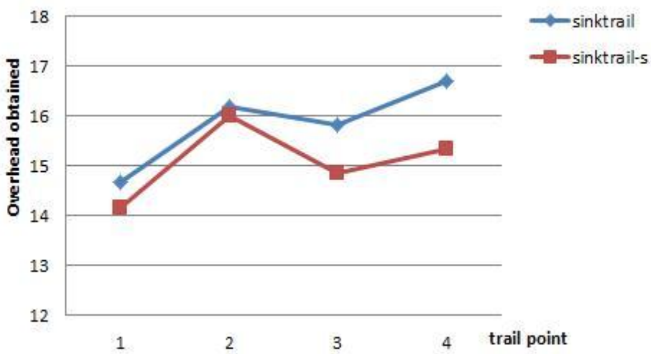

Fig 4. Overhead obtained

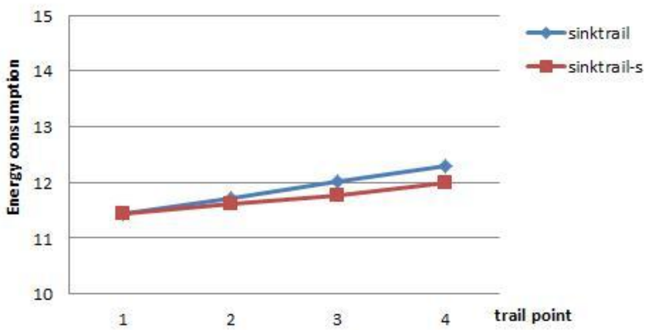

Fig 5. Energy consumption

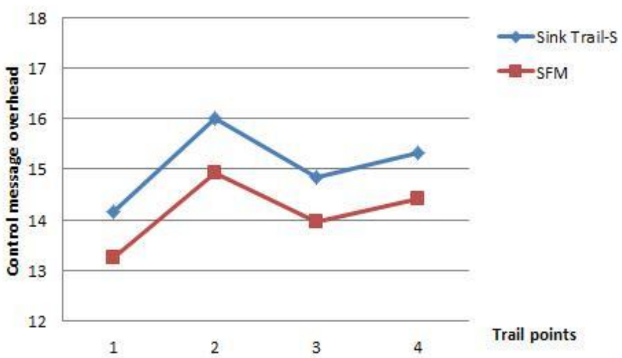

Fig 6. Control message overhead

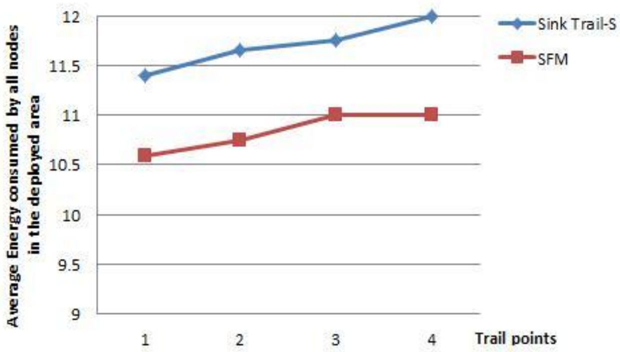

Fig 7. Average energy consumption

CONCLUSION AND FUTURE ENHANCEMENT

In this paper, the trail reference update algorithm is used to update the trail reference of Sensor which constructs the logical coordinate that represents the hop count distance between the sensor node and the mobile sink to find out the location of the sink without the help of any GPS device. And the data is forwarded through the energy efficient path to forward the data to sink. It is a low complexity algorithm. Satisfactory performance is obtained in finding the energy efficient path. Sink Trail-S protocol used to reduce the control messages. It reduces the overhead of transmission. SFM algorithm determines the energy efficient route in the network. The Simulation result shows the reduction of control messages overhead and improves energy efficiently. In future it can also be further integrated into heterogeneous network and also to the large scale network.

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