

Robust Topology, Self-Scheduling Approach Based on Remaining Energy for WSN

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Abstract-Wireless Sensor Networks is a fastly growing research area. In WSN coverage problem and network lifetime are two major issues on which research scholars are giving more attention. In [1] ERGS algorithm is used for randomly deployed WSN in order to increase the network lifetime. ERGS algorithm offers good performance in terms of saving energy to increase the network lifetime in randomly deployed sensor network. Different network topologies have been considered for full area coverage by the researchers. In this research work we are presenting new idea which will increase the network lifetime and also provide the full target area coverage. To provide full area coverage we have introduced new topology for sensor node deployment. ERGS algorithm is used to improve the network lifetime.

I. INTRODUCTION

Wireless sensor networks are useful in military, scientific and environmental applications. Network lifetime and coverage are two important issues noticed by the researchers. In WSN [1] coverage can be defined as a measure of how well and for how long sensors are able to monitor the physical space. Nodes communicate [12] via RF signal using built-in antenna. Basically WSN's are used for monitoring the field of interest to detect temperature changes, movements etc.

¹S. Zairi et al: The coverage problem may be divided into three categories depending on what exactly that you are attempting to monitor. 'Area coverage' [4]: the overall goal is to have each location of the interest area within the sensing range of at least one node. 'Target coverage' [6]: observes a fixed number of targets. 'Barrier coverage' [7]: refers to the detection of movement across a barrier of sensors.

In [12] the coverage idea is used as QoS metric for WSN. This idea is introduced to answer the fundamental question, "How well the sensor can monitor the target area?". Connectivity can be considered as the ability of the sensor nodes to reach the data sink. If the path is not present between the sensor nodes to data sink then collected data cannot be processed.

Communication range of the node can be defined as the area in which another node can be located in order to receive data. Sensing range of the node can be defined as the area which can be monitored or observed by a node. The two ranges may be equal but are often different.

¹ S. Zairi, B. Zouari, E. Niel, E. Dumitrescu "Nodes self-scheduling approach for maximizing wireless sensor network lifetime based on remaining energy" Published in IET Wireless Sensor Systems.

• Issues in WSN

1. Coverage Types

Before deploying a wireless sensor network, the determination of area of interest that needs to be monitored is very important. The area of interest may be an entire area, set of targets or may be a breach among a barrier [9]. If every single point within the field of interest is within the sensing range of at least one sensor node then coverage area is known as full or blanket coverage. Ideally we expect the minimum number of sensors must be deployed in order to achieve blanket coverage [9].

2. Deployment

A sensor network deployment [9] can usually be categorized as a dense deployment and a sparse deployment. In dense deployment higher number of sensor nodes are deployed in a given field of interest while in a sparse deployment will have fewer nodes. A situation in which it is very important to detect every event dense deployment model is used. [9] When the target area needs to covered with minimum number of nodes then sparse deployment model can be used.

In most of the WSN's sensor node deployment is assumed to be static, node stays in the same place once they are deployed. [9]Newer sensor nodes (mobile nodes) have the ability to relocate after they are deployed. The algorithm in [9] has each sensor node determining the location it needs to move, in order to provide maximum coverage.

II. RELATED WORK

The coverage problem was also addressed in [13] where nodes are placed in an r-strip construct. In an r-strip construct nodes are located r distance away from the neighboring node. Where, r is the radius of sensing area. The problem with this method is deployment of nodes in this formation is impractical.

The key weakness of an algorithm presented in [10] is that each node must be within the sensing range of another node. Nodes in the network need to move in order to determine the optimal location. If any node can not be seen by any other node then it will not be able to determine its relative location.

In most of the sensor network nodes are deployed in the field of interest by either placing them in predetermined locations or having the nodes randomly deployed in the area. Networks with mobile sensors [10] usually start out with a random deployment and utilize the mobility property in order

to relocate to the optimal location. Random deployments of sensor nodes regard the ability to maintain coverage while minimizing the amount of energy used.

Sensor nodes are battery dependent for getting energy and in most deployments battery replacement is not feasible. Due to this reason it is very important to conserve the energy and increase the network lifetime. ²“When sensors are arranged in a hierarchical network then cluster heads can be used to aggregate data and reduce the amount of information sent up to the sink. This will relieve some of the burden on the nodes that are along the transmission path and increase their lifetimes.”

Chen et al. [7] extend a barrier coverage protocol to increase energy efficiency. Node will put itself in a sleep state once it will detect adequate k -coverage in the area. Node will enter wakeup mode after a random amount of time and perform next check. When node is not needed then it will decide when it should wakeup again.

Single coverage ensures that each target or point in the field of interest must be monitored by at least one active node. In multiple coverage, field of interest or point in the area needs to be monitored by at least k different active or working nodes, this is called as flat k -area-coverage problem [10] for area coverage. If the area is covered by k -distinct set of sensor in order to provide full coverage of sensing area, then area is k -covered. Problem is called as k -area coverage problem. The coverage problem can be further divided into 1-connectivity and k -connectivity coverage problem.

In algorithm presented in [11], node plays multiple roles, namely head, sponsor, and regular node. Each node determines the set of its sponsors covering its sensing area and sends a request message (REQ) to each presumed sponsor.

OGDC [15] Zhang et al. 2005, a localized protocol provides coverage control while maintaining connectivity. Protocol computes positions for all active nodes to achieve full coverage. Then OGDC selects nodes closest to these positions as active node and change the all other nodes into sleep state to conserve energy. This approach is built with the assumption that the network density is high.

³“The main approach in Ottawa protocol Xing et al., 2002 is to derive off-duty eligibility rules for redundant nodes and then schedule the work status of these eligible nodes. The Ottawa protocol can result in redundancy after turning off only a subset of eligible nodes. However, Ottawa protocol support only 1-coverage and can not meet the requirements of some applications such as target localization or tracking which requires at least 3-coverage.”

² Raymond Mulligan , Habib M. Ammari “Coverage in wireless sensor network: A survey” Network Protocols and Algorithms ISSN 1943-3581 , 2010, Vol. 2, No. 2

³ Xing, G., X. Wang and Y. Zhang, C. Lu and R. Pless, et al., 2005. Integrated coverage and connectivity configuration for energy conservation in sensor networks. ACM Trans. Sensor Netw., 1: 36-72.

In [16] problem related to energy consumption is described, the sensor node resources are limited due to the high density. Number of nodes may generate and transmit duplicate data causing unnecessary energy consumption which reduces the network lifetime. Hence the basic issue in WSN is the redundancy. If the area of a node is covered by k -active nodes then that nodes is called as k -covered and is a redundant node. By turning of such redundant nodes energy can be conserved to great extent. Hence a redundant node is also called as off-duty eligible node [5]. Solution to find redundant node is to find out all sub regions divided by the sensing circles of all neighboring nodes and checking whether each sub region is k -covered or not.

If such eligible nodes are found by CER then, a sleep scheduling protocol CMP is used to balance energy consumption and network life time is increased.

A centralized algorithm is run on one or more nodes in a centralized location usually near the data sink. Author's cardei et al. put the idea of central data collector node called as base station. The base station will determine which sensor to deactivate in order to conserve energy and preserve k -coverage. Also the authors in [4] used a central data collector node to gather information from the other sensor nodes to decide which sensors to put into sleep mode.

III. PROPOSED WORK

The proposed ERGS algorithm [1] considers the problem of nodes scheduling while preserving the full coverage of a target area and achieving balanced energy depletion among nodes. ERGS algorithm ensures the exchange of minimum messages for the nodes scheduling and with minimum number of active nodes. ERGS is a localized self-scheduling algorithm as it uses only one hop neighbor knowledge.

Consideration:

1. As in [1] flat architecture is used for WSN under consideration.
2. Initially nodes are randomly deployed in the field of interest using dense deployment model [10] and are connected to the unique base station.
3. All deployed nodes are homogeneous (having same sensing range and initial energy).
4. All nodes have mobility property.
5. Location service module is present in order to get relative positions.
6. Each node is able to determine its remaining energy [18].

Objectives:

Proposed ERGS algorithm aims to provide full coverage of field of interest with minimum number of active nodes. This decision must done with minimum knowledge and message exchange [1].

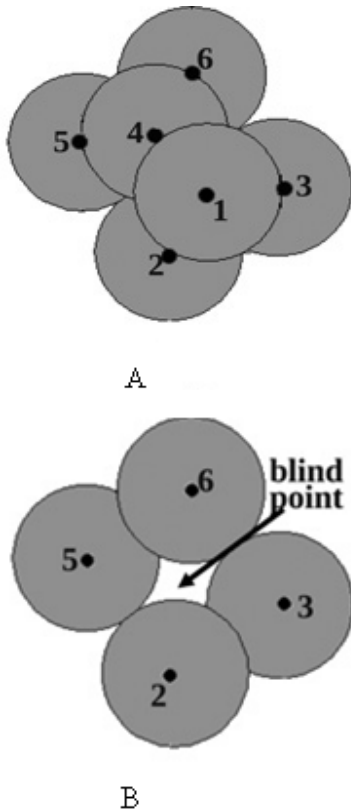
Principles of the ERGS algorithm:

As in [1] nodes contribute to the coverage of area of interest through its sensing area. Hence,

Each node guarantees the full coverage of it sensing area by subset of working nodes before entering in sleep state.

Each node can self-schedule its activity using local decisions. If all nodes take the simultaneous decision to enter in sleep state then blind point may appear as in fig.1b

Most of the scheduling algorithm uses additional exchange of messages (deactivation or negotiation messages) to avoid such blind points.



Extracted from [1] : Fig. 1 A, B

Now, it is clear that no two nodes should take decision of entering sleep state to avoid blind point. To achieve this objective a notion of priority is introduced [1] between nodes. The value of priority is based on local information i.e. remaining energy of node, so that it can be computed by nodes locally. Exhausted nodes [1] should have higher priority to enter into sleep state.

So decisions can be easily made by each node in the network using its own remaining energy and remaining energies of neighbor. Still, a problem may occur if two nodes will have same remaining energy which can be avoided by comparing the node unique ID.

Assumption about topology:

1. Once the network is up, all randomly deployed nodes will change their location and arrange themselves in such a way that all nodes will be r-distance away from each other.
2. According to above assumption each node will get surrounded by six nodes except the boundary nodes.

Now, for above structured topology the ERGS algorithm can be applied easily using following steps.

Steps in ergs algorithm:

The ERGS algorithm works in rounds. Each node begins with the self-scheduling phase, in which nodes verifies that their sensing area is fully covered by the subset of working nodes.

Self-scheduling phase operates in two steps,

1. Obtain the neighbor information
2. Check the eligibility to enter sleep state.

Fig. 2 shows the structure of rounds in ERGS algorithm.

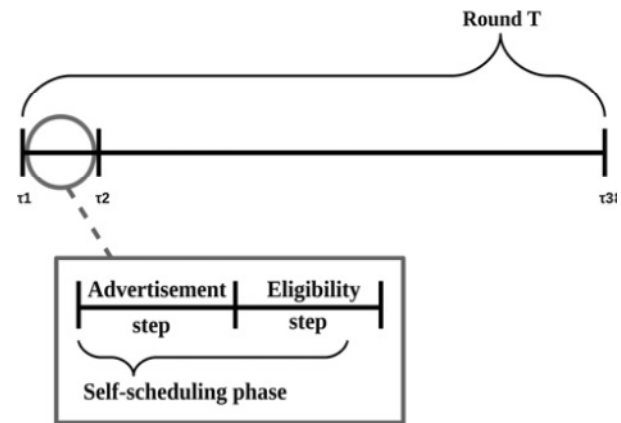


Fig 2. Extracted from [1], ERGS rounds.

Step I: Advertisement Step

1. Advertisement message ADV (ID, Erm) containing the nodes ID and its remaining energy is sent with minimum power consumption to all neighboring nodes located at one hop distance.
2. Upon receiving the ADV(ID, Erm) message, every node compare its remaining energy with transmitters remaining energy.
3. If Erm of transmitter is greater than Erm of current node then current node will send the negative ACK to transmitter. Current node adds itself to eligible list and transmitter to ineligible list.
4. If Erm of transmitter is less than Erm of current node then current node will send the positive ACK to transmitter. Current node adds itself to ineligible list and transmitter to eligible list.
5. Upon reception of negative ACK node will add itself to ineligible list and transmitter to the eligible list.
6. Upon reception of positive ACK node will add itself to eligible list and transmitter to the ineligible list.

Step II: Eligibility check to enter into sleep state

1. Every node will ensure that it belongs to the eligible list.
2. If node is not eligible then it can be considered for cluster head selection.

3. Eligible node should contain the at least three nodes in its ineligible list.
4. If above step returns true then node checks that its sensing area is fully covered by its all ineligible nodes.
5. If above steps returns true then node can enter into sleep state.
6. Else node will stay active and adds itself to ineligible list.

The ERGS algorithm with the above considered topology structure will offer the robust performance by providing the full area coverage. Also the ERGS algorithm guarantees the longer network lifetime as in [1].

IV. CONCLUSION

In the above proposed work we have assumed all nodes with mobility property, which enable WSN's to be very robust in order to fully monitor the field of interest. Also this mobility of nodes will allow us to deal with the node failure. In case of failure of any node all node can be moved to the required positions, to maintain the robust topology WSN. Also the ERGS algorithm [1] is used by the sensor nodes to enter into sleep state in order to preserve energy.

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