VGDRA: A Virtual Grid-Based Dynamic Routes Adjustment Scheme for Mobile Sink-Based Wireless Sensor Network

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ABSTRACT: In wireless sensor networks, nodes energy decadence can be managed by exploiting the sinks mobility. Due to the dynamic network topology caused by the sinks mobility, distribution of information to sink node is considered as a challenging task. In order to reduce energy consumption by nodes, nodes need to reconstruct their route to the latest location of mobile sink and that result in efficient data delivery. The main aim of this paper is to reduce reconstruct cost of the sensor nodes by maintaining minimal route to the latest location of sink node. In order to reduce energy consumption and route reconstruction cost, sets of communication rules are proposed .These rules governs route reconstruction process thereby requiring only few nodes to readjust their route to the latest location of mobile sink.

KEYWORDS:—Route reconstruction cost, energy consumption, sink mobility , wireless sensor network.

I.INTRODUCTION

A Wireless sensor networks can be used to sense data from various fields such as environment, healthcare, military operation and that sense data will be sent to centralized processing units such as base station or sink nodes for processing. Wireless sensor network consists of enormous amount of sensor nodes sense the change in physical parameters from the sensing range and forward the information to the mobile sink. Uniform distribution of nodes exhibit n-to-1 communication that means observed information is sent to single sink. Sensor nodes are placed at different points of interest based on application. In an intelligent transport system sensors are placed at junctions, carparks, these can provide early warning to mobile sink. The topology of the network is dynamic as sink nodes moves from one location to another. In order to provide efficient data delivery nodes need to reconstruct their route to the latest location of mobile sink. As scant energy resources are available propagation of sink`s mobility updates should be reduced as it consumes more energy. In the virtual infrastructure based data distribution schemes, only few nodes present in the sensor field need to keep track of sink`s location. Those selected nodes will gather information from nodes present in the vicinity and they send the gathered information to sink node, this can be done proactively or reactively. Virtual grid based dynamic routes adjustment is proposed for periodic collection of data from wireless sensor network. In existing techniques multiple mobile sinks were deployed in order to improve network performance and also to improve data delivery ratio of nodes. In the proposed technique only single mobile sink is considered as it aims to minimize the trade-off between data delivery performance and energy consumption.

The proposed technique permits sensor nodes to maintain a minimal route to the latest location of the mobile sink. The sensor field is divided into k equal sized cells and constructs a virtual backbone network, which consists of all cell-headers. Nodes present at the midpoint of cells are considered as cell-headers. Cell-header are responsible for collecting data from the member nodes present in the cell, and then delivering the data to the sink node by using virtual backbone structure.

The main goal of constructing virtual structure is to minimize energy consumption and also to reduce route-reconstruction cost by setting only few nodes to construct their route to latest location of sink. VGDRA also sets up communication routes such that the end-to-end delay and energy cost is minimized in the data delivery phase to the latest location of mobile sink. Mobile sink moves along the boundary of the sensor field and communicates with border cell-header for data collection. By using sets of rules route is re-construct. Using VGDRA, only a subset of the cell-headers needs to take part in re-constructing their routes to the latest location of the mobile sink thereby reducing the cost. The rest of this paper is as follows: Section II describes the related work. Section III presents our VGDRA scheme. To evaluate the performance of the VGDRA scheme, simulation and results are presented in Section IV. Finally, Section V is conclusion about our paper.

II.RELATED WORK

Many virtual infrastructure based data distribution protocols have been proposed for mobile sink based WSN in the last decade. Based on the mobility of sink in the sensor field, the data collection or distribution techniques can be classified into controlled and uncontrolled sink mobility techniques. In controlled sink mobility schemes [7]-[10], the speed and direction of the sink is changed and controlled either by an external user or in accordance with the network dynamics. The uncontrolled sink mobility based techniques distinguished by the fact that the sink makes its next move autonomously in terms of speed and direction. This paper considers the uncontrolled sink mobility environments and in the following lines, briefly describes the related works in this context including their approach and the relative strengths and weaknesses.

Chen et al. [11], this paper presented a converge-cast tree algorithm called, Virtual Circle Combined Straight Routing (VCCSR), which collects data in a wireless sensor network (WSN) using a mobile sink. Tree-based routing will provide the shortest routes to deliver data, and it is a common technique used by mobile sinks to collect data from sensors. When a mobile sink moves, the routes between the sink and the sensors must be reconstructed dynamically, which wastes a great amount of energy. VCCSR selects a set of cluster heads located near the virtual backbone, and when the sink issues a query in the wireless sensor network, a spanning tree is constructed to collect data. With VCCSR, the spanning tree does not need to be reconstructed when the mobile sink's location changes because the algorithm is able to update the location of the mobile sink, which then delivers this information to the cluster heads and adjusts the routing. The goal Of the VCCSR is to decrease the reconstruction cost and increase the data delivery ratio.

The advantage of tree-based routing is that it finds the shortest routes between a sink and the sensors. In the reconstruction process, the sink usually uses broadcast packets to construct a new tree, which consumes a great amount of communication cost and increases the possibility of data collision.

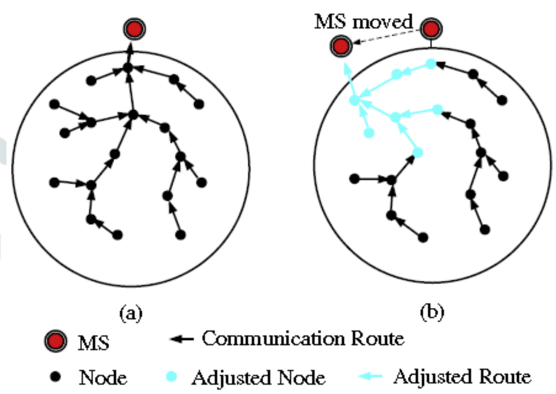

Fig. 1. Examples of tree-based routing for the mobile sink.

Fig. 1(a) shows a mobile sink (MS) that has constructed a tree structure to collect data.

When the mobile sink moves, it must reconstruct the tree structure to collect periodic data from the sensors. However, the reconstruction cost is very high in terms of energy consumption and communication load. To solve this problem, an adjustable routing tree is needed to decrease the reconstruction cost. Fig. 1(b) shows that the mobile sink does not need to reconstruct a new tree when it moves because it adjusts its route based on the adjusted nodes, thus decreasing the reconstruction cost. Using this type of algorithm, only part of the tree needs to be reconstructed, and the adjusted routes are regular.

The construction of the virtual structure combines virtual circles and virtual straight lines to form virtual backbones. The goals of the virtual structure are to construct an efficient data collection structure for the mobile sink and to decrease the reconstruction cost of the collection routes. The mobile sink is located outside the sensing area, but it circles the sensing area and maintains constant communication with the border nodes of the sensing area during data collection. The mobile sink then constructs a routing tree along the virtual backbones to collect data. VCCSR uses a set of clusters to collect local data, and each sensor sends its sensing data to the mobile sink via these cluster heads. The cluster heads then forward the data packets along the shortest virtual backbones to the mobile sink. VCCSR decreases the energy consumption of restructuring while the mobile sink continuously collects data from the WSN.

Hexagonal cell-based Data Distribution proposed in [12] constructs a hexagonal grid structure. In data distribution protocol, we use the concept of central re-dissemination in which packets will flow towards centre cells and they follow in the previously selected direction. Information is sent through borderlines towards center cell to store the generated information in border line so that mobile sink can easily collect the data using a query based data reporting method.

Honeycomb architecture defines three principle diagonal lines labeled as l, b, and r which are drawn through the origin of center cell, as shown in Fig. 2. These lines divide the sensor field into six parts which are named as Hextants. Each of six hextants is marked with roman number in the figure. All hexagonal cells on diagonal lines l, b, and r are borders of hextants so called as border cells. These three diagonal lines meet at a point for data storage and look-up.

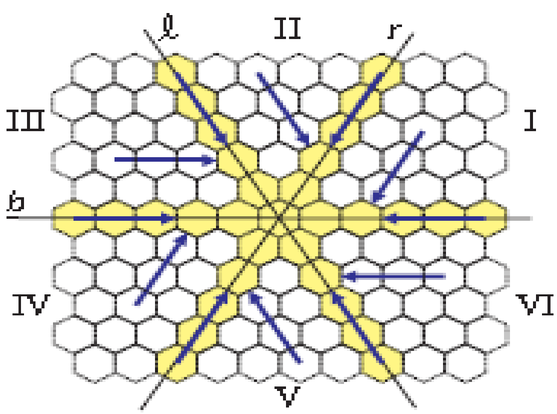

FIGURE 2: Honeycomb architecture

When the data reaches one of the Diagonal lines, data is forwarded towards the center cell through diagonal line. After the center cell receives information, then it is directed to one of the diagonal line based on the latest location of the sink, which is given in the sink's query. Nodes in the border lines act as rendezvous points for data storage. For example the second border node upon receiving the sink's query forwards it to center cell. Nodes in the border cells check its cache when it receives a query from sink node. If the requested data is in the cache of border cell, then that particular node will send data back to sink in reverse direction. The reverse path of the sink's query can be calculated by using cell address of the sink.

In Quadtree-based Data Distribution (QDD) proposed by Mir and Ko in [18], a node upon detecting sink's location calculates a set of rendezvous points (RPs) by dividing the network into four quadrants of equal sizes. After dividing the network, QDD routes the observed data to those nodes which are close to the midpoint of each division. The mobile sink distributes the query packet using the same strategy by questioning the node at closest RP first, followed by the next RP nodes till it reaches the required data report. In static nodes deployments, the same set of nodes become RPs repeatedly which results in more energy consumption of those nodes and thus decreases the overall network lifetime.

III. EXISTING SCHEME

Virtual infrastructure is designed by dividing the sensor field into virtual grids of equal sized cells. Where total no of cells is a function of the no of nodes present in a network. The node close to the mid-point of the cell is elected as cell-headers, to calculate the mid-point of the cell, user need to know the sensor field dimensions. Nodes other than the cell-headers connect themselves with the closest cell-headers and report the observed information to their cell-headers. To reduce communication cost in the cell-header election, only those nodes take part in the election whose distance to the mid-point of the cell is less than a certain threshold. The threshold distance to the mid-point will be increased accordingly if no node is found within the threshold distance around the mid-point of the cell.

After the cell-header election, each cell-header sends notification about its status not only to the surrounding nodes within its cell but also to the nodes which are slightly behind the cell boundary. Nodes might receive cell-header notifications from more than one cell-header and connect themselves to the closest cell-header. Nodes that receive notifications from many cell-headers also share the information of the secondary cell-header with their primary cell-header. In this way, each cell-header form adjacencies with neighboring cell-headers using gateway nodes. The set of cell-header nodes together with the gateway nodes constructs a chain like virtual backbone structure as shown in Fig. 1.

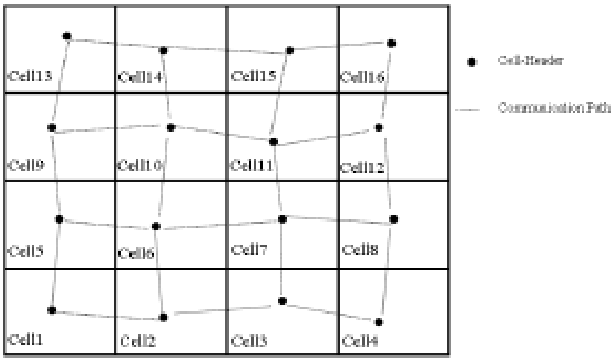

FIGURE 3:- Virtual backbone structure after establishing adjacencies.

After the cell-header election and establishing the adjacencies, communication routes are setup considering the mobile sink located at (0,0).Fig.2.shows the virtual backbone structure when the sensor field is divide into 16 cells.

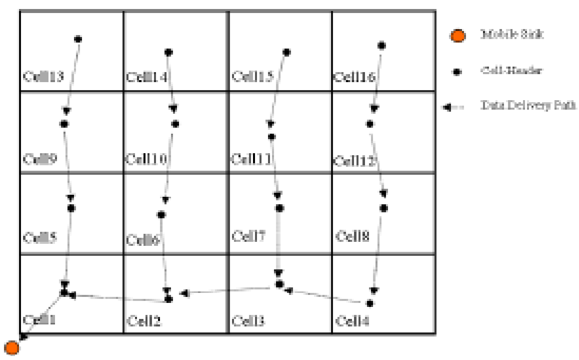

FIGURE 4:-Virtual backbone structure after initial routes setup.

3.1 DYNAMIC ROUTE ADJUSTMENT:

In order to manage with dynamic network topology caused by sink mobility, nodes need to construct their data delivery routes according to the the latest location of mobile sink. Using our VGDRA scheme, only the set of cell-headers that establish the virtual backbone structure are responsible for maintaining fresh routes to the latest location of mobile sink. The mobile sink moves around the sensor field and collects data via the closest border-line cell-header. The closest border-line cell-header is (originating cell-header) upon discovering the sink's location, shares this information with the rest of the cell-headers. VGDRA scheme defines a set of rules so that only selected cell-headers take part in the route re-construction process. Propagation rules are as follows:

Rule 1: The originating cell-header upon sink discovery first verifies whether its next-hop is already set to the mobile sink or not. If the mobile sink was previously being setup as its next-hop, the originating cell-header does not propagate sink's location update. If the next-hop entry of the originating cell-header is other than the mobile sink, it exercises rule 2.

Rule 2: The originating cell-header being one-hop from the mobile sink sets the mobile sink as its next-hop and shares this information with the previous originating cell-header and its downstream adjacent cell-header.

Rule 3: The previous originating cell-header upon receiving the sink's location update from the current originating cell-header, adjusts its data delivery route by setting the current originating cell-header as its next-hop towards the sink.

Rule 4: The downstream cell-header upon receiving the sink's location update checks whether the sender cell-header is the same as its previous next-hop or different. If it is the same, the downstream cell-header drops the sink's location update packet and does not propagate it further to the next downstream cell-header. In the case when it is different, the downstream cell-header updates its next-hop entry to the new sender cell-header and further propagates the sink's location update to the next downstream cell-header. This procedure is repeated till all the downstream cell-headers adjust their data delivery routes towards the latest location of the mobile sink.

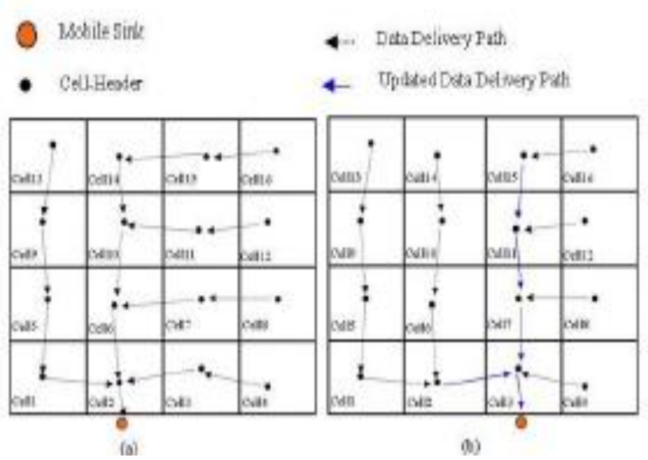

FIGURE 5:-Route re-adjustment when sink moves from cell 2 to cell 3

Fig. 3(a) shows an example of the data delivery paths when the sink node is located near to cell-2. When the mobile sink moves from cell2 to cell3, the cell-header at cell3 exercises rule2 and rule3 to update the cell-header at cell2, followed by rule4 to update its downstream cell-headers i.e., 7, 11 and 15 as shown in Fig. 3(b). In this way, only limited number of cell-headers take part in the routes re-adjustment process thereby reducing the overall routes re-adjustment cost of the network.

3.2 CELL-HEADER ROTATION

An integral part of the proposed VGDRA scheme is rotating the role of the cell-header in every cell. The cell-header being the local data collector is exposed to high energy consumption and therefore to increase the network lifetime, the cell-header role needs to be distributed among the nodes within the cell. In order to achieve uniform energy degeneracy, the VGDRA scheme keeps track of the remaining energy level of the current cell-header, if energy gets below a certain threshold, the new cell-header election is introduced by the current cell-header. In the re-election process, the node that is relatively more close to the mid-point of the cell and has a higher energy level compared to other cell is elected as the new cell-header. Also in the re-election process, the search area around the mid-point in every cell is slightly increased or the energy threshold level is decreased accordingly if no suitable node can be found. In order to preserve the virtual backbone structure, the current cell-header before stepping down, shares the information of the new cell-header not only with all its member nodes but also with the adjacent cell-headers in its neighborhood.

3.3Algorithm 1 Routes Re-Adjustment Using VGDRA Scheme

1. Mobile Sink (MS) updates its location to the closest Cell-Header (CH).

2. The closest CH becomes Originating Cell-Header (OCH).

3.if the previous Next_Hop of OCH is not the MS

4. {

5. set Next_Hop of OCH ← MS

6. OCH sends route update packet to the previous OCH

7. set Next_Hop of previous OCH← OCH

8. OCH sends route update packet to its immediate downstream CH

9. **for** each downstream CH receives route update packet

10. {

11. **if** the previous Next_Hop of CH is not the current sender

12. {

13. set Next_Hop of CH ← current sender

14. **if** next downstream CH is not **NULL**

15. {

16. set sender ← current CH

17. Current CH sends route update packet to its immediate downstream CH

18. }

19. **else**

20. drop the packet

21. }

22. **else**

23. drop the packet

24. }

25. }

26. else
27. Drop the packet

3.4 Proposed work:

The data distribution to the mobile sink is a challenging task for the resource constrained sensor nodes, because of change in the network topology caused by the sink mobility. A mobile sink while moving around the sensor field keeps on changing its location and interacts with the closest border-line cell-header for data collection. In terms of nodes energy consumption, delay and throughput. The simulation results reveal improved performance of proposed work for different sink's speed.

In proposed technique, speed of the sink is considered and based on it network performance is maintained. Consumption of energy and delay is reduced as only required number of hopes are involved in data transmission as speed of the sink is slow compared to existing technique. The throughput is increased as less number of packet drops takes place in the transmission.

IV.PERFORMANCE EVALUATION

Network performance depends upon energy, delay and throughput, performance is evaluated based on the factor sink's speed.

In existing technique consumption of energy by nodes is reduced as only required number of nodes are involved in route reconstruction process. From figure 6 among existing and proposed, proposed has got less energy consumption as speed of the sink is less in proposed compared to existing.

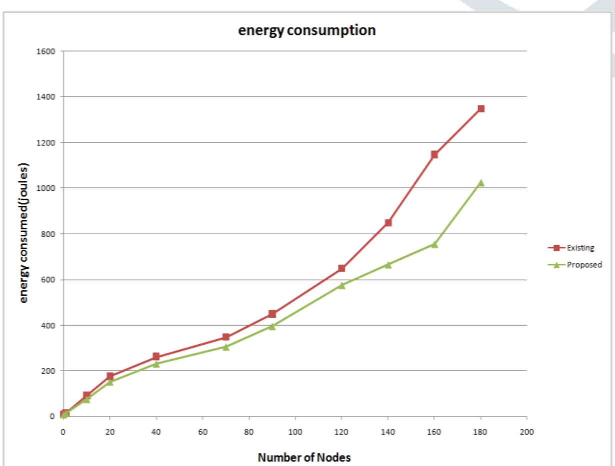

FIGURE 6: Energy consumption

From figure 7 among existing and proposed, throughput is more for proposed when compared to existing because sink's speed is less compared to existing that means drop of packets will be less in proposed technique.

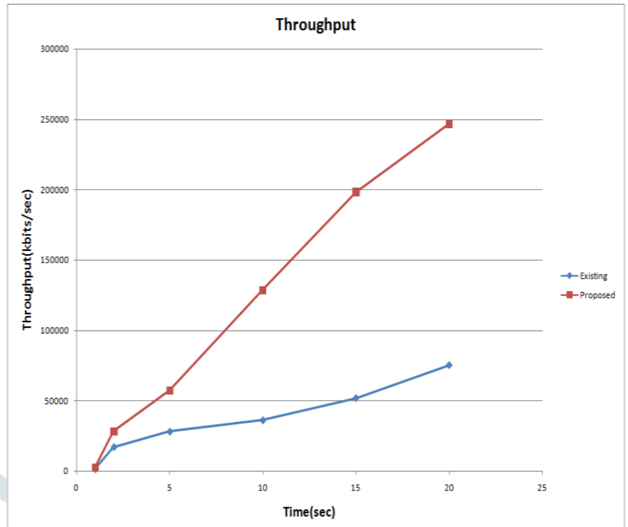

FIGURE 7: THROUGHPUT

When compared to existing , speed of the sink is less in proposed technique. Thus, delay is less in proposed as less number of hopes are involved in data transmission.

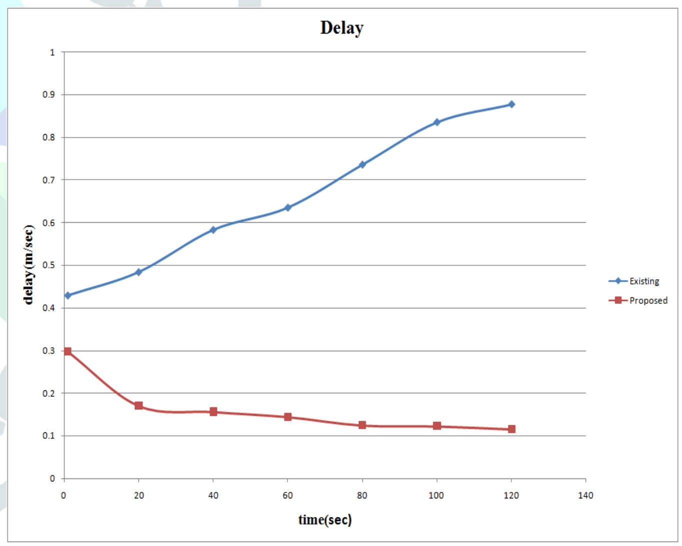

FIGURE 8 :End to End delay

V.CONCLUSION

In Existing scheme that experiences less energy consumption while maintaining minimal routes to the latest location of the mobile sink.The sensor field is divided into cells based on number of nodes and each cell has its own cell header .Sink will move around the border line of the cell-header with certain speed for data collection, sink speed is less in proposed that results in less energy consumption compared to existing . Using a set of communication rules, only limited number of the nodes take part in the transmission of data, no of hopes involved in data transmissin will be decreased thus results in less delay.

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