AN ENERGY EFFICIENT RING ROUTING PROTOCOL WITH A MOBILE SINK FOR WSN

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***Abstract*—Routing is one of the challenging tasks in wireless sensor network. In wireless sensor network, the energy of the sensor nodes near the sink drains more rapidly than other nodes due to the data traffic focused towards the sink. To limit the problem of data traffic in a network, energy efficient mobile sink routing protocol is proposed, which aims to reduce the overhead in terms of packet delay and energy utilization. Mobile sinks entirely provide load-balancing and helps in achieving uniform energy consumption diagonally over the network. In sensor network, a center node is selected and with the distance of 100-150 m the ring nodes are identified which forms the ring structure. Further in order to reduce the activation of the nodes in the ring in motive of reducing the energy consumed, the sensor nodes forward its data to the ring nodes and mobile sink moves through this ring structure and aggregates the data.**

***Keywords* — Energy Efficiency, Mobile Sink. Data Aggregation, Wireless Sensor Networks, Ring Routing.**

I. INTRODUCTION

The most important concern in wireless sensor network is the energy efficiency due to the limited capacity of the battery. While the sensor nodes are placed in the area of static sinks the energy drains which causes the energy imbalance problems and separation of the sinks. The packet forwarding procedures in wireless sensor network results in the concentration of data traffic near the sink. To overcome these problems, mobile sink is proposed which provides the load balanced data delivery, spreads the energy around the sink and shifts the hotspots. This extends the lifetime and delivers uniform energy consumption all over the network. The main problem of the routing protocol is the sink's position advertisement. The simplest mechanism to overcome this problem is the flooding mechanism which introduces high overhead due to the repeated broadcast communications. To decrease this overhead, hierarchical routing protocol is proposed which determines the multi-tier hierarchy of roles among the sensor nodes.

II. LITERATURE SURVEY

A. *Distributed Mobile Sink Routing For Wireless Sensor Networks: A Survey*

(Can Tunca, Sinan Isik and M. Yunus Donmez, 2014)

The distributed methods do not depend on a central entity to make decisions and to manage routes. Hierarchical approaches decrease the load of advertising the position of the sink to the network. The assembled hierarchy may compose of two or more tiers. The nodes in the overlay virtual structure obtain the sink's position while the remaining nodes query the high tier nodes to acquire the information of sink's position whenever necessary. The non-hierarchical routing protocols do not make use of a high-tier structure and is able to operate without position-aware sensors. This approach eliminates the overhead of creating a virtual structure.

B. *Trailing Mobile Sinks: A Proactive Data Reporting Protocol For Wireless Sensor Networks*

(Xin Xin Liu, Han Zhao, Xin Yang, 2013)

A proactive data reporting protocol, Sink Trail is proposed, which achieves energy efficient data forwarding to multiple mobile sinks, and effectively reduces the number of sink location broadcasting messages. Sink Trail makes the Frequent Flooding Method (FFM) in finding shorter routing path and consumes less energy during data gathering process. It uses sink location prediction and selects data reporting routes in a greedy manner. This solves the problem of movement estimation for data gathering.

C. *Strategies For Data Dissemination To Mobile Sinks In Wireless Sensor Networks*

(Elyes Ben Hamida and Guillaume Chelius, 2008)

The measured and monitored events are then sent for data post-analysis toward a base station or sink. This procedure is called data dissemination and is performed from source nodes, toward a static sink. When a node detects a new event, it determines the location of the sink, and then the data is forwarded to this location. The first type of data dissemination protocols is the rendezvous-based virtual infrastructure. Each node is aware of its geographic location through the use of a global positioning system. The second category of data dissemination protocols with mobile sinks is the backbone-based virtual infrastructure. It uses a self-organization scheme to build a virtual structure over the physical network to facilitate the process of data dissemination.

D. *TTDD: Two-Tier Data Dissemination In Large-Scale Wireless Sensor Networks*

(Haiyun Luo, Fan Ye and Jerry Cheng, 2005)

TTDD uses a grid structure so that only sensors located at grid points need to acquire the forwarding information. With this grid structure in place, a query from a sink goes across two tiers to reach a source. The lower tier is within the local grid square of the sink's current location and the higher tier is made of the dissemination nodes on the grid.

When the nearest dissemination node receives the query for the requested data, it forwards the query to its upstream dissemination node toward the source. TTDD can use simple greedy geographical forwarding to construct and conserve the grid structure with low overhead.

E. GPSR: Greedy Perimeter Stateless Routing For Wireless Networks

(Brad Karp, H. T. Kung, 2000)

GPSR uses the positions of routers and a packet's destination to make packet decisions. GPSR makes greedy forwarding decisions using only information about a router's immediate neighbors in the network topology. When a packet reaches a region where greedy forwarding is impossible, the algorithm recovers by routing around the perimeter of the region. Greedy forwarding tries to bring the message closer to the destination using only local information and each node forwards the message to the neighbor. If this neighbor is closer to the destination, the node forwards the packet to that neighbor. When no neighbor is closer, the node marks the packet into perimeter mode. If the greedy forwarding fails, perimeter forwarding is used which routes around the perimeter of the region. It applies the right hand to traverse the edges of the void and finds a path using the topology's perimeter. The perimeter forwarding algorithm uses a longer path to the destination so this algorithm is less efficient.

III. RING ROUTING

Ring routing is a hierarchical routing protocol with a mobile sink in wireless sensor network which uses greedy geographic routing. Geographic routing is an attractive routing solution as it is energy-efficient and scalable. The protocol has three roles on the sensor nodes. They are ring node, regular node and anchor node. Ring nodes form a ring structure and it is a closed loop of one node width. The sources of Ring Routing are (a) advertising the information of the sink's position to the ring (b) the regular node obtains the sink position information's from the ring (c) the nodes disseminate their data through the anchor nodes. The anchor node serves as the intermediate agents connecting the sink to the network.

IV. STEPS FOR RING ROUTING

A. Ring Construction

The node forms a ring structure and it consists of single node width which has the closed loop of nodes. These nodes are referred to as the ring nodes. Initially a ring radius is determined which is the network center. By geographic forwarding, starting from certain node the ring nodes are determined in a greedy manner until the first node is reached until it forms a closed loop. As long as the ring node elongates the network center, it can be changed. The shape of the ring structure will be imperfect. With the network center and the radius, the ring structure is formed by some threshold. The ring path is constructed by certain node starting from the leftmost point on the ring in clockwise or counterclockwise direction by greedy manner until it forms a closed loop gets complete.

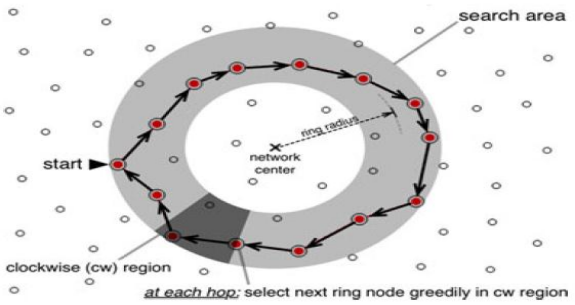

Figure.1. Construction of Ring

Otherwise, the procedure is repeated by means of the selecting different neighbor nodes at each hop. If the ring cannot be formed after a certain number of trials, then radius is set to a different value and the process is again repeated.

B. Advertisement of Sink Position

The anchor nodes (ANs) are selected when the sink moves around the neighbor nodes. The anchor node manages the communication between the sensor node and the mobile sink. Normally the sink selects the closest node with the greatest SNR value as its anchor node and it broadcasts an AN Selection (ANS) packet. The sink selects a new AN, before leaving the communication range of AN and informs it to the old AN about the position and MAC address of the new AN by a new ANS packet. Now the old AN knows the new AN and it sends data packets directly to the sink. This mechanism is known as the follow-up mechanism. The AN selection depends on the link quality estimation which uses the resilient method called beaconing. The follow-up mechanism and AN selection are based on progressive footprint chaining.

If a source node obtains the fixed position of the current AN, it sends the data directly to the sink by geographic forwarding. If the data reaches the old AN, it sends the data to the sink by the follow-up mechanism. The advertisement of sink position delivers the MAC address and new AN's position information to the ring and it sends an AN Position Information (ANPI) packet towards the ring. It sends the ANPI packet towards the network center, if the AN is outside the ring. If the AN is inside the ring, it directs it to a point which resides on the opposite direction of the network center by means of greedy geographic forwarding. The ring node after receiving the ANPI packet, gives this information to its clockwise or counter-clockwise ring neighbors by sending AN Position Information Share (ANPIS) packet. At this point all the ring nodes are aware of the MAC address and the position of the AN and hence the sink position advertisement is completed.

C. Obtaining Sink Position from the Ring

Before disseminating the data to the sink, the source node has to acquire the position of the AN. The fresh position of the AN is stored in the ring. In order to retrieve it, a mechanism related to the delivery of ANPI packets to the ring is used. Here the source node sends an AN Position Information REQuest (ANPIREQ) packet towards the ring. The position of the source node is also involved within the

packet. The ring node on receiving the ANPIREQ packet generates an AN Position Information RESPonse (ANPIRESP) packet which holds the current AN's position and delivers it to the source node by geographic routing. In the reception of ANPIREQ packet, the source node acquires the position of the AN and sends data towards it. All the intermediate nodes takes the the position information of AN from these packets and uses it for transmitting their own data to the AN.

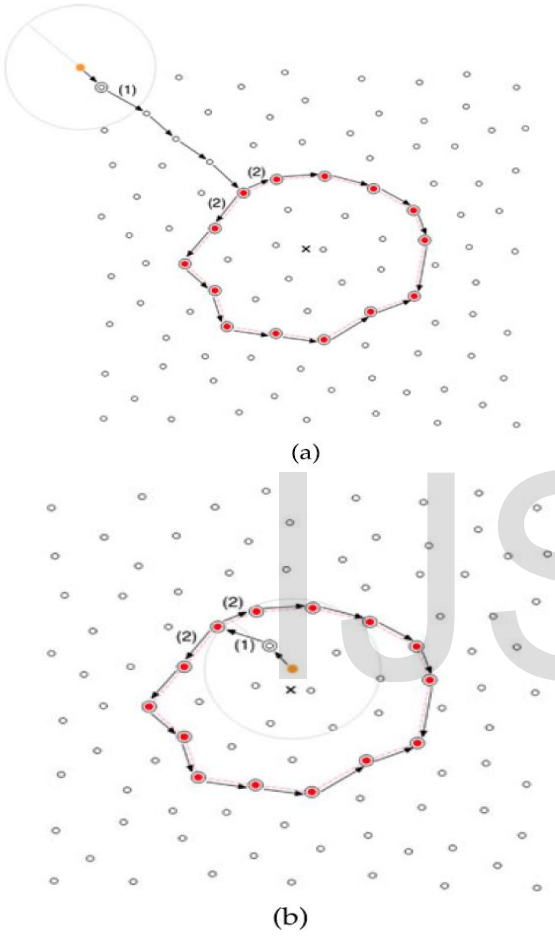

Figure.2.AN position advertisement. (a) sink is outside the ring and (b) sink is inside the ring.

D. Data Dissemination

When the source node obtains a response (ANPIRESP) to its request (ANPIREQ), it learns the position of the AN and delivers its data directly to it by means of geographic forwarding mechanism. If data reaches an old AN, means that the AN has already changed by the time data has arrived at the destined AN, the follow-up mechanism is used to distribute data to the current AN.

E. Ring Change

Ring nodes consume more energy than other nodes as they process AN position information advertisements and requests. Ring nodes handle more traffic than regular nodes. To prevent it from dying, the ring nodes have to switch roles from time to time with regular nodes. The ring node is independent to switch its role with a regular node. When the ring node decides to modify its role to a regular node, it selects ring node candidates which will take on the role of ring nodes. The two properties of the ring have to be preserved with the newly selected ring nodes: closed loop property and encapsulation of the network center property.

To preserve the closed loop property, the ring node candidates have to create a connection between the clockwise and counter-clockwise ring neighbors. This is done by the shortest path algorithm. When ring candidates are determined, a simple geometric check is done to ensure that network center is still encapsulated by the ring. When both the procedures are concluded, the ring node shows a ring change (RC) packet which informs the ring of their new role. At this point, the ring node drops its role and becomes a regular node and it informs its new role to its neighbors. As the ring change decisions are made locally, the arrangement of the ring might be imperfect in an instance of operation. Although imperfection would not impact the operation as long as encapsulation and closed loop properties are met.

V. RESULT AND DISCUSSION

The performance of Ring Routing under various parameters is simulated using Network Simulator (NS2). A topology of 100 sensor nodes deployed uniform randomly on an area of 500×500 m2 is used for simulations. A single sink moves randomly in the area of deployment with constant speed.

Figure.3 shows the selection of ring nodes. Ring nodes are formed at the distance of 100 to 150 m from the center of 250×250 m2 and the mobile sink is placed outside to collect the data packets.

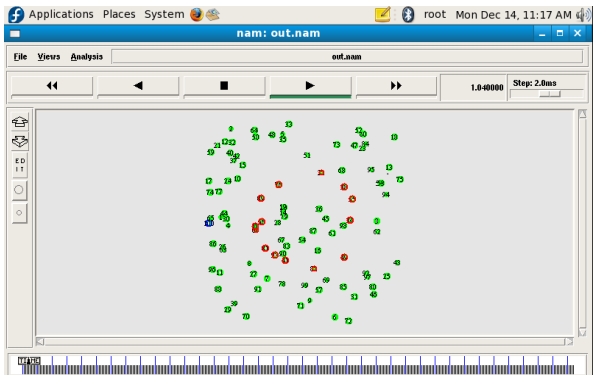

Figure.3. Selection of ring nodes

There are two types of communication. One is between ring node and sensor nodes. The other is between the ring node and the mobile sink. Figure.4 shows the communication between the ring and sensor nodes. The remaining sensor nodes gets attach to any of the ring node either directly or by some other sensor nodes to deliver data packets to the ring node.

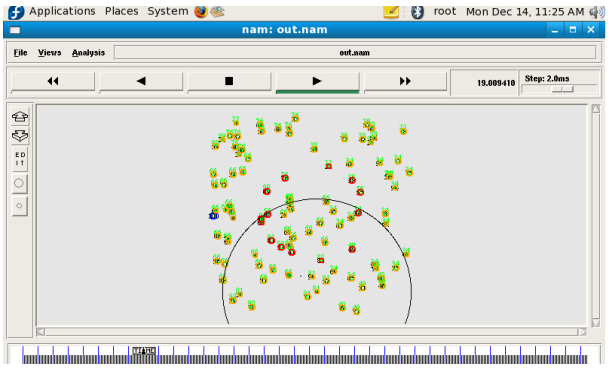

Figure.4.Communication between ring and sensor nodes

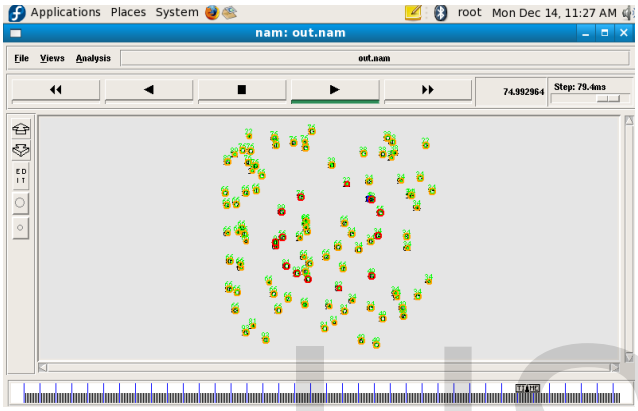

Figure.5.Communication between ring and mobile sink

Figure 5 shows the communication between the ring and the mobile sink. The mobile sink moves through the ring to collect the data packets.

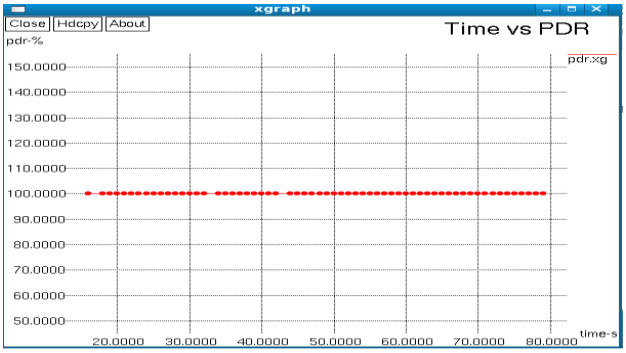

Figure.6. Time vs. PDR

Figure.6 shows the characteristics of time and packet delivery ratio. It is approximately constant throughout the simulation time which shows the stable delivery of the packet in the given network range.

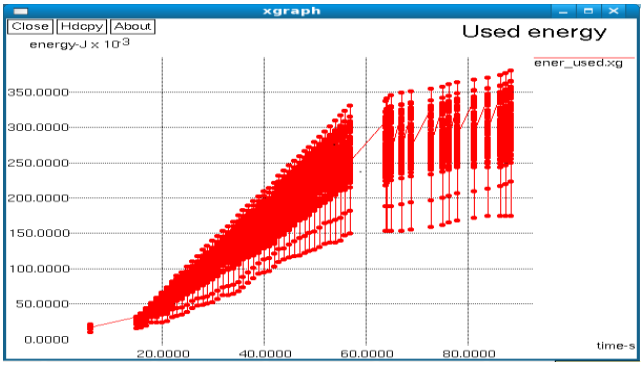

Figure.7. Remaining energy

Figure.7 shows the energy used throughout the communication range. It shows the consumed energy over the time. The first slot shows the energy for the communication between ring and sensor nodes. The second slot shows the energy for the communication between the ring and the sink. Figure.8 shows remaining energy after the simulation.

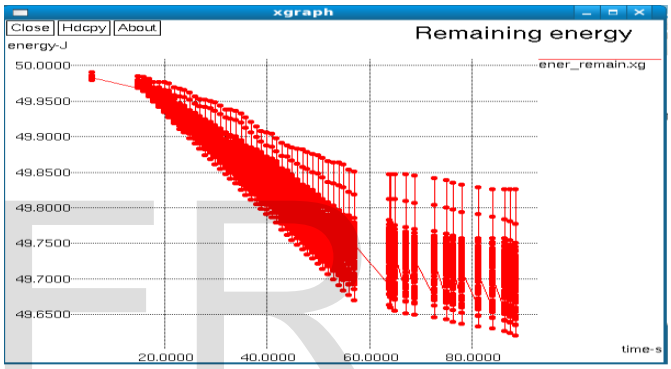

Figure.8. Used energy

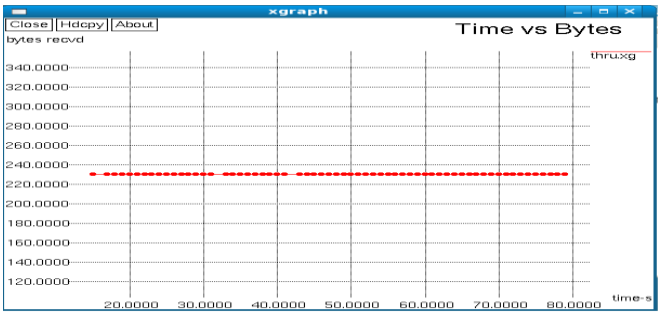

Figure.9. Time vs. Bytes

Figure.10 shows the characteristics of ID and end to end delay. The time taken for the packet to reach receiver from the sender.

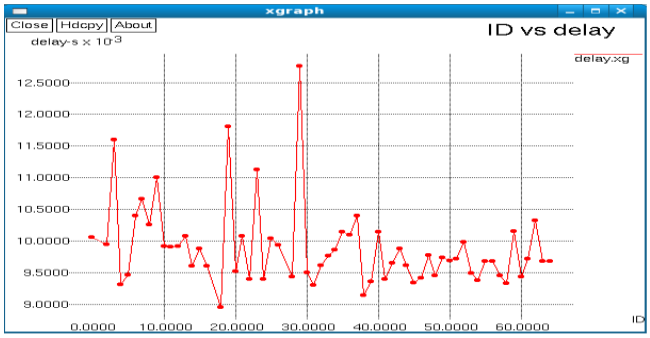

Figure.10. ID vs Delay

VI. CONCLUSION

In this work, the Ring Routing is constructed as it is a Hierarchical routing protocol which provides the benefits of accessibility and this overcomes the hotspot problems in the network. Here the mobile sink moves over the network to collect the data packets from the ring nodes as it takes more distance to cover the entire network and requires more time where the energy consumption will be more.

In the future work, an aggregator nodes is formed for certain ring node where the data packets from the ring nodes collected by the aggregator nodes. Thereby the mobile sink moves to the aggregator nodes to collect the packets. Hence the energy required will be less as the distance to complete for the sink will be less.

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