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A Novel Survey on Various Grid Based Data Dissemination

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Abstract: In Wireless Sensor Networks, data dissemination to multiple mobile sinks consumes a lot of energy. Various grid-based data dissemination strategy [12] has been proposed over the years to reduce the energy consumption in Wireless Sensor Networks. In this paper, we have proposed an energy aware data dissemination strategy for reducing the energy consumption during grid construction, dissemination node failure handling and data and query forwarding. The proposed EGDD scheme uses a single virtual grid for data dissemination and sensor nodes are energy aware so a data dissemination node is replaced by an alternate dissemination node as soon as its residual energy reaches to a predefined threshold value. We have proposed a novel scheme for determining the cell size of the grid, selecting the dissemination nodes and alternate dissemination nodes. The proposed scheme reduces the energy consumption during the query and data forwarding and handling dissemination node failure. It also solves the problem of sink mobility. Theoretical analysis shows that the proposed EGDD scheme performs better than the existing the data .

Keywords-Data Dissemination, Mobile Sink, Expected zone, Source Id, Threshold energy.

1. Introduction

A typical wireless sensor network consists of several low-cost, low-powers but multi-functional devices called sensor nodes. A large number of the sensor nodes are randomly distributed over a vast field to self-organize a large-scale wireless sensor network [1], [2]. The sensor nodes monitor some events in surrounding environments, for examples as sound, heat, vibration, presence of objects, and so on. If a sensor node detects an event, the sensor node produces data and makes data announcement to sinks subscribing the data. The sensor node denotes a source node and this procedure is called data dissemination [3].

Several virtual grid-based data s have been proposed over the years for forwarding the sensed data from source node to mobile sink in wireless sensor networks. These data dissemination protocols such as TTDD [4], GBDD [5] and ARBITER [6] rely on constructing a virtual grid infrastructure for query and data forwarding. These protocols proactively build a virtual grid over the entire sensor field and the crossing points of the grid are known as dissemination points. The grid consists of small square cells of cell size α. The sensor nodes at each dissemination point or crossing point are called dissemination nodes. In the query and data forwarding the dissemination nodes are used. All other nodes do not participate in query/data forwarding.

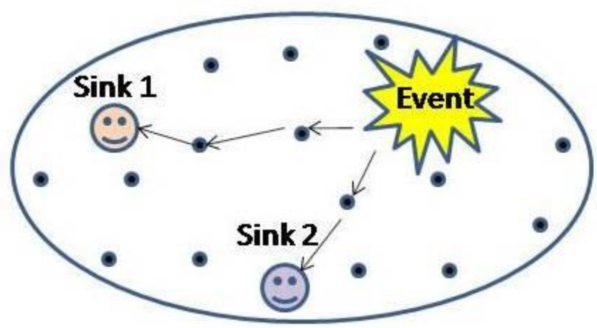

Figure1. Data dissemination to multiple sinks

The main problems in existing the data dissemination protocols are-

- How to determine the cell size α of the grid?
- There may not be a sensor node at the exact estimated location of the grid crossing point. So how to deal with the uncertainty in sensor node location?
- The sensor node at the estimated crossing point may have very low energy while the second closest node to the crossing point has very high energy. So how to select the best node as a dissemination node.

- How to handle when the dissemination node failure problem?
- Handling sinks mobility in an energy efficient manner.

2. Energy-Aware Grid-based Data (EGDD)

EGDD is a rendezvous-based data in which the grid is constructed only when no valid grid is present in the sensor field. The first source appearing in the sensor field initiates the grid construction process with its source id, its own location co-ordinates and a predefined radius (*d*) of the expected zone in the dissemination node location. The value *d* is used because it is not always possible to find the sensor nodes at the exact location estimated for the dissemination point. It is also possible that the node closest to the crossing point has very low energy while other nodes have higher energy level. So it is desired to select the node with the maximum residual energy in the neighborhood. It also restricts the flooding of messages over the sensor field as only those nodes which have distance from estimated dissemination point less than the value of *d* will reply to dissemination node. The expected zone is a circular region of radius *d*. For handling the dissemination node failure, each sensor node which forwards a Grid Construction Message (GCM) for grid construction maintains a list of all sensor nodes that belong to the expected zone.

In the proposed scheme, a minimum threshold energy E_t is defined. This is the minimum energy which is required for a node to work as a dissemination node. When the residual energy of a dissemination node becomes equal to E_t, it sends an Alternate Dissemination Message (ADM) to the alternate dissemination node. Thus the alternate dissemination node takes over this node. In this way there is no dissemination node failure and energy is not wasted in alternate dissemination node selection process as a list of alternate dissemination nodes is already maintained during grid construction process.

2.1. Network Model

The following concepts are used in this paper for network modeling-

- A broad field is covered by a large number of homogeneous sensor nodes which communicate with each other through radio signals.
- Each and every sensor nodes is aware of its own location co-ordinates in a two-dimensional sensor field (for example, using GPS signals).
- Sensor nodes are stationary, capable of storing some information regarding the neighboring nodes and aware of their own residual energy.
- Sinks send query packet to the source with the Source Id of the corresponding source node.
- The data are forwarded by the source nodes to the sink using the back-ward path followed by the query packet from sink.
- The grid is constructed by the source only when there is no already existing grid.

2.2 Grid Construction

EGDD is a virtual grid-based data in which the grid construction process is initiated only by the first source appearing in the sensor field. Unlike TTDD, a new grid is constructed only when there is no valid grid present in the sensor field which prevents the loss of energy due to unnecessary grid construction.

The grid construction process is similar to TTDD [4]. A source divides the entire sensor field into a grid of square sized cells of dimension α×α. A source itself is at one crossing point of the grid and it propagates Grid Construction Message (GCM) to reach every other crossings, considered as dissemination points, on the grid. GCM consists of the co-ordinates of calculated dissemination point and the radius of the expected zone (d). For a particular source at location Ls = (X, Y), dissemination points are located at Lp = (Xi, Yj) such that:

$$\{X_i = X + i\alpha,\ Y_j = Y + j\alpha;\ i, j = \pm 0, \pm 1, \pm 2, \ldots\}.$$

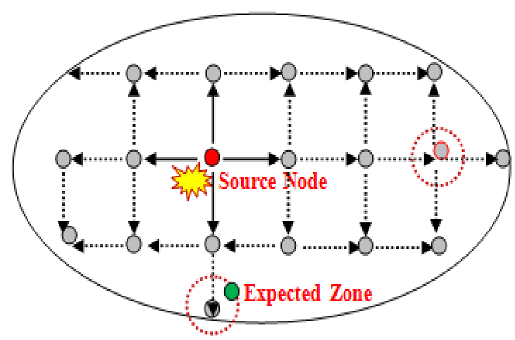

Figure 2: Grid construction by source S

While constructing the grid, there may not be a sensor node present at the calculated dissemination point or the sensor node located at the calculated dissemination point may have very low energy. In the proposed scheme, a circular region of radius d is constructed which is known as *Expected zone*. On receiving a GCM message, all the nodes belonging to the expected zone reply back to the sender node with their residual energy levels and distances from the original dissemination point. Now the dissemination node (sender) arranges all neighbor nodes in descending order of residual energy levels. The node with maximum residual energy level is selected as the dissemination node and the other nodes will serve as alternate dissemination nodes.

When the residual energy level of a dissemination node becomes equal to the minimum threshold energy level Et, the sensor node with maximum energy is selected from the list and it becomes the dissemination node. Thus EGDD does not suffer from dissemination node failure problem and saves the energy wasted in selecting an alternate dissemination node as in GBDD [5].

2.2.1. Determining the Cell-size. Cell size is determined by using the radio range R of sensor nodes and the limiting distance d. We can determine the cell size α with the help of figure 3.

AB = BC = CD = AD = α … (cell size)

AP = CQ = d … (radius of expected zone)

In triangle ABC, ∟ABC = 90°

So, AC = √2α (Applying Pythagoras Theorem)

Radio range of the node might be equals to PQ.

PQ = R … (Radio range)

So, QC + CA + AP = R

Or d + α√2 + d = R

Or α√2 + 2d =R

Or α√2 = R – 2d

Or **α = (R – 2d) / √2** (1)

So from the above derivation it can be find out that the cell size α should be equals to (R – 2d) / √2.

2.2.2. Determining the Radius of Expected Zone. We will construct a circular expected zone with radius d.

So the area of the expected zone will be πd^2.

Let there are n sensor nodes deployed in the sensor field and the area of the region is A.

Then

Area of finding 1 sensor node = (total number of sensors / total area)

$$\pi d^2 = n / A$$

$$\mathbf{d = (n / \pi A)^{1/2}}$$

We will take the upper bound (floor value) of the calculated value, so that there will be the probability of finding more than one sensor nodes in that area-

$$d = \left\lceil (\mathbf{n} / \boldsymbol{\pi} \mathbf{A})^{1/2} \right\rceil \qquad (2.0)$$

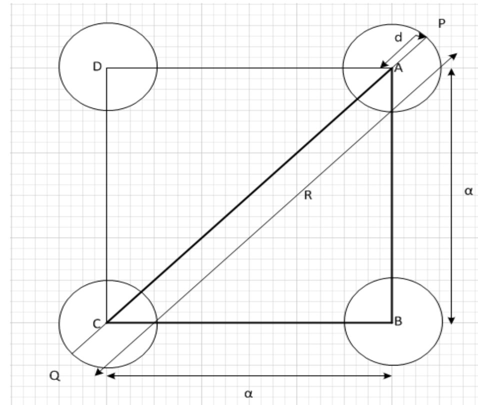

Figure 3: The cell size for grid construction strategy

2.3 Query and Data Forwarding

We propose a query forwarding scheme (Figure 4) for data dissemination to mobile sinks in WSN. Unlike TTDD and GBDD, EGDD does not forward query along the sides of the grid-cell instead it relies on forwarding the query through the shortest path between source and sink. Thus EGDD scheme reduces the energy consumption due to query and data transmission. In the proposed scheme, only the dissemination node which is closest to the source forwards the query.

We assume that each dissemination node is aware of its own location (coordinates). When a sink wants to forward the query to a particular source, it generates a query packet with the Sink id, Source Sequence Number and coordinates of the source dissemination node's point such as (Xs, Ys). Now it forwards the query packet to all its neighbors and when the query packet received by the dissemination node, the following steps are followed-

Algorithm for query forwarding

1) Update the query packets by including its own point as (Xi, Yi) coordinates in the packet.
2) Forward the query packets to all its neighboring dissemination nodes with coordinates (Xj, Yj).
3) While (Ys =! Yj & Xs =! Xj)
   a) Calculate the distance Dsi between source node S and node I, and also distance Dsj between source node S and node j.
   b) If Dsj < Dsi, then forward the query packet, otherwise discard.
4) If (Ys = Yj)
   a) Calculate |Xs-Xi| and |Xs-Xj| where Xi is the X coordinate of sender dissemination node from

where the query is received and Xj is the X coordinate of the receiving dissemination node.

b) If |Xs-Xi| > |Xs-Xj|, then forward the query packet, otherwise discard.

5) If (Xs = Xj)

a) Calculate |Ys-Yi| and |Ys-Yj| where Yi is the Y coordinate of sender dissemination node from where the query is received and Yj is the Y coordinate of the receiving dissemination node.

b) If |Ys-Yi| > |Ys-Yj|, then forward the query packet, otherwise discard.

Once the query is received by a dissemination node, it is forwarded to the data source. Data is forwarded to the sinks through the reverse path followed by the query. If a dissemination node had received queries from the different neighboring nodes and it sends a data copy to each of them. Once when the data arrives at a sink's local dissemination node, trajectory forwarding [4] is employed to further relay the data to the sink as shown in the figure 4.

2.4 Query Forwarding from Multiple Sinks

When a dissemination node receives multiple queries for the same data from different sinks, it forwards only one query to the source and stores the sink ids of all the sinks from where the query for same data is received.

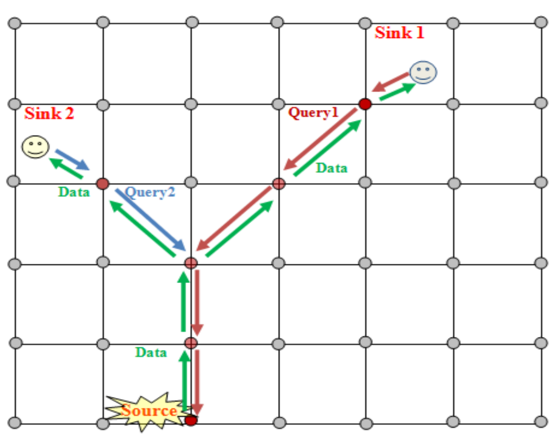

Figure 4: Query and data forwarding in EGDD

When Data is received at this dissemination node, duplicate copies of data are generated and forwarded to all the sinks from where query was received as shown in the figure 4. Thus EGDD prevents the flooding of duplicate and redundant data and query packets in the network.

2.5 Data Forwarding from Multiple Sources

When a source appears in the sensor field, it uses the existing grid for data forwarding. Each source has a unique source id as the location co-ordinates of the immediate dissemination node (IDN) are used as the source id. Event source makes data announcement with its unique source id and the sink interested in that event forwards the query using the existing grid in the sensor field. Query is forwarded using the same scheme as discussed above (in section 2.3).

Data is forwarded from multiple sources to different sinks using the back-ward path traversed by the query packet. Query and data forwarding is shown in the figure 5.

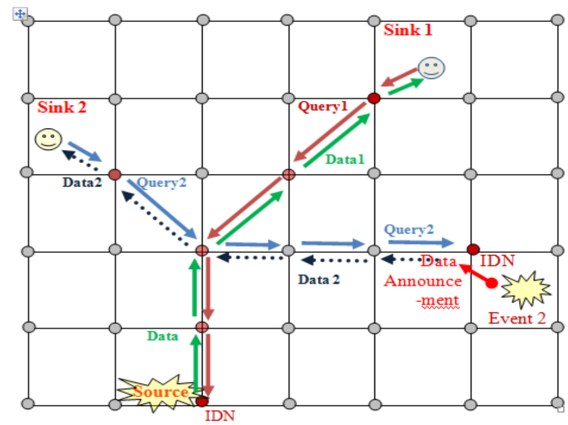

Figure 5: Data dissemination from multiple sources to different sinks

2.6 Handling Sink Mobility

Sink mobility introduces several challenges to data dissemination in wireless sensor networks. When a sink moves away from its original location from where it has forwarded the query, data delivery to sink becomes difficult. A sink may move within the local cell or outside the local cell in the grid. In the proposed EGDD scheme, Sink movement within the local cell area is handled through local flooding of data within the local cell.

In EGDD, sink manager is used to handle the sink movement outside the local cell. Each time when a sink moves into adjacent cell, a sink manager is selected by the sink. Sink manager is the dissemination node which is common to both the new cell and the old cell of the sink and closest to the previous immediate dissemination node (IDN). Thus each time a mobile sink moves into a new cell a dissemination node is selected to work as a sink manager for that sink. It reduces the overhead of selecting a new sensor node as a sink manager.

When a sink, which has already queried for some data, moves into a new cell, it forwards the MQuery to the sink manager. MQuery is a query with a special flag bit indicating that the query is from a mobile sink which had already forwarded the same query. The sink manager forwards the query to the original IDN of the sink as shown in the figure 6. MQuery contains the co-ordinates of original IDN of the sink. When the MQuery reaches to IDN, the data is forwarded to mobile sink through the back-ward path.

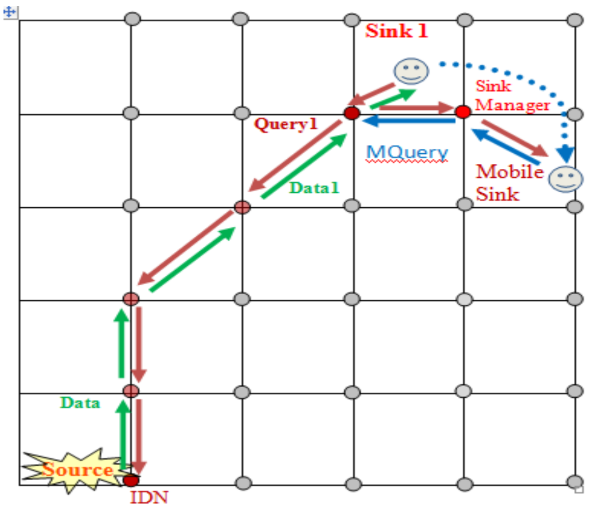

Figure 6: The data dissemination strategy to the mobile sink

2.7 Handling Dissemination Node Failure

EGDD does not suffer from dissemination node failure problem. In the proposed scheme a minimum threshold energy level is defined for dissemination nodes. As soon as the residual energy of any dissemination node reaches to this scale and this dissemination node is now replaced by an alternate dissemination node. Alternate dissemination node is selected from the list maintained during the grid construction process. Thus EGDD does not allow a dissemination node to fail.

3. Performance Evaluation

In this section we evaluate the performance of our EGDD approach. Energy Efficiency is the major concern of EGDD scheme so we have analyzed for energy only. The energy consumption is defined as the total energy consumed in the network during communication (transmitting and receiving) excluding the idle state of sensors. Table 1 shows the comparison of EGDD with TTDD and GBDD.

Table 1. Comparison between EGDD and other data s

Comparison	TTDD	GBDD	EGDD
Grid Construction	Separate grid for each source i.e. each source starts grid construction.	Sink constructs a grid only when no valid grid is present.	Source constructs a grid only when no valid grid is present in the sensor field.
Query Forwarding	Query is forwarded along the sides of the grid-cell.	Query is forwarded along the sides of the grid-cell.	Query is forwarded diagonally in the grid-cell.
Sink Mobility	Immediate dissemination nodes are selected for handling sink mobility.	Dissemination node closest to the initial crossing point is selected for handling sink mobility.	The dissemination node common to the original cell and the new cell is selected as sink manager.
Dissemination node failure	No dissemination node failure as separate grid is constructed by each source.	Dissemination node failure is handled by flooding the query using low-range radio in order to select the alternate dissemination node.	No dissemination node failure. Alternate dissemination nodes are selected in advance during the grid construction process.
Energy Efficiency	Consumes a lot of energy in separate grid construction for each source.	Energy is wasted due to query flooding during alternate dissemination node selection.	Energy-efficient, no dissemination node failure and saves energy in grid construction.

4. Conclusion

In this paper we have proposed a data which makes use of a single virtual grid infrastructure for query and data forwarding. EGDD determines the cell size on the basis of radio range of sensors, the area of the sensor field and the number of nodes deployed in the area. The EGDD network model ensures query and data forwarding through the shortest path between source and sink. The proposed scheme reduces the energy consumption during the grid construction and maintenance. A minimum threshold energy level is defined for the dissemination nodes in order to avoid the dissemination node failure. Theoretical analysis and comparison with other existing the data s show that the proposed scheme is energy efficient for multiple sinks and multiple sources.

5. Future Work

In future, we plan to simulate the proposed EGDD data and compare its performance with other existing the data s such as TTDD, GBDD and ARBITER etc. We would like to exploit the design for mobile events and improve the performance of the proposed scheme for handling multiple mobile sinks and mobile events.

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