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RESEARCH ARTICLE

Energy Efficient Data Gathering in Wireless Sensor Network

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Abstract: In Wireless Sensor Networks (WSN), is used in many applications. Numbers of sensor nodes are deployed to gather the data from environment and process over it. During the formation of WSN main issue which comes under consideration is battery life of the sensor nodes. Once the sensor nodes deployed in sensor network, there maintains becomes difficult. To save the energy of sensor nodes we allow the mobile sink to move in the field and gather the data from the sensor nodes. In this paper we use mobile sink to gather the data from sensor nodes to conserve the battery life of network. Again there is a chance of creation of loopholes during the data gathering process. There is a need to detect the loopholes and to correct them. In this paper we use contiki algorithm to find loopholes and remove them from the network.

Keywords: Mobile Sinks, SinkTrail, Data gathering, Senor Nodes, loophole

I. INTRODUCTION

Sensor nodes are typically deployed into a large scale sensing field without a pre-configured infrastructure. Sensor nodes must be able to discover neighbouring nodes before monitoring the environment after which organizes them into a network. Most of the energy of a sensor is consumed during sensing the field and uploading data to the data sink. Energy consumption on sensing only depends on the sampling rate not on the network topology or the location of sensors thus energy consumption on sensing is relatively stable.

Wireless sensor network is widely used network as the data gathering paradigm. WSN has used in many applications such as environment monitoring forest fire detection etc. to collect the information from the given network many sensor nodes can be deploy in the network[1]. Which then collect the information from the network and process over it. But once the node is deployed in the network it is impossible to replenish the power supply. Means the sensor nodes are not rechargeable. Therefore energy saving is one of the important issue while designing the WSN since the battery life of the sensor nodes are limited. If the sensor nodes and sink both are static then more energy is required by the sensor nodes to convey the energy towards the sink nodes. Thus to reduce the power consumption of sensor nodes researchers includes the concept of sink movability [2]. Sinks are allowed to move in the network and gather the information from the sensor node and process over it. Thus, Sensor nodes does not require to expense energy to transfer the data toward sink nodes. When the concept of mobile sink is introducing, the sink can be a robot, vehicle or animals which are equipped with radio devices are used which are send into the network and directly communicate with the sensor nodes

which results in optimized data transmission path and reduces the energy consumption. Sink mobility reduces the energy consumption; it introduces new challenges in sensor network applications. When the sink is allowed to move in the network, path should be followed by the sink so that it can work more effectively. For the better movement of the sink in the network, route must be find, on which sink can move efficiently and gather the data in minimum time. Several algorithms has been suggested to find the optimized route such as on-demand routing, distance vector routing, geographical routing etc. when geographical routing is used the disadvantage in that is, it assumes that the geographical location of all the nodes are known. Many researchers focuses on planning a mobile sink's moving trajectory in advance to optimize the network performance. But in many applications predefined trajectory is not applicable. So without predefining the trajectory we allow the moveable sink to frequently announce the location information throughout the network. SinkTrail, a proactive data reporting protocol is used in sensor network where the sink moves continuously in the network, in relatively low speed and gather the data[3]. At particular distance after same time of interval sink nodes broadcast the control massage in much lower frequency than it ordinarily required in existing data gathering protocol. The position where the message is broadcast is called as "footprints"[4]. This footprint is considered as virtual landmark. Using this virtual landmark sensor node can easily identify its hop count distance from the landmark. These hop count distances combined represent the sensor node's coordinate in the logical coordinate space constructed by the mobile sink. By using the destination coordinates and its own coordinates, each sensor nodes selects the next hop with the optimized distance.

II. Related Work

Energy consumption and limited battery life is the main issue in wireless communication especially in wireless sensor network. Due to energy efficient property of mobile sink, it is used to gather the data in wireless sensor network. To track the moving mobile sink multicasting is mostly used. Spatial-temporal multicast protocol is proposed to establish a delivery zone ahead of mobile sink's arrival. Similarly, Park et al. [15] proposed DRMOS that divides sensors into "wake-up" zones to save energy. Important issue in the multicasting methods is its flooding nature. In existing work it is assumes that mobile sinks either move at fixed velocity and fixed direction, or move following a fixed pattern, which largely confine their application. To minimize the flooding effect of control messages without confining mobile sink's moving the SinkTrail protocol with message suppression is used.

A. Mobile element scheduling (MES) algorithms

There are number mobile elements deployed in sensor network which act as a base station that does the job of the data gathering. Once the mobile element visits a sensor node, Data is transfers into its own memory and the sensor's memory is freed. A problem that naturally crops up is the scheduling of the visits of the mobile node so that none of the sensor nodes' buffer overflows. We call this the **Mobile Element Scheduling (MES)** problem[5].

B. Vehicle Routing Problem

TSP is a special case of the Vehicle Routing Problem (VRP). In VRP, like TSP, each node should be visited, but unlike TSP, there can be more than one vehicle. At the nodes where the Vehicles start and end the travelling, referred to as the depot[6]. The goal is to find the number of vehicles and the Hamiltonian tour assigned to each, such that sum of the distances travelled by each vehicle is minimum.

C. Processor Scheduling

In processor scheduling Tasks come periodically, have a execution time, and need to be finished before their deadline. We can have two analogies of this to our problem. The inter node travel time can be considered as the context switch time, and servicing time at a node can be considered as the execution time[7]. Another way of looking is that the travel time is the execution time.

D. Energy-Conscious Message Routing

Energy-Conscious Message Routing is a approach for managing the sensor network with a main objective of extending the life of the sensors in a particular cluster. This routing focus on the adjustment of topology and the message routing. Sensor energy is mainly decided on changes to the network topology and in setting routes.

Latency in data delivery and other performance attributes are also considered in the routing decision. In addition, message traffic between the sensors and the gateway is arbitrated in time to avoid collision and to allow turning off the sensor radio when not needed. Route setup in a cluster is centralized at the gateway[8]. Centralized routing is simple and fits the nature of the sensor networks. Since the sensor is committed to data processing and communication, it is advantageous to offload routing decision from the resource-constrained sensor nodes.

ROUTING PROTOCOLS

A. TTDD protocol

The TTDD protocol, proposed in [14], constructed a two-tier data dissemination structure in advance to enable fast data forwarding. Control messages are flooded to wake up nodes in the delivery zone.

B. DRMOS (Dynamic Routing protocol for Mobile Sink)

Park et al. [15] proposed DRMOS that saves the energy by dividing sensors into “wake-up” zones. DRMOS consist of set of protocols which includes various algorithms which handles the mobile sinks by reusing routing tree. Fodorand Vida’s lowered communication overheads by proposing a restricted flooding method; routes are updated only when topology changes. Luo and Hubaux proposed that a mobile sink should move following a circle trail in deployed sensor field to maximize data gathering efficiency.

C. Grid Location Service

Grid Location Service proposed in[16], is scalable location service which is designed for the mobile phones with the use of GPS. It is a decentralized approach to distribute the data in the network. Periodically all nodes publishes the Location-to-ID in the network. GLS chooses the node on the basis of predefined grid hierarchy. This hierarchy is used to find the closest location servers. But these services are not appropriate by means of life time of sensor nodes.

D. The Landmark Routing

The landmark routing is similar to GLS routing. Location service gives the node ID’s to the coordinates. These coordinates, or landmark address, is a set of node identifiers of designated landmarks closest to the node. Each node publishes its land mark address information to a location server by hashing its own ID and using the result as the landmark address for the location server.

E. Mobile Element Scheduling (MES) algorithm

Mobile Element Scheduling (MES) algorithms[14] is used to controlled mobile sink mobility and advanced planning of mobile sink’s moving path. 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 data gathering.

F. SinkTrail Protocol

Unlike MES algorithms, SinkTrail[1], is more flexible as it dynamically adapt changing field situations while still maintains low communication overheads. SinkTrail uses sink location prediction and selects data reporting routes in a greedy manner. 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. Greedy algorithm is used in sinkTrail protocol for data gathering using logical coordinates rather than the geographical coordinates. Fonseca et.al.Proposed vector form of virtual coordinates, in which every element represent hop count from the landmark node. SinkTrail uses this method and finds the last location of the mobile sink as virtual landmark. When SinkTrail protocol is used mobile node allow to moves in the area in relatively slow speed and keep listening to data reporting packets. The sink stops at some places for short time of period and broadcast its location in the network. Now the sensor nodes view this place or footprint as virtual landmarks. The places are called as “Trail Points” and massage as “Trail Massages”.

III. Proposed Work

A. SinkTrail Protocol

Consider a sensor network as a large scale, uniformly distributed network. The nodes in the network communicate with each other using radio links. Sensor nodes are in awake state only when the process data collection starts.

To gather the data from the network mobile sinks are used which are periodically send in network. As energy supply of mobile sinks can be replaced or recharged easily, they are assumed to have unlimited power[17]. When mobile sink enters in the network it terminates only when enough data is gathered or there is no data to gather. The SinkTrail protocol is proposed for sensor nodes to proactively report their data back to one of the mobile sinks.

In SinkTrail Protocol during the data gathering sink moves in the given network in low speed and concentrate on the reporting data packet. Mobile sink stops at some places for short duration of time, broadcast the message to whole network and starts moving forward. The points where the sink stops are called as trail points and the broadcast message are called as trail messages. There is no any predefined pattern followed by this trail points. Trail messages generated by the sink contain the sequence number and the hop count of sink. The time intervals between two Trail points are known as “move”.

In sinkTrail protocol predefined landmarks are not used in place of predefined landmarks logical coordinates are used. To represent the logical coordinate sink references are used. Each nodes maintain the trail reference and used during the data forwarding. Two phases are used in SinkTrail Protocol. Logical coordinate space construction is the first phase. In this phase according to mobile sink’s trail messages sensor nodes update their trail references.

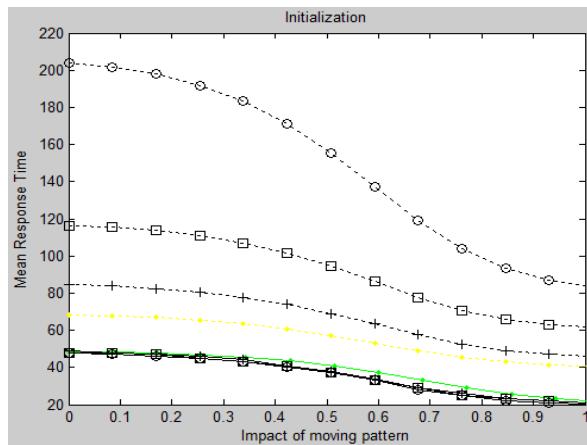


Fig 1 Impact of moving pattern

Destination Identification is the second phase of SinkTrail. Instead of scheduling a mobile sink’s movement, it allows a mobile sink to spontaneously stop at convenient locations according to current field situations or desired moving paths[20]. These trail points in SinkTrail, are footprints of a mobile sink, and they provide valuable information for tracing the current location of a mobile sink.

B. Impact of number of mobile sink in network

In sensor network number of mobile sinks affects the overall system performance. When multiple mobile sinks are used in network, several logical coordinate spaces are constructed concurrently and data packets are forwarded to the destination reference using the shortest path in any coordinate space. As the number of mobile sinks increases it reduces the average route length and also reduces the total energy consumption. But more mobile sinks also introduce heavier burdens for trail message broadcasting and routing information maintenance. Even worse, multiple number of mobile sinks in a network aggravate control traffic congestion and communication delays, which will in turn result in higher packet loss and retransmission rate.

C. SinkTrail protocol with multiple mobile sink

The proposed SinkTrail protocol can be readily extended to multiple mobile sinks scenario with small modifications. When there are more than one sink in a network, each mobile sink broadcasts trail messages following

Algorithm 1. 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, each corresponds to a different mobile sink at the same time. In the above graph the number of mobile sinks used is up to 3 and they are injected into the network at the same time. For fair comparison all the mobile sinks moved randomly in different routes, and broadcasted at the same frequency.

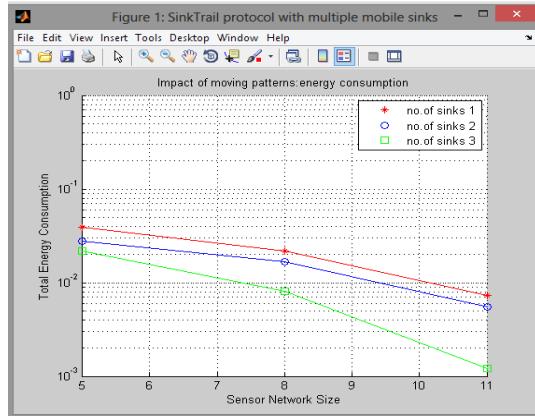


Fig 2 Energy Consumption: SinkTrail protocol with multiple mobile sink

D. Moving patterns of a mobile sink

First we examine how the moving pattern of a mobile sink can affect the system performance, as directional change in a mobile sink's movement is unavoidable due to occasional obstacles To numerically model the moves conducted by the mobile sink, we trace the moving trail of a mobile sink on a plain and measure the directional change at each trail point.

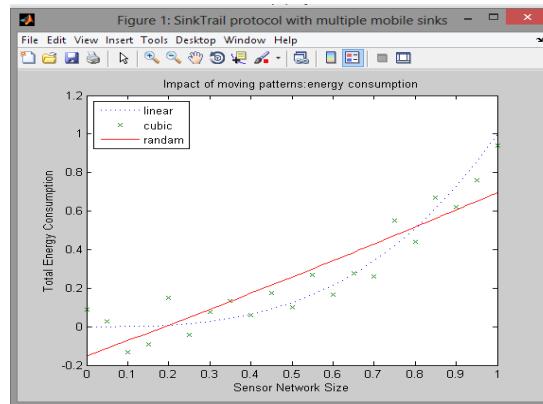


Fig 3 Impact of moving pattern: Energy consumption

Three moving patterns including cubic, random, and linear moves are compared From these above figures we observe that, an energy consumption increase as the network size grows. For the three moving patterns, linear movement incurs the least energy consumption and the shortest average route length. As to the circular movement case, the mobile sink changes its direction regularly and smoothly, leading to performance close to the linear movement case. Finally, for the random move case, the results vary in a wide range. This is because it is difficult to predict the behaviours of random movement as trail messages are broadcasted at random intervals. Therefore, the overall system performance may suffer greatly when the directional change is radical at some trail point.

E. Protocol to detect and correct loopholes in sensor network

The proposed SinkTrail protocol is used in fix network. SinkTrail protocol find the optimum route for the mobile sink in define network only. If any sensor node lies beyond the fix sensor network mobile sink cannot visit that sensor node because it does not lies within the predefined network. Thus the sink node moves only within the predefined

network and form a loop within the sensor node lies within the sensor nodes. To avoid creation of loophole and to allow the mobile sink to find a route in variable length network size we use Contiki Collect algorithm with SinkTrail protocol.

There are two options to have a mobility aware Collect protocol:

- 1) Re-designing and re-implementing new algorithm.
- 2) Optimizing Contiki Collect algorithm.

- **Link Evaluation:** Link Evaluation block saves the estimation history upto 8 estimation is default value. $ETX1_{hop}$ is calculated based on these values. Again, according to the number of (re)transmission needed for a successful packet delivery, link estimator updates $ETX1_{hop}$. As a reminder, it should be mentioned that low link quality (failure and retransmission) leads to increase in the $ETX1_{hop}$ value.
- **Neighbours Organizer:** Information about detected neighbours or in networking terminology is saved in this block, it provides the routing table for a sensor node. Address (node ID) of a neighbour are saved in the routing tables and its advertised ETX . To remove an entry which is not updated for a long time one timer is used and another timer to remove link estimation information in link estimator block. Moreover, an algorithm for parent selection is implemented in the block of neighbour management.
- **Neighbor Identifier:** To detect the nodes neighbour identifier is used. It uses beacon message to broadcasts neighbor discovery packets in which “node ID” and are included.
- **Collect:** This block is the central unit for the collect algorithm. It provides interfaces to the upper and lower layers and initializes other previously mentioned modules in Contiki Collect. It handles sending and receiving packets as well as their acknowledgments. If there is a major change in current node, it forces the module of neighbour discovery to broadcast a beacon to inform other nodes in the neighbourhood about recent reorganization.

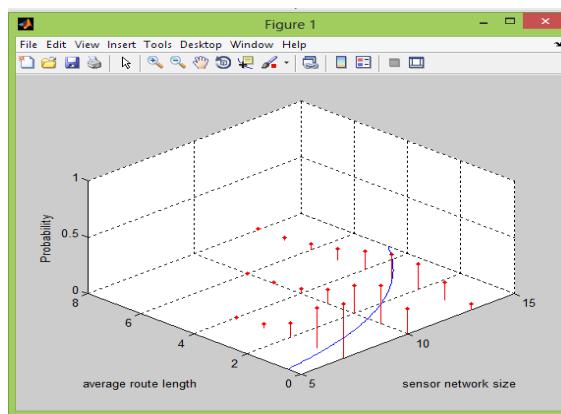


Fig 4 : 3-D view of sensor network

Above fig show the 3 dimension view of the sensor network where the sensor nodes are deployed and it also shows the optimized route for the mobile sink using the sinkTrail protocol. The red dots shows the sensor nodes deployed in the network and the blue curve show the possible optimized route for the mobile sink.

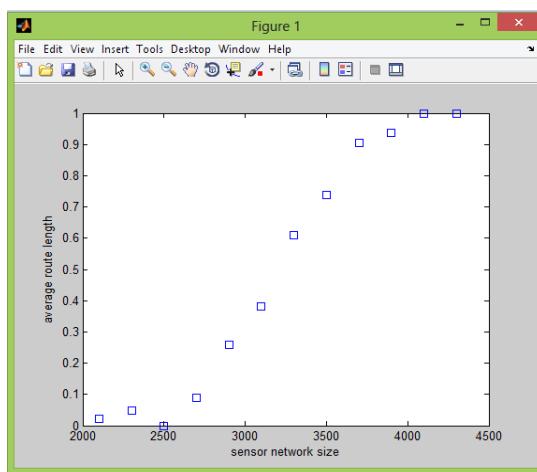


Fig 5- 2-D view of the sensor network

Fig 5 shows the 2 dimensional view or graphical representation of sensor nodes deployed in sensor network. Where the blue square represent sensor nodes deployed in sensor network.

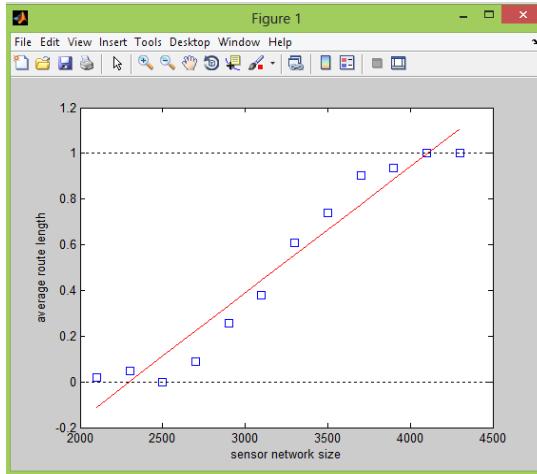


Fig 6 Possible Shortest Path for mobile sink in the sensor network

Graph 6 shows the possible optimized path for the mobile sink in the sensor network. It is considerable that the path should be a straight line for the mobile sink. When the mobile sinks are allow to move on the network the path which is less energy consuming and is optimized, can be a straight path.

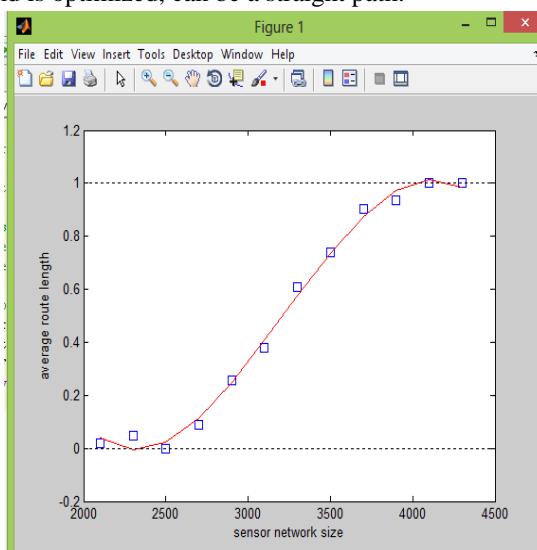


Fig 7: Optimized Route by using SinkTrail Protocol

Above fig shows the route of mobile sink within fix network. The sink node moves only in the network which are predefined. It forms a loop between the sensor nodes within predefined network only. And does not visit any other node added beyond the fix network size. Thus to avoid the formation of loop and to provide variable size network contki collect algorithm is used.

To accept the variable size network and to allow the sink node to visit the sensor node which are deployed beyond the predefined network size Contki Collect Algorithm is used. This algorithm allows sink node to move in the variable size network and visit each and every node in the network without forming any loops.

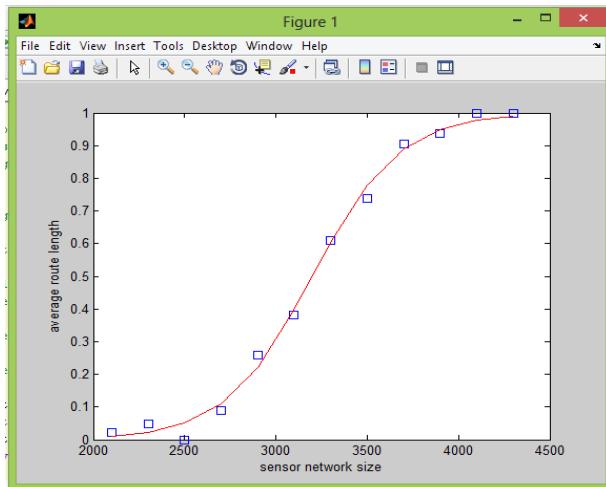


Fig 8 Contki Collect Algorithm

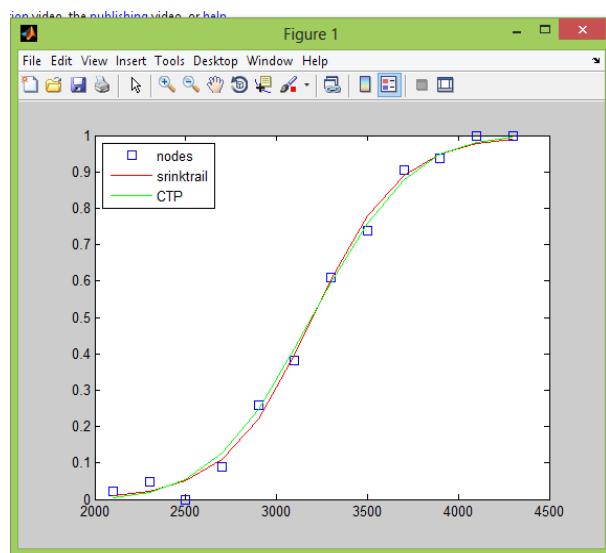


Fig 9 Comparison of SinkTrail and Contki Collect algorithm

Above fig shows the comparison between SinkTrail and Contki algorithm. There is no much difference in the route selection and energy consumption of mobile sink. The main difference is the avoidance of loop formation. SinkTrail protocol does not allow a sink node to move in the variable size network and form a loop within the existing network. On the other hand Contki Collect algorithm allows the use of variable size network and also allow sink node to visit each and every sensor node in network without forming a loop.

IV. Conclusion

In this paper various aspect of data gathering schemes such as uncontrolled mobility, controlled mobility, efficient relay routing, hierarchical infrastructure are discussed, furthermore brief concept of SinkTail protocol is described for energy efficient data gathering where impact of multiple sink in network is described. SinkTrail uses logical

coordinates to decide distances, and establishes data reporting path by greedily selecting the shortest path to the destination reference. The problem of loophole formation is also detected and removed using contki algorithm. The sensor nodes which are beyond the network limit is detected and the data from those nodes is gathered using contki algorithm which allow scalable data gathering in wireless sensor network. It also consist desired features of geographical routing without requiring GPS devices or extra landmarks installed.

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