A Novel Routing Fusion algorithm for Topology aware Wireless Sensor Networks

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***Abstract*- In this research paper, we consider wireless sensor networks in which the topology is under the control of the user. There are several applications in this category. We propose a novel levelling and clustering algorithm in such networks. By comparing the algorithm with earlier protocols, performance evaluation is carried out. It is realized that the algorithm can also be used for localization.**

I. Introduction

Wireless Sensor Networks is recognized as the ten technologies that will change the world. In the design of such networks various research problems needs to be solve. Some of them are routing, data fusion, localization etc. It is well recognized that these problems have solutions which depend on the application in mind. Broadly the application are classified into two groups

i. Those in which the topology of the network is under the control of the user.
ii. Those in which the topology is not under control of user.

Large number of protocols is designed for the application of wireless sensor networks in the category (ii). We realized that the applications in category (i) need routing, fusion, localization protocols which capitalize the fact that the topology is under the control of the user. An effort in this directions resulted in this research paper. This research paper is organised as follows. In section II, we summarize the previous research literature. In section III, we present our proposed algorithm. Section IV, we present performance evaluations. Section V concludes this paper.

II. Related work

In [5], the authors introduced a hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a probabilistic distributed clustering algorithm. LEACH randomly selects a few sensor nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy load among the sensors in the network. In [6], the authors introduced a Hybrid, Energy-Efficient, Distributed Clustering Approach (HEED), a clustering algorithm in which the initial probability for each node to become a tentative CH depends on its residual energy, and the final CHs are selected according to the cost. It is well known that flooding routing protocol is easy to implement but waste the network resources. Thus one is lead to "Gossiping" [4] as a better alternative. After careful understanding of variations of flooding protocol we proposed a directed flooding protocol which conserves the network resources. In [2], the authors proposed a levelled controlled Gossip technique which is used in Tsunami warning systems. In this paper, the authors partition the sensor field into circular levels of increasing radius from the base station (BS). Level controlled gossip is a technique that is being proposed which employs circular levelling and gossiping together. In [3], the authors proposed a novel localization algorithm using levelling (based on circular levels) and sectorization.

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III. Issuses addressed and underlined assumptions

The following are the issues addressed in our proposed protocol:

- Reduce the numbers of nodes involved in the data transfer through virtual grid placement and levelling (rectangular levels).
- Avoids unnecessary flooding (i.e. discard data packets) throughout the network.
- Creates an energy efficient path towards the base station and hence is power aware.
- Increases the reliability of the gateways (routes) and reduces the complexity of the overall network.

The assumptions made on the nature of the sensor network are as follows:

- The nodes in the network are assumed to be stationary.
- The sensor network is densely deployed.
- Topology is under control of the user.
- All nodes are considered to have similar capabilities in the network.
- Base station (BS) is in the centre of the sensor field.

IV. Proposed algorithm

To decrease the consumption of energy of the battery, in our proposed algorithm instead of broadcasting the data packet into network, initially we are maintaining the data base of the adjacent cluster heads(CHs) as CH-table and only to selected CHs data packet is being forwarded.Our proposed algorithm has two phases *setup phase* and *routing phase*. In first phase total sensor field is divided into permanent grid structure using a global location information irrespective of the number of events. After the sensing field is divided into the grid structure, sensor nodes decide their grids (clusters) based on the location information and the CH is randomly selected which is responsible for aggregating the data in the cluster and forward it to sink. Each CH maintains a CH-table. From CH-table next-CH is selected and this process is explained in section 4.2.

When an event occurs, an event node sends a data packet to CH.CH already has the CH-table. It selects the CH with level number one lesser than current level number and column number one higher than the current column and row number of grid.

Setup phase

Setup phase has mainly three steps. They are as follows

a. Placing virtual grid and grid numbering

The sensor field is divided into a virtual grid using a global location information which is provided by localization system, such as GPS (Global Positioning System) or through techniques such as [1]. When sensor nodes are deployed in the field, they decide their grids with location information. The size of the grid is $\alpha \times \alpha$ and represented as ij where i represents row number and j represents column number

Now total sensing field is divided into I rows and J columns. Corner right side top most grid is numbered as00. Column number is incremented on moving left from grid 00 till the column with BS. Column next to BS station is numbered column number as $J-1$ and next onwards the column number is decremented on moving left. Row number is incremented on moving from top (00) to bottom till the row with BS. Row next to BS is numbered row as $I-1$ and next onward the row number is decremented on moving down. This is illustrated in fig. 1.

b. Clustering

Each grid is considered as a cluster. In order to select the head of each cluster, if sensor nodes begin with equal battery power, all sensor nodes locally flood a packet (head–packet) during the random period. The announcement of the head-packet is limited within the single cluster by simply dropping the packet from neighbour clusters. The sensor node which sends the head-packet first plays the role of CH.

c. Rectangular levelling

Rectangular levelling is done by using "hop count based method". In this method hop count is used to determine the levels. Initially hop count of CHs is set to infinity (or arbitrary large number). First BS broadcasts packets with hop count field set as zero. CHs which receive this packet set their hop count field as zero and level as one and the hop count field in the packet is incremented by one. These updated packets are broadcasted again. CHs that receive these packets update their level to *'hop count + 1'*, if their current level is higher than '*hop count + 1*'. If CHs that are having their level equal to or less than the '*hop count + 1*' value of the received packet, then their do not update their current level value.

This way the whole network is assigned as levels based on their hop count from the sink. Fig.1 depicts the sensing field at the end of setup phase.

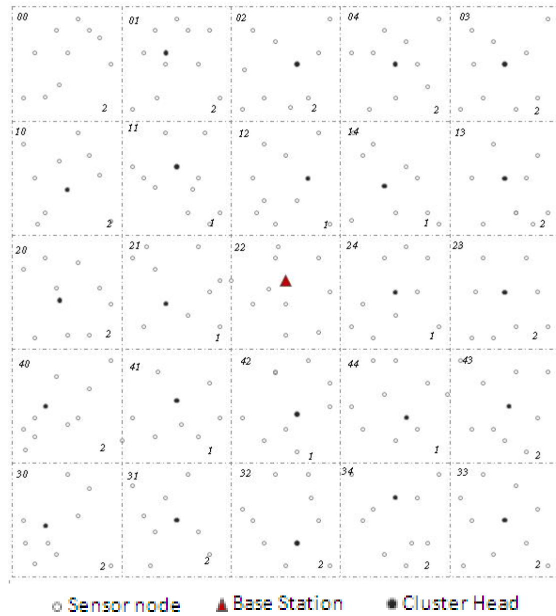

Fig. 1 sensor field at the end of setup phase, in each grid number in top right represents grid number and bottom left level number.

D . Routing phase

After the end of first phase CHs need to maintain adjacent CHs information in CH-table. So after the first phase each CH broadcasts information-packet. Information-packet consists of three fields, *level number, grid number and CH ID*. CHs which receive this packet update their CH-table with the information-packet. Being grid like structure each CH has only eight adjacent CHs.When an event occurs at any node say it as event node the packet it routed to BS as follows:

1. Event node sends the packet to CH.
2. CH sends the packet to *next-CH*. *Next-CH* is chosen from CH-table if and only if it follows following conditions
   i. *Level of next-CH must be one lesser than current CH.*
   ii. *Column or row number must be one greater than current grid column and row number respectively but not both column and rows.*
   iii. *If there is no such CH which satisfies above condition then select next-CH as the one with level lesser by one of current CH and column and row numbers greater by one of current grid column and row numbers respectively.*
3. Step 2 is followed until packet is send to BS.

This algorithm is illustrated in fig. 2.

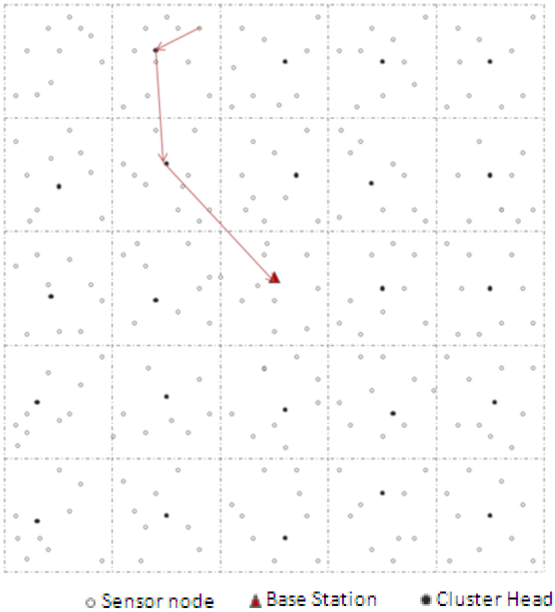

Fig. 2: routing of packet from event node to BS.

A. Cluster Rotation

Limited battery capacity of sensor nodes make CHs to drain out of power after a certain amount of time, which causes failure of transmission. To overcome this issue cluster rotation algorithm is implemented.
When CH remains with 5% of its total power it broadcasts a *CH-rotate* packet. This broadcast is limited to its cluster (grid) only. Nodes which receive this packet send *head-packet* to CH. Node with highest power is selected as CH.

V. PERFORMANCE EVALUATION

In this section, we have made comparative performance evaluation of our proposed algorithm with Flooding, Gossip and traditional circular levelling. The results have proven that the approach proposed by us increase the lifetime of the network and is thus the energy efficient. These results were plotted by several runs of the experiment.

A. Network Model

For the purpose of evaluating the algorithms, we simulated them by varying the number of nodes in the network. For each algorithm we started with a 100 node network and thereby generating the number of events that the network could handle. Similarly, the number of nodes has been varied up to 900 nodes and the corresponding number of events that these networks could handle was plotted in the plot. The two metrics of interest provided by the simulator are*Number of events:* It defines the life time of the network. *Number of Nodes*: The number of nodes that are present in the network.*Lifetime:* The time to failure of say 5% or 10% of nodes closer to the base station is considered to be the lifetime. The closeness to BS is measured based on the level number.

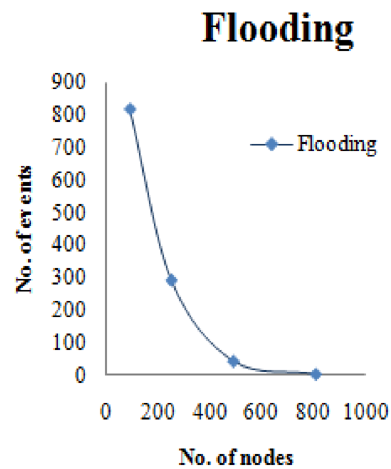

Fig.3: Nodes VS Network lifetime for flooding

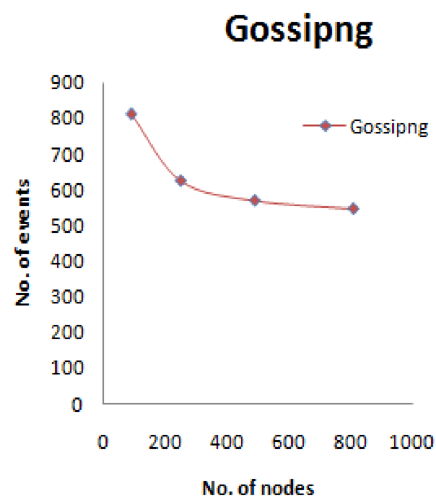

Fig. 4: Nodes VS Network lifetime for Gossip based approach.

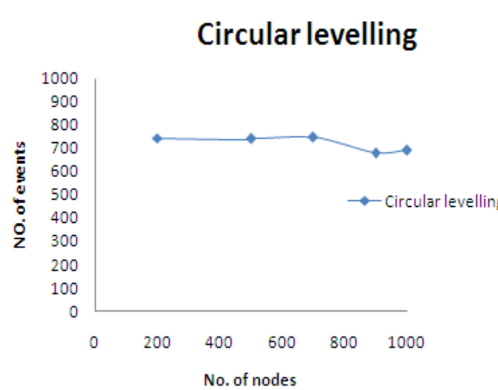

Fig. 5: Nodes VS Network lifetime for Circular levelling approach.

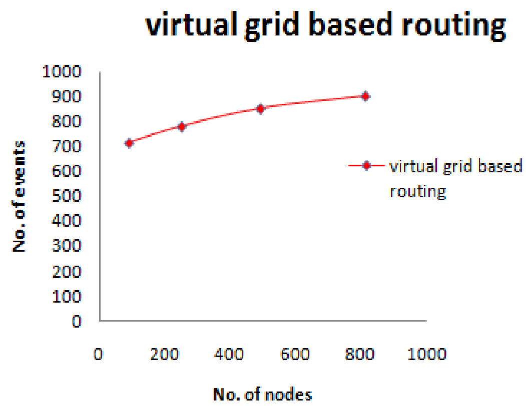

Fig. 6: Nodes VS Network lifetime for our proposed algorithm.

VI. Conclusions

In this paper we have proposed a routing and fusion algorithm for topology under control Wireless Sensor Networks We have made comparative evaluation with existing algorithms and this has proven that our proposed algorithm performs better than previous algorithms.

VII. References

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