A Geographical Location Aware Energy Efficient Routing Scheme for Query Based Wireless Sensor Networks

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Abstract: - ***In this paper, a geographical location based routing scheme is proposed that works effectively for different hierarchical networks and thus supports an important aspect of network scalability. Further, herein a heuristic is proposed that minimizes the occurrence of hot spot to improve the overall life time of Wireless Sensor Networks (WSNs).This utilizes residual energy estimation based on energy of each sensor node. Its implementation mainly comprises of the geographical location of each sensor in Binary Location Index (BLI) representation form, precise updates about the link with shortest path, and coverage of the each sensor; the method which is without change of cluster head is compared with the change of cluster head based on BLI for fixed single sink.***

Keywords-Binary location index, Grids, Hot spot, Residual energy status, Life time.

I. INTRODUCTION

A Wireless Sensor Network (WSN) contains hundreds or thousands of tiny sensor nodes. These sensors are also known as motes and they have the ability to communicate either among each other's or directly to an external base-station (BS)/sink node. Compared to other conventional networks, relatively higher densities of these sensors (motes) facilitate job of sensing over larger geographical regions with greater accuracy. Fig. 1 shows the functional schematic diagram of sensor node architecture. Basically, each sensor node comprises sensing, processing, transmission, mobilizer, position finding system, and power units (some of these components are optional like the mobilizer and position finding system).Fig. 1 also shows the signal flow/data communication in WSN using directional arrows. Usually, the sensor nodes

are scatteredly deployed in the given monitoring area. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external base station(s). Base-stations may be stationary or mobile and is capable of connecting the sensor network to outside world using an existing communications infrastructure/Internet where users can have access to the reported data [1].
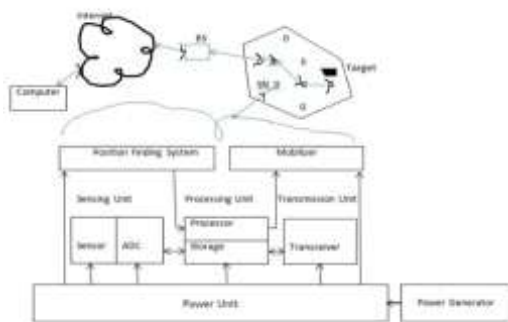

Figure 1: The System architecture of a sensor node[1]

In queries based network, to have priory knowledge about number of queries a sensor node can handle before it enters into hibernation or completely drained out in terms of it energy reserve a simple logic is used. In that context, an obvious choice to select a test node is any arbitrary node that belongs to a cluster, which is closest to sink node; and this particular node remains do the job of cluster head. With this strategy; as this particular node is going to be used exhaustively; in tern it will drained out in speedy manner and thus the number of query handling capacity of a node can be inference. This strategy helps out in getting approximate estimate about number of queries supported by an individual node. At this stage; work concludes by comparing

without change of cluster heads approach with proposed scheme with change of cluster heads makes use of heuristic to set the threatening threshold and residual energy level after that cluster must find out new cluster head. The outcomes of proposed scheme are promising one as they inhabits the prolonging residual energy status of individual sensor node and thereby maximization of network life time. In this paper, a scheme is proposed to overcome "hot spot" effect with low overhead [6].The rest of the paper is organized as follows: the location indexing of grids in section 2; proposed methodology for change of cluster head and residual energy estimation is compared with without change of cluster head in section 3, while section 4 concludes the paper.

II. LOCATION INDEXING OF GRIDS

In majority of sensing applications, the sensor network architecture is usually hierarchical based. In multi-level hierarchical network, to establish a (need based unilateral/bidirectional) communication link between any source-destination pair; an important issue is location identification so as to support multicasting while conserving a very important resource in wireless sensor network (WSN) domain, i.e., energy or power reserve of an individual nodes. So in this approach; entire service is divided into four zones and indexed as (I, II, III & IV), further these zones are subdivided into subzones, subzones are subdivided into regions, regions are subdivided into sub-regions, and sub-regions are subdivided into grids. Locations of each grid are represented by the Binary location Index (BLI) frame. In a hierarchical manner, these grids are further decomposed into smallest size of infinitesimal area and are

known as cells. In query based protocol every query is passes through the initially selected local aggregators (LAs), As time passes; consistent uses pattern of these LAs and simple nodes might leads to a situation, where these LAs as well as the sensor nodes attains pre specified lowest possible energy level (threshold) and it leads to a phenomenon "HOT SPOT". For life time maximization of entire network selection of LAs (from the set of nodes) should be done in such a way that likelihood of the HOT SPOT effect can be prolonged till the occurrence of horizon time (maximum expected life time)[7].

III. PROPOSED METHODOLOGY FOR CLUSTER HEAD DEPLOYMENT AND RESIDUAL ENERGY ESTIMATION

In this work, nominal values of various operational parameters of all sensor nodes are typically set as per adopted practical norms. In present studies; initial energy of each sensor node and its electric current consumption rate is chosen as 1.725 Joule and 575 mAh (milli Ampere Hour) respectively. To support these specifications, each sensor node is equipped with two 1.5 Volts alkaline batteries. As per reported in many research literature; the energy to transmit and receive a single binary digit (bit) is taken as $1\mu J$ and $0.5\mu J$ respectively.

Depending upon application specific purposes, the size of query message and its response (reply) message varies arbitrarily; in reported work, size of these two are considered as 240 bits and 1200 bits respectively. Thus, on using packetization of these number of bits to form a query & response frame; a pair consisting of transmit energy and energy required to carry out reception task is

(240,120) and (1200, 600) µJ for each generated query & response respectively [8].Thus, considering these two frames, the overall energy consumption at each sensor node for each query is 2.2mJ.In this work, two different case studies are explored to imitate the design scenario for query based sensor network, these are as follow:

(1) Surveillance of a given geographical area using a single stationary sink for without change of headship.

(2) Surveillance of a given geographical area using a single stationary sink for temporal change of headship.

1. SIMULATION PARAMETERS

To test and validate the proposed scheme; a square shaped geographical area dimensions along with associated deployed sensor nodes specification are listed in Table 1.

2. STREAM LINE PROCEDURE AND SIMULATION RESULTS

The step by step procedural details to implement the without change of cluster heads scheme and change of cluster heads for fixed single sink scheme along with obtained simulation results are outlined as follows. To implement the mechanism of the without change of cluster heads scheme and proposed scheme for change of cluster heads for fixed single sink , various operational parameters are taken from Table-1.

Table 1

Sr. No.	Network Parameters	Value
1.	Service area; square in shape having its area	250X250 m^2
2.	Maximum No. of query a node can handle before it drains out completely	1634
3.	Number of Sensor Nodes deployed	2304
4.	Number of clusters & respective heads	278
5.	Average number of sensor nodes in each cluster	8
6.	Initial energy of each sensor nodes	1.7250 J
7.	Set threshold of sensor node when its attains critical residual energy status (RES)	10% of Total Energy 0.17250J
8.	Set threshold for a node to relinquish the job of cluster head & subsequently passes onus to other member of cluster having better energy profile	70% of Total Energy 1.2075J
9.	Energy consumed at each participating node (per query basis)	2.2mJ

2.1 PROCEDURAL DETAILS & SIMULATION RESULTS USING WITHOUT CHANGE OF CLUSTER HEADS SCHEME

1. Given number of sensor nodes are deployed in a square shape geographical area with approximate uniform distribution and this nodes distribution is shown in Fig. 2.

2. Formation of arbitrary clusters using neighbouring nodes; towards this, it has been taken care that number of sensor nodes in each cluster is more or less uniform and initially deputing any one node from each cluster as cluster head, this entire process is depicted in Fig. 3.

3. Sink location is arbitrarily fixed and is shown in Fig. 3 at the top edge of service area.

4. For specific sensor node having it Binary Location Index (BLI) 1104; as it is cluster head for the cluster that is closest to the sink; for this sensor node (indexed as 1104), the changing residual energy pattern is shown in Fig. 4, till this node attains critical residual energy status (RES).

5. Step 4 gives approximate estimate about number of queries that can be handled by any arbitrary sensor node.

2.2. STEP BY STEP PROCEDURE FOR PROPOSED SCHEME FOR CHANGE OF CLUSTER HEADS FOR FIXED SINGLE SINK

1. First three steps are followed exactly in a similar manner as mentioned in without change of cluster heads scheme.

2. For every cluster head (CH); set the threshold level of RES as 70 % of the total energy.

3. If any particular CH attains this set threshold of RES; relieved it from the coordinated task of headship and depute any other sensor node within the same cluster having highest RES profile amongst the other contenders.

4. Step 3 is executed on similar lines, even in eventuality of all nodes within any cluster deprived of 70 % of RES.

5. A node that attains critical RES (10% of initial energy) should be avoided as being the CH, as far as other alternative choices are available within same cluster.
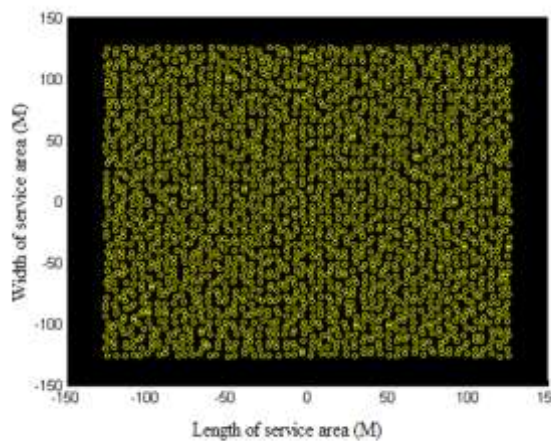
Figure 2: Uniformly deployment of sensor nodes.
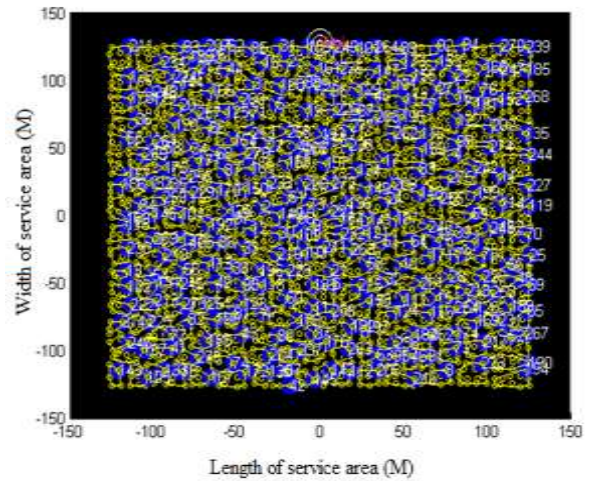
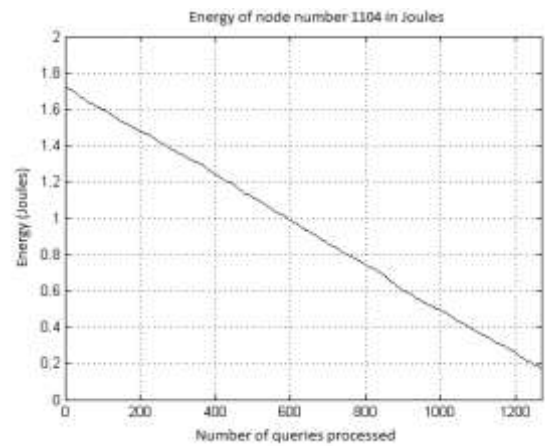Figure 3: Cluster formation and their respective heads

Figure 4.Number of queries supported by a sensor node (BLI-1104) till it attains critical RES.

The energy status of all sensor network nodes on using without change of cluster heads scheme is shown in Fig. 5 to 7. Fig. 5 shows that only very few nodes are deputed as a cluster head till they attains critical RES. These nodes having their BLI in the range 1000 to slightly more than 1500 are characterized with impulsive falls in Fig. 5.

Fig. 6 shows the behavioral pattern of energy consumed for all the sensor nodes, when, so far the network has entertained a total number of 1269 queries. These queries are generated towards any localized (in any arbitrary

direction) part of the network while cluster heads (CHs) are fixed. As a complementary analysis; Fig. 7 depicts the residual energy status (RES) for all the network nodes under the circumstances that network experiences a total of 1269 queries with fixed CHs.
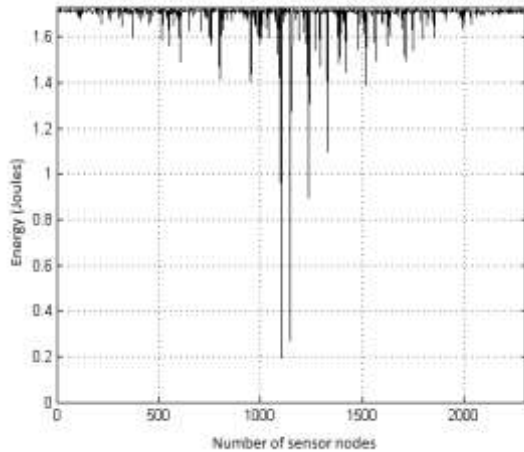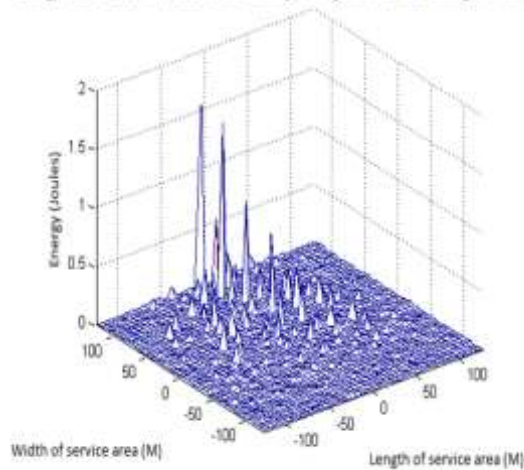

Figure 7: Energy status of each node, when more number of queries generated in without change of cluster heads.

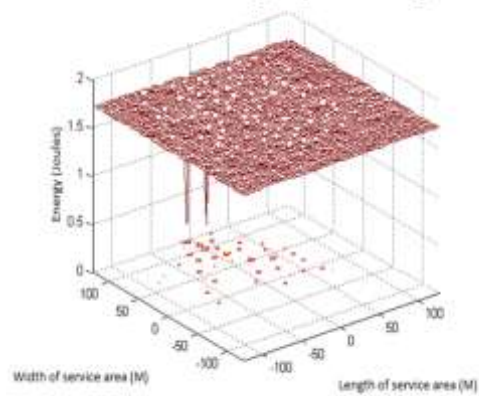Figure 5: Energy status of all network nodes using for without change of cluster heads.

Figure 6: Energy status of each node, when more number of queries generated in without change of cluster heads.

The estimated key energy parameters namely energy exhausted (consumed) and RES behaviors for all sensor nodes using proposed approach are shown in Fig. 8 to 11. In that, a heuristic strategy take cares assignment and thus rotation of the cluster headship to most suitable node within that cluster.

In Fig. 8, a sensor node with BLI-1104 handles highest number of queries as it is a cluster head of cluster that is closest to the sink node. It can be inference here that this specific node (BLI-1104) performs the job of cluster head for approximately first four hundred queries and then it relinquishes headship for other nodes having better energy profile. However, it can be observed here that this node still actively participated in sensing process when so desired and this in particularly happens for query intervals (625-650), (740-750) and (1020-1040); these intervals are characterized with slight dips in Fig. 8.

Whereas, Fig. 9 indicates energy profile of all network nodes when cluster headship is keep changing based on proposed heuristics. Exactly in analogous way the key energy observations like RES and Energy consumed for all

deployed sensor nodes for a total number of 1269 handled queries are illustrated in Fig. 10 and 11 respectively on using the proposed scheme.
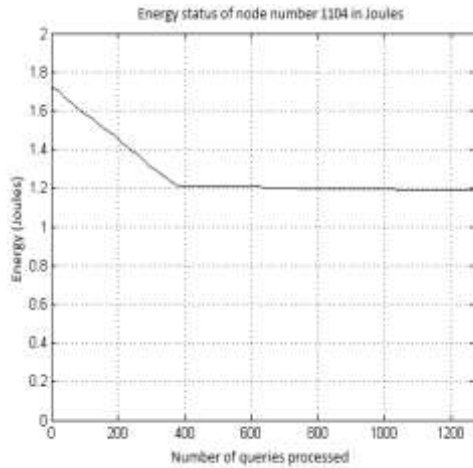

Figure 8: Energy status of a sensor node (BLI-1104) in proposed scheme for change of cluster heads.
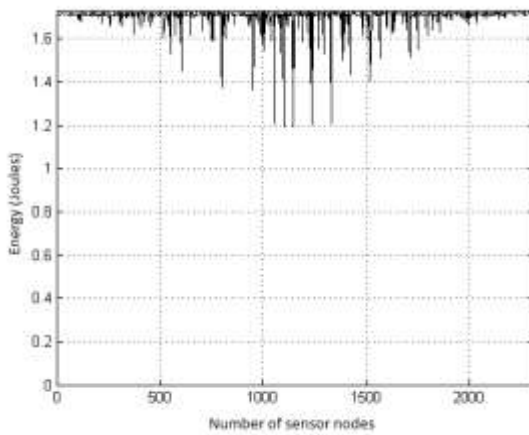

Figure 9: Energy status of each node in proposed scheme for change of cluster heads.
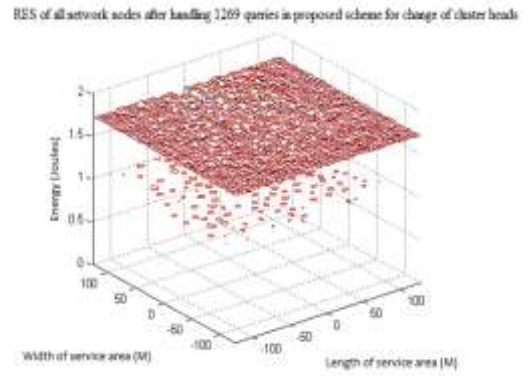

Figure 10: Energy status of each node, when more number of queries generated in proposed scheme for change of cluster heads.
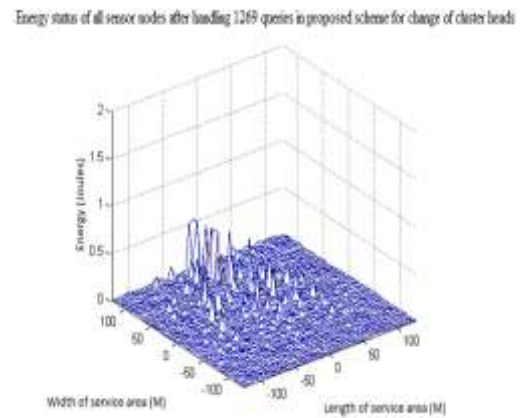

Figure 11: Energy status of each node, when more number of queries generated in proposed scheme for change of cluster heads.

CONCLUSIONS

In this work, an attempt is made to analyze geographical location based hierarchical routing algorithms. The without change of cluster heads scheme is tested and compared with proposed scheme with change of cluster heads. As the network life time depends upon the energy of individual nodes; to utilize this scare resource more proficiently, the routing algorithm is amended in such a way that it highly depends upon locational information. The proposed algorithm shows that as the energy level of sensor node reaches to the set threshold level; its changes the

cluster head. Thus, each sensor node gets an opportunity to participate as cluster head in routing protocol; that prolongs an individual sensor node life and thereby overall life-span of a sensor network. Hence it is concluded that properly framed heuristics which utilizes residual energy level of each sensor nodes and binary location index avoided the "hot spot" effect till network attains its set/targeted span of life-time.

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