ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization) Vol.2, Special Issue 1, March 2014

Proceedings of International Conference On Global Innovations In Computing Technology (ICGICT'14)

Organized by

Department of CSE, JayShriram Group of Institutions, Tirupur, Tamilnadu, India on 6th & 7th March 2014

A Rational Approach For Data Reporting In Wireless Sensor Networks Using Sink Trial Protocol

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ABSTRACT: In recent years rendering data sink's vigourness for data gathering has gaunt affluent interest in Wireless Sensor Networks (WSNs). On the double we are knuckle down on outdoing network performance either by drafting a ambulatory sink's heart-warming orbit in proffer or bullseye at accumulate a slender region of intuit data in the network. In multitudinous enactment framework, still, an ambulatory sink cannot decamp freely in the situate area. Therefore, the foreordained orbit may not be germane. To circumvent immutable sink locale overhaul peddles when a sink's fortune locales cannot be programmed in foreordained, we propound two energy methodical ardent data reporting protocols, Sink Trail and Sink Trail-S, for mobile sink-based data throng. The propounded protocols feature low-complexity and diminished control overheads. Two idiosyncratic aspects discern our approach from previous ones: 1) we empower ample pliability in the manoeuvre of mobile sinks to lively revamp to miscellaneous mundane recasts; and 2) without demands of GPS gadget or foreordained lodestars, Sink Trail inaugurates a logical coordinate framework for routing and shipping data packets, making it fit for sundry enactment framework. In addition to that we are going to perform data aggregations by data clustering technique among sensors.We systematically scrutinize the effect of sundry design determinant in the propounded algorithms. Both theoretical scrutiny and facsimile results corroborate that the propounded algorithms diminish control overheads and bestow fair parade in finding shorter routing paths.

KEYWORDS: Ambulatory, Clustering, Sink Trial, logical coordinates, routing

I. INTRODUCTION

Wireless Sensor Networks (WSNs) have authorized a spacious field of enactments through networked low-cost low-power sensor nodes, e.g., habitat monitoring, precision agriculture, and forested area fire discovery. In these applications, the sensor network will operate under few human interventions either because of the hostile environment or high management complexity for manual maintenance. Since sensor nodes have limited battery life, energy saving is of paramount importance in the design of sensor network protocols. Recent research on data collection reveals that, rather than reporting data through long, multihop, and error prone routes to a static sink using tree or cluster network structure, allowing and leveraging sink mobility is more promising for energy efficient data jamboree. Mobile sinks, such as animals or vehicles equipped with radio devices, are sent into a field and communicate directly with sensor nodes, resulting in shorter data transmission paths and reduced energy consumption. To better benefit from the sink's mobility, many research efforts have been focused on studying or scheduling movement patterns of a mobile sink to visit some special places in a deployed area, in order to minimize data gathering time. In such approaches a mobile sink moves to predetermined sojourn points and query each sensor node individually. Although several Mobile Elements Scheduling (MES) protocols have been proposed to achieve efficient data collection via controlled sink mobility determining an optimal moving trajectory for a mobile sink is itself an NP-hard problem and may not be able to adapt to constrained access areas and changing field situations. It leads to large amount of energy consumption, control messages, change of routing paths due to the sinks' movement, and energy cost on detouring large data packets (originally targeted at the previous sink location, now changed to the current sink location) severely impair protocol performances & also data repetition takes place.

This problem can be alleviated by transmitting data via the shortest route to the mobile sink's future locations. Therefore, if sensors can predict the mobile sink's movement, the energy consumption would be greatly reduced and data packets handoff would be smoother. In this paper, we propose SinkTrail, a proactive data reporting protocol that is self-adaptive to various application scenarios, and its improved version, SinkTrail-S, with further control message suppression. In SinkTrail, mobile sinks move continuously in the field in relatively low speed, and gather data on the fly. Control messages are broadcasted at certain points in much lower frequency than ordinarily required in existing data gathering protocols. These sojourn positions are viewed as "footprints" of a mobile sink. Considering each footprint as a virtual landmark, a sensor node can conveniently identify its hop count distances to these landmarks. These hop count distances combined represent the sensor node's coordinate in the logical coordinate space constructed by the mobile sink. Similarly, the coordinate of the mobile sink is its hop count distances from the current location to previous virtual landmarks. Having the destination coordinate and its own coordinate, each sensor node greedily selects next hop with the shortest logical distance to the mobile sink. As a result, SinkTrail solves the problem of movement prediction for data gathering with mobile sinks.

All clustering techniques consist of two phases; setup phase and steady state phase. In setup phase, formation of clusters and election of CHs is performed and in steady state phase, nodes transmit data to CH and it aggregates the data for sending to BS. When sink moves, CHs near to sink transmits the data so consumed less energy and maximize the network lifetime.

II. RELATED WORK

Leveraging data sinks' mobility in sensor data collection has been a topic of tremendous practical interests and drawn intensive research efforts in the past few years. The most challenging part of this approach is to effectively handle the control overheads introduced by a sink's movement. At the first look, broadcasting a mobile sink's current location to the whole network is the most natural solution to track a moving mobile sink. This type of approach is sink oriented and some early research efforts, e.g., [3], [8], [25], have demonstrated its effectiveness in collecting a small amount of data from the network. Several mechanisms have been suggested to reduce control messages. The TTDD protocol, proposed in [24], constructed a two-tier data dissemination structure in advance to enable fast data forwarding. In [7], a spatial-temporal multicast protocol is proposed to establish a delivery zone ahead of mobile sink's arrival. Control messages are flooded to wake up nodes in the delivery zone. Similarly, Park et al. [17] proposed DRMOS that divides sensors into "wake-up" zones to save energy. Fodor and Vida´cs [5] lowered communication overheads by proposing a restricted flooding method; routes are updated only when topology changes. Luo and Hubaux [13] proposed that a mobile sink should move following a circle trail in deployed sensor field to maximize data gathering efficiency. One big problem of the multicasting methods lies in its flooding nature. 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 the flooding effect of control messages without confining a mobile sink's movement, thus is more attractive in real-world deployment. Another solution utilizes opportunistic data reporting. For instance, in [19], Shah and Shakkottai studied data collection performance when a mobile sink presents at random places in the network. The method relies heavily on network topology and density, and suffers scalability issues when all data packets need to be forwarded in the network.

Another category of methods, called Mobile Element Scheduling (MES) algorithms [4], [14], [21], [22], [23], [28], [29], [30], considered controlled mobile sink mobility and advanced planning of mobile sink's moving path. Ma and Yang [14] focused on minimizing the length of each data gathering tour by intentionally controlling the mobile sink's movement to query every sensor node in the network. When data sampling rates in the network are heterogeneous, scheduling mobile sinks to visit hot-spots of the sensor network becomes helpful. Example algorithms can be found in [4], [22], and [23]. Although the MES methods effectively reduce data transmission costs, they require a mobile sink to cover every node in the sensor field, which makes it hard to accommodate to large scale and introduces high latency in

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data gathering. Even worse, finding an optimal data gathering tour in general is itself an NP-hard problem [12], [14], and constrained access areas or obstacles in the deployed field pose more complexity. Unlike MES algorithms, SinkTrail, with almost no constraint on the moving trajectory of mobile sinks, achieves much more flexibility to adapt to dynamically changing field situations while still maintains low communication overheads. SinkTrail uses sink location prediction and selects data reporting routes in a greedy manner. In [9], Keally et al. used sequential Monte Carlo theory to predict sink locations to enhance data reporting. SinkTrail employs a different prediction technique that has much lower complexity. 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 [2], [6], [16], [18]. Rao et al. [18] proposed a greedy algorithm for data reporting using logical coordinates rather than geographic coordinates. Fonseca et al. [6] presented vector form virtual coordinates, in which each element in the vector represented the hop count to a landmark node. SinkTrail adopts this vector representation and uses past locations of the mobile sink as virtual landmarks. To the best of our knowledge, we are the first to associate a mobile sink's "footprints" left at moving path with routing algorithm construction. The vector form coordinates, called trail references, are used to guide data reporting without knowledge of the physical locations and velocity of the mobile sink.Javid and Ain have analyzed about various clustering algorithms that can be implemented for both static and mobile sinks.By their comparative analysis among the clusterings algorithms in terms of throughtput,energy efficiency and network lifetime,H-TEEN algorithm yields less energy consumption.H-TEEN is more energy efficient because of hierarchical clustering and threshold value. HTEEN outperforms in case of mobile sink.

III. PROTOCOL DESIGN

3.1 PROBLEM FORMULATION

We consider a large scale, uniformly distributed sensor network IN deployed in an outdoor area. Nodes in the network communicate with each other via radio links. We assume the whole sensor network is connected, which is achieved by deploying sensors densely. We also assume sensor nodes are awake when data gathering process starts (by synchronized schedule or a short "wakeup" message).In order to gather data from IN, we periodically send out a number of mobile sinks into the field. These mobile sinks, such as robots or vehicles with laptops installed, have radios and processors to communication with sensor nodes and processing sensed data. Since energy supply of mobile sinks can be replaced or recharged easily, they are assumed to have unlimited power.

A data gathering process starts from the time mobile sinks enter the field and terminates when: either 1) enough data are collected (measured by a user defined threshold); or 2) there are no more data report in a certain period. The Sink Trail protocol is proposed for sensor nodes to proactively report their data back to one of the mobile sinks.

3.2 SINK TRIAL PROTOCOL WITH ONE MOBILE SINK

During the data gathering process, the mobile sink moves around in IN with, relatively, low speed, and keeps listening for data report packets. It stops at some places for a very short time, broadcasts a message to the whole network, and moves on to another place. We call these places "Trail Points," and these messages "Trail Messages." However, distribution of these trail points does not necessarily follow any pattern. A trail message from a mobile sink contains a sequence number and a hop count to the sink. The time interval between a mobile sink stops at one trail point and arrives at the next trail point is called one "move." There are multiple moves during a data gathering round. In the Sink Trail algorithm, we use vectors called "Trail References" to represent logical coordinates in a network. The trail reference maintained by each node is used as a location indicator for packet forwarding. All trail references are of the same size. The data reporting procedure consists mainly two phases. The first phase is called logical coordinate space construction. During this phase, sensor nodes update their trail references corresponding to the mobile sink's trail messages. After hop counts have been collected, a sensor node enters the greedy forwarding phase, where it decides how to report data packets to the mobile sink.

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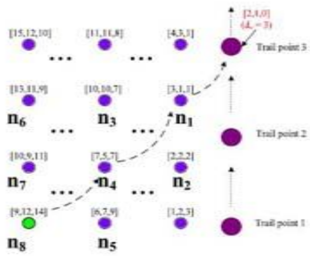

Fig.1 Example execution snapshot of SinkTrail: large solid dots indicate trail points and its moving path.

3.3 SINK TRIAL PROTOCOL WITH MULTIPLE MOBILE SINKS

The proposed Sink Trail protocol can be readily extended to multi sink scenario with small modifications. When there is more than one sink in a network, each mobile sink broadcasts trail messages following. Different from one sink scenario, a sender ID field, msg.sID, is added to each trail message to distinguish them from different senders. Algorithms executed on the sensor node side should be modified to accommodate multi sink scenario as well. Instead of using only one trail reference, a sensor node maintains multiple trail references that each corresponds to a different mobile sink at the same time. Two trail references, colored in black and red, coexist in the same sensor node. In this way, multiple logical coordinate spaces are constructed concurrently, one for each mobile sink. When a trail message arrives, a sensor node checks the mobile sink's ID in the message to determine if it is necessary to create a new trail reference. In Sink Trail trail references of each node represent node locations in different logical coordinate spaces, when it comes to data forwarding, because reporting to any mobile sink is valid, the node can choose the neighbour closest to a mobile sink in any coordinate space. If each mobile sink has a different value, sensor nodes will calculate neighbours' distances to multiple destination references and select route accordingly.

3.4 SINKTRAIL-S PROTOCOL

In Sink Trail, flooding trail messages to the whole network can be nontrivial in terms of energy consumption. To further optimize the energy usage and eliminate unnecessary control messages in the network, we propose Sink Trail- S algorithm as an improvement to the original Sink Trail. Sink Trail-S algorithm is mainly based on the following two observations. First, in a large-scale sensor network, the sensor nodes that are far away from a mobile sink may not be significantly affected by a single movement of the mobile sink.

When the mobile sink moves from trail point A to trail point B, the yellow sensor node at the left bottom corner may still have the same hop count distance to the mobile sink, and the routing path chosen from last "move" of the mobile sink may still be valid. In this case, the trail messages can be suppressed with high probability. Second, when a node has finished data reporting and forwarding, trail reference updating becomes meaningless and results in huge waste of energy, especially for peripheral sensor nodes. To properly handle these two situations, we propose a message suppression policy at a small cost of extra state storage at each sensor node.

Each sensor node will compare the current hop count distance to a mobile sink with the most recently received one. If these two are same, it indicates the path length through the node to the mobile sink is still same, making it unnecessary to rebroadcast this trail message. In case of the second situation, each node maintains a state variable in its memory. When a node finishes data reporting, it marks itself as "finished," and informs all its neighbour nodes. A node stops trail reference updating and trail message rebroadcasting whenever it and all its neighbours are "finished." Again, this method is guaranteed by the timer mechanism that ensures sequential data packets reporting order from network peripheral to a mobile sink's current location. For accidental situations due to timer failure, a new data packet may arrive at a node that has already stopped trail reference updating. In that case old trail references are used. This may cause a longer routing path but the result is still acceptable for data reporting.

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3.5 DATA CLUSTERING PROTOCOL - H-TEEN

H-TEEN is a variant of TEEN protocol, introducing a hierarchy of clustering to better cope with large network area. When number of layers in hierarchy is small TEEN consumes lot of energy because of larger distance so, H-TEEN performs better due to less consumption of energy in large network. H-TEEN is a 4 layer hierarchal clustering where sensors self-organize into clusters and build a tree of transmissions and propagate data to the CH. CH selection is same as in TEEN and LEACH. The threshold equation is given as ,

$$\sum_{i=1}^{N} Pi = \sum_{i=1}^{N} Popt \frac{Ei(v)}{\bar{E}} = Popt \sum_{i=1}^{N} \frac{Ei(v)}{\bar{E}(v)} = NPopt$$

$$T(n) = \frac{Pc}{1 - Pc\,(a \bmod \frac{1}{Pc})} \quad \text{if } n€F$$

Otherwise it will be 0

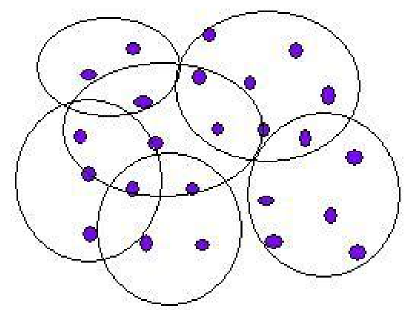

Fig.2Chosen Cluster Heads

Here a is the current round and G is the set of nodes eligible to become CH. The threshold value increases as rounds pass; alive nodes become a CH after rounds 1p. When a node becomes it broadcasts an advertisement message to all member nodes. Nodes receive the message and elect the CH which depends on signal strength. When node decides cluster, it transmits a message to CH belonging to that cluster. This process is done by using CSMA MAC protocol to avoid collisions. The CH broadcasts a TDMA schedule for transmissions to all its members. Now the next level of hierarchy is build. Previous CHs decides whether they could be CH for next level of hierarchy. If they are eligible then sends an advertisement message otherwise another node is selected to be CH. After clustering, data transmission starts from nodes to CH. TDMA schedule is broadcasted to all member nodes for transmission. To reduce interference CDMA code is used, each node chooses a different code. Moreover, two threshold values are used, the hard and soft threshold values. Nodes sense the field continuously, when hard threshold is reached node transmit data to BS. Soft threshold is small change in that sensed value.

IV. SYSTEM MODEL

4.1TOPOLOGY FORMATION

As sensor nodes are usually battery-powered, and they should be able to operate without attendance for a relatively long period of time, energy efficiency is of critical importance in the design of wireless sensor networks. The sensor nodes that are spatially arranged in underwater environments are not capable to stay in the active mode always. Sensor nodes strategically change between sleeping mode and active mode.

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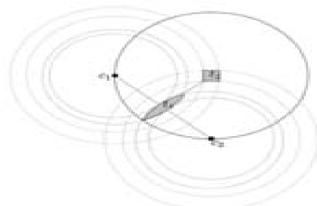

Fig .3 Nodes Present In Coverage Region

The nodes that are present in active mode are used to transfer the data from one node to another in acoustic environments. Once the data transfer is completed the sensor nodes are set to sleep mode. Since nodes in sleep mode consume much less energy than in active mode, these schemes can save energy by keeping nodes in sleeping mode as long as possible. Large density of sensor nodes maintains the connectivity of the network by a subset of nodes which are ON (Active) all the time, while letting the other nodes sleep.

Hence, the neighboring nodes are identified for each node and priority is assigned for all the neighboring nodes based on the distance from the source node. This step is repeated for all the nodes present in underwater environments and this reduces the energy consumption of sensor nodes in underwater environments. In the topology formation, each node will send hello packets to its neighbor node which are in its communication range to update their topology.

4.2 TRIAL MESSAGE BROADCASTING

The mobile sink moves around in IN with, relatively, low speed, and keeps listening for data report packets. It stops at some places for a very short time, broadcasts a message to the whole network, and moves on to another place. We call these places "Trail Points," and these messages "Trail Messages." A trail message from a mobile sink contains a sequence number and a hop count to the sink. The time interval between a mobile sink stops at one trail point and arrives at the next trail point is called one "move." There are multiple moves during a data gathering round.

4.3 DATA COLLECTION ASSISTED BY MOBILE SINK

The data reporting procedure consists mainly two phases. The first phase is called logical coordinate space construction. During this phase, sensor nodes update their trail references corresponding to the mobile sink's trail messages. After hop counts have been collected, a sensor node enters the greedy forwarding phase, where it decide how to report data packets to the cluster heads. The cluster heads will in turn report the data packets to the mobile sinks.

V. CONCLUSION

We ventured the SinkTrail and its ameliorated version, SinkTrail-S protocol, two low-complexity, ardent data reporting protocols for energy-methodical data tweetup. SinkTrail uses logical coordinates to surmise distances, and entrenched data reporting routes by greedily selecting the shortest path to the destination citation. In addition, SinkTrail is proficient to orbit miscellaneous ambulatory sinks concomitantly through miscellaneous logical coordinate locates. It procure covet attributes of geographical routing without demanding GPS gadgets or ancillary beacons installed. SinkTrail is capable of revamping to miscellaneous sensor field shapes and disparate moving patterns of ambulatory sinks. Further, it abolishes the need of special treatments for reorienting field situations. We methodically scrutinized energy consumptions of SinkTrail and other representative approaches and proved our scrutinize through substantial simulations. The results manifest that SinkTrail finds short data reporting routes and energitically diminish energy utilization. And by data clustering technique we have reduced the data repetition and we have achieved better data gathering in this analysis.

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