3rd International Conference on New Horizons in Science, Engineering and Management and Humanities
IIMT College of Engineering, Greater Noida (India)
19th April 2019 www.conferenceworld.in
ISBN : 978-93-87793-82-8

A Mobile-Sink Based Distributed Energy-Efficient Clustering Algorithm for WSNs

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ABSTRACT

Wireless Sensor Networks (WSNs) have capability to sense a specified region for physically measurable parameters and report the data to a central repository for further processing. They have self organized topology and can be used to monitor remote and harsh environments. The only issue in WSNs is energy saving. Clustering in WSNs is a technique to group neighboring nodes under a head node so that the data from nodes can be collected and aggregated before sending to base station (BS). This saves energy by reducing number of packets floating in network. Due to popularity of this approach many clustering methods have been proposed in literature; very few considering a moving base station.This work proposes a clustering protocol in WSN where BS moves in a fixed circular path around the region of interest. The idea is based on division of region into sub regions depending on number of alive nodes. The sub regions are treated as clusters and head is elected one within a sub region. The criterion for election is combination of energy and distance to BS.

Key Words: Wireless sensor networks (WSNs),DistributedEnergy (DE),Cluster Head (CH), Mobile-Sink (MS)and Clustering Algorithm (CA)

II INTRODUCTION

Wireless sensor networks are very suitable for sensing and monitoring tasks. Their wide applications and utility make the routing and communication related research important. The main focus of most of the research works is energy efficiency. . Each sensor node communicates with other nodes within its radio communication range. The nodes can be

ISBN : 978-93-87793-82-8

simply deployed in random or deterministic fashion and are normally battery operated.In DE Clustering Algorithm, each sensor node selects a CH within its communication range to forward its data to the sink by considering a cost factor[1].

1.1 WIRELESS SENSOR NETWORKS

Advances in micro-electrical and mechanical systems (MEMS) enabled manufacturing of very small devices that can be equipped with various sensors, controller and communication equipment. Such an assembled device is called a wireless sensor node since the communication it uses is wireless. When several nodes are deployed in a region, the sensed data is transmitted to a central station using ad-hoc networking among the nodes. These networks are called wireless sensor networks (WSNs).

1.2 APPLICATIONS OF WSNs

- Military surveillance
- Environmental
- Traffic
- Temperature
- Pressure
- Vibration monitoring
- Agriculture monitoring
- Disaster areas.

1.3Working and applicability of WSNs- The sensors are deployed in such a way so as to cover the RoI from every aspect. A sensing task goes through three phases before completion. These three phases are the sensing, processing and transferring to BS [1]. The sensing phase involves monitoring the desired region or subregion. The sensed data is then processed locally in the processing phase for routing and aggregation purposes to make it ready for transfer to the BS. Each of the nodes then transfers the sensed and processed data to the BS. The processing and transfer phase involves communication between the nodes for efficient sensing.

WSNs are widely used in numerous fields. Applicability of WSNs can be seen in healthcare, tracking of highly confidential assets and transport, smart home, energy saving smart grid

ISBN : 978-93-87793-82-8

The very first field where WSNs were deployed to track unseen undesirable activities is military applications [1]., Since then, WSNs have never seen a downhill. Their prevalence observed in different sectors paves way for its applicability in various other fields too. However, all nodes individually performing all the three phases of the sensing task consume much energy thereby decreasing the overall network lifetime enemy intrusion, target detection, security and more.

1.4Energy issues and plausible solution

WSNs have been encountered with a number of issues, related to limited energy, bandwidth, processing and memory of nodes in the network. Out of all, energy is the foremost issue to deal with [2]. The energy concerns arise from the fact that the sensor nodes operate on batteries thus relying on a limited battery life for working. The batteries are irreplaceable and non-rechargeable. If a battery expires in the middle of an ongoing sensing task, then the sensing of that subregion may not be properly done adding to the complexity of the network. The deployment of sensor nodes is another issue to deal with in WSNs; if done randomly, the nodes can be placed anywhere with no location information about other nodes and can cause redundant sensing of the same subregion due to overpopulation and non-availability of senor nodes at some other subregion of the area to be covered. Considering the fact that each node has a limited bandwidth, covering far-off distances may require multi-hop routing. Multi-hop routing involves two additional operations of sending data and routing from one hop to the next. Energy consumed in these operations is therefore more, mostly by the nodes acting as intermediates/ hops consume more energy. Overloading some nodes in the network compared to others lead to their early deaths and re-routing and re-organization of network is then required to pay for the disturbance occurred in the sensing task. In dynamic environments, additional energy is consumed in movement of nodes and simultaneously updating their location information. A detailed survey on the energy challenges of WSNs is given by Tarannum [2].

1.5 Data Aggregation

For the energy saving, the most discussed solution is of data aggregation. The primary objective of sensor nodes is to collect data and send it to the Base Station (BS) for further

ISBN : 978-93-87793-82-8

processing. The frequency of reporting the data and the number of sensors which report the data depends on the particular application. In a region that can be easily covered through 100 nodes, some thousands of nodes may be deployed. Data gathering involves systematic collection of data from multiple sensors and transmitting it to the BS. The data generated from all the sensors may be redundant and such a large amount of data when processed at the BS leads to much energy consumption. It is better to have methods that can combine data from several sensors and thereby reduce the amount of data being transmitted to the BS without losing the information it conveys. It is achieved through Data aggregation [3]. Data aggregation is the general term used for all those techniques that are used to eliminate redundancy, and combine information contained in sensed data in a compact form to be sent to the BS. Data Aggregation is defined as the process of aggregating the data from multiple sensors to eliminate redundant transmission and estimating the desired answer about the sensed environment, then providing fused information to the BS. This has been used in several routing protocols to achieve energy efficiency and optimize the amount data floating in the network.

Some design issues in data aggregation are [3]:

i) Sensor networks are inherently unreliable and certain information may be unavailable or expensive to obtain; like the number of nodes present in the network and the number of nodes that are responding and also it is difficult to obtain complete and up-to date information of the neighboring sensor nodes to gather information.

ii) Making some of the nodes to transmit the data directly to BS or to have less transmission of data to the BS to reduce energy is a question in applications that require accurate measurements

iii) Improving clustering techniques for data aggregation to conserve energy of the sensors would imply proper defining of roles of cluster heads.

iv) Selection of aggregation function if multiple types of data are being sensed

v) Improving In-Network aggregation techniques to improve energy efficiency. In-Network aggregation means sending partially aggregated values rather than raw values, thereby reducing power consumption.

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1. 6 Clustering in WSNs

A related problem arises regarding which nodes in the network will be responsible for aggregation. For this, nodes need to be identified that serve as data aggregators. A direct application to data aggregation is clustering [4]. Clustering enables the desired identification of aggregator nodes in the sensing process. These aggregator nodes are called cluster heads (CHs). It is more similar to leader election. All non-CH nodes join any one Chas a member and send sensed data to it for aggregation. Thus, the network topology gets divided into groups, one per CH. Hence this is called clustering.

Clustering in WSNs involves following steps: first CHs are elected; and then the members choose which CH to join (cluster formation). The election is performed considering a variety of aspects. Most common criteria are residual energy of a node, its distance from BS and number of criteria and manage a rotation so that almost every node gets a chance to be CH. Later works, like EECS [6] included criteria to make CH election resemble a best-node style of leader election. The criteria can be combined into a utility function as in DEGRA[7]. Certain researchers have added constraints of coverage and connectivity to the problem of clustering, like COCA [8].

Clustering makes a hierarchical structure of network topology, that is, the process of data gathering takes place in hierarchical manner. Nodes collect and send data to the CHs; these are primary CHs and may have secondary CHs which then collect data from primary CHs. Thus, CHs can also be at many levels, the final level CH sending data to the BS.

Clustering can be balanced or unbalanced [9]. In balanced clustering, the clusters are of equal size having equal number of nodes. Thus, every CH has equal load of data collection. Yet, energy consumption will also depend on distance of the CH from BS. This results into nodes far from BS to spend more energy if single hop communication is used. Or routing load on nodes nearer to BS is more if multi-hop communication is used. Nodes may die pre-maturely causing a hole in routes through it. This is also called hot-spot problem. A solution to this is decide size of clusters according to distance of the CH from BS and the type of communication used [10]. This is termed as unequal clustering. In multihop communication model, the clusters nearer to the BS are smaller in size and get larger as distance of CH from BS increases. Fig illustrates equal and unequal clustering.

ISBN : 978-93-87793-82-8

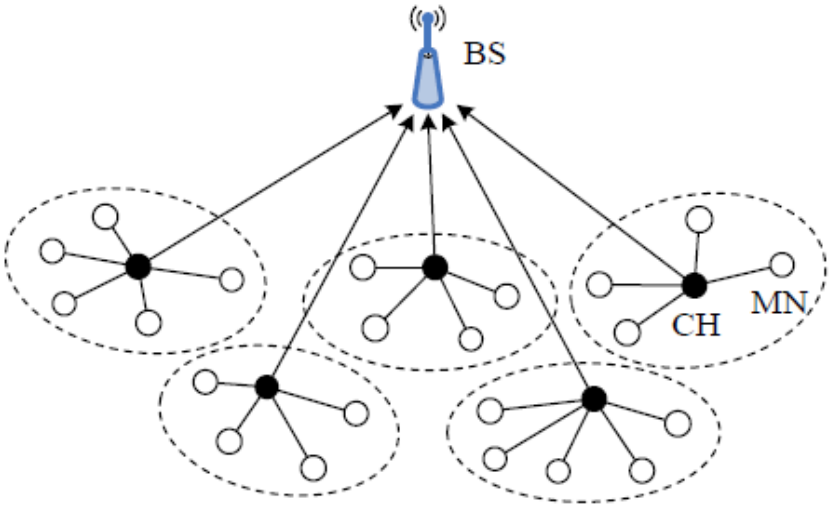

Fig: llustration of equal clustering in a WSN

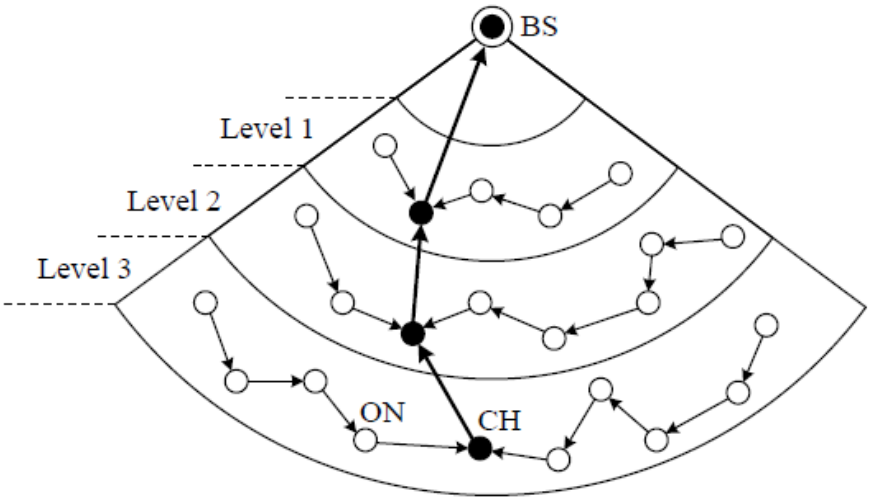

Fig . Illustration of unequal clustering in a WSN

1.7 Advantages of Clustering in WSNs

The major benefits of clustering in a WSN are [4, 9]:

a) Clustering minimizes the need for central organization and promotes local decisions.The changes made within a cluster need not be communicated to entire network, thus reducing the information and data load of the network

ISBN : 978-93-87793-82-8

b) CH can perform data aggregation in its cluster and decrease the number of redundant packets.Many applications that monitor only certain statistics of the sensed data can benefit much by data aggregation. It reduces the data load of the network to a large extent.

c) By scheduling the activities within the cluster CH can reduce the rate of energy consumption.

d) Resources can be efficiently used. Like, if cluster heads are not neighbors then they can use same frequency to communicate with the BS, thus reusing the spatial resource which becomes very limited when number of nodes is very large.

e) Routing is also energy efficient as routing information of a cluster is stored only at the head node. This reduces size of routing tables stored and the number of messages to be exchanged for distributing this information. Compared with a flat topology, this kind of network topology is easier to manage, and more scalable to respond to events in the environment [4].

f) Through clustering where multiple types of sensors prevail, a CH combines data from different sources that reduces redundancy and also provides a rich and multi-dimensional view of the targets being monitored [9].

1.8Problem Statement

Several applications have a mobile BS that moves around the region being monitored to collect information from the sensor nodes. Very few clustering techniques have considered this situation. The settings are special enough to give a separate treatment.

We aim to develop a clustering method for WSN in which the BS moves in a circular path with uniform speed. The technique of dividing region into sub-regions so that each region has only one CH in it saves communication load. Also, the objective is to design CH election method such that best node in the sub-region is appointed as CH. the goal is to prolong lifetime of network by even distribution of energy consumption.

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III Summary and Conclusion

Remote sensing and monitoring applications have joined pace due to wireless technology .The sensor nodes are able to establish ad- hoc topology in a network to collect and transmit sensed data. A good communication protocol should be able to cluster neighbouring nodes together under few leader nodes such that lead is uniformly divided and hence lifetime of network is prolonged. This work is such a clustering and communication protocol for homogeneous network with base station moving with uniform speed in a circle around region of interest. Instead of uneven clustering in space, the region is divided into equal sub region (sectors of circle) so that no overhead for scheduling or cluster formation is imposed. Thus, energy of nodes is saved CHs are elected based on highest score derived from two criteria residual energy of node and its distance from path of BS. It is a modification of an existing protocol DECA. The benefits of clustering: reduced redundant packets, local control, parallel use of resources etc are all achieved in the proposal.

Experiments are conducted by varying the number of nodes and simulation area. Performance is evaluated on the basis of network lifetime, average number of heads, First Node Die, Half Node Die, the average energy consumption per round. Experiments over simulated networks show a considerable improvement in lifetime of network. The values of average energy consumption per round are lower in proposed technique as compared to DECA. High values of FND and HND indicate that proposed algorithm is able to distribute load over the nodes properly.

Future Scope

The proposal is run in homogeneous settings with nodes deployed randomly in the region of interest. However, the proposed selection criterion can also be tested for heterogeneous setting. The protocol can also be compared with other clustering proposals to analyze the scopes of improvement, if any.

ISBN : 978-93-87793-82-8

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