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DISTRIBUTED CLUSTERING APPROACH FOR WIRELESS SENSOR NETWORKS BASED ON HYBRID CONCEPT

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Abstract*:*

To diminish the data transmission time and energy consumption, the sensor nodes are assembled into a number of little groups referred as clusters and the phenomenon is referred as clustering. Every cluster comprise of a leader which is known as cluster head. The cluster head will be chosen by the sensor nodes in the individual cluster or be pre-assigned by the user. The main advantages of clustering are the transmission of aggregated data to the base station, offers scalability for huge number of nodes and trims down energy consumption. Fundamentally, clustering could be classified into centralized clustering, distributed clustering and hybrid clustering. In centralized clustering, the cluster head is fixed. The rest of the nodes in the cluster act as member nodes. In distributed clustering, the cluster head is not fixed. The cluster head keeps on shifting form node to node within the cluster on the basis of some parameters. Hybrid clustering is the combination of both centralized clustering and distributed clustering mechanisms. This paper gives a brief overview on clustering process in wireless sensor networks. A research on the well evaluated distributed clustering algorithm Low Energy Adaptive Clustering Hierarchy (LEACH) and its followers are portrayed artistically. To overcome the drawbacks of these existing algorithms a hybrid distributed clustering model has been proposed for attaining energy efficiency to a larger scale.

Keywords. Wireless sensor network (WSN), distributed clustering algorithm, coverage based clustering, energy efficiency, network lifetime.

1. INTRODUCTION

Sensor network inter-networks with an Internet Protocol (IP) core network via a number of gateways. A gateway routes queries or commands to appropriate nodes within a sensor network. It also routes sensor data, at times aggregated and summarized to users who have requested it or are expected to utilize the information. A data repository or storage service is available at the gateway, in addition to data logging at each sensor. The repository may serve as an intermediary between the users and sensors thereby providing persistent data storage. Additionally, one or more data storage devices are attached to the IP network to archive the sensor data from a number of edge sensor networks. One of the major advantages of wireless sensor network is their ability to operate in unattended, harsh environments in which existing human-in-the-loop monitoring schemes are uncertain, inefficient and sometimes impossible. Therefore, wireless sensors are expected to be deployed randomly in the predetermined area of interest by a relatively uncontrolled manner. Given the huge area to be covered, the short lifespan of the battery-operated wireless sensors and the possibility of having damaged sensor nodes during deployment, large population of sensors are expected in the majority of wireless sensor applications. Generally a wireless sensor node consists of low power processor, tiny memory, radio frequency module, various kinds of sensing devices and limited powered batteries which finds applicable in target tracking, environmental monitoring and oceanography (figure 1). Much of energy consumption happens during wireless communications [11]. The energy consumption when transmitting one bit of data equals to several thousands of cycles of CPU operations.

Hence the energy efficiency of a wireless communication protocol brutally affects the energy efficiency and lifetime of the network. Many researchers have projected several algorithms for WSNs to improve energy consumption and network lifetime. Since these wireless sensor devices are power-constrained, long-distance communications are not encouraged. Thereby direct communication between the nodes and base station is generally avoided. A proficient way is to arrange the network into several clusters and each

individual cluster has a cluster-head (CH). CH is one of the sensor nodes which is affluent in resources. Sensor nodes send their sensed information to the CH during their respective TDMA time-slots. The CH performs data aggregation process and forwards the aggregated data to base station (BS) [3-10]. Clustering follows some advantages like network scalability, localizing route setup within the cluster, uses communication bandwidth efficiently and makes best use of network lifetime. Since clustering uses the mechanism of data aggregation, unnecessary communication between the sensor nodes, CH and BS is avoided. In this paper, a model of distributed clustering algorithm is proposed which is based degree of capacity (DOC) of a node within a cluster. The DOC of a node is the combination of three parameters: the number of tasks assigned to a particular node, remaining energy and coverage with neighboring nodes. The node with highest DOC is selected as a CH for the current round. The primary objective of the proposed algorithm is to attain energy efficiency and extended network lifetime.

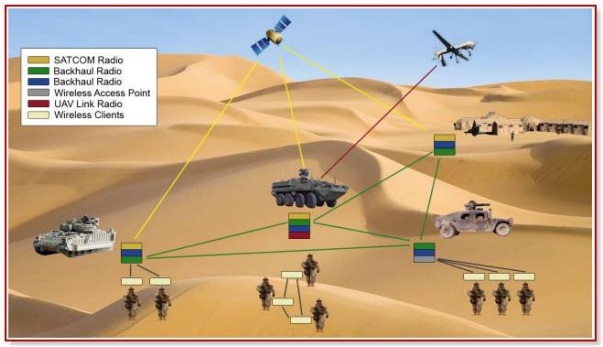

Figure 1: Military application of WSN

The rest of this paper is organized as follows. A review of existing distributed clustering algorithms is discussed in Section 2. An evaluation of LEACH and its followers are elaborated in Section 3. Section 4 sketches a model of the proposed distributed clustering algorithm. Section 5 gives an elaborated view on CH selection mechanism of the proposed algorithm. Finally, the last section gives the conclusion.

2. DISTRIBUTED CLUSTERING ALGORITHMS

One of the well-known clustering algorithms is Energy-Efficient Hierarchical Clustering (EEHC), a randomized clustering algorithm organizing the sensor nodes into hierarchy of clusters with an idea of minimizing the total energy spent in the system to communicate the information gathered by the sensors to the information processing center [17-26]. One real world application of clustering mechanism in oceanography is sketched in figure 2.

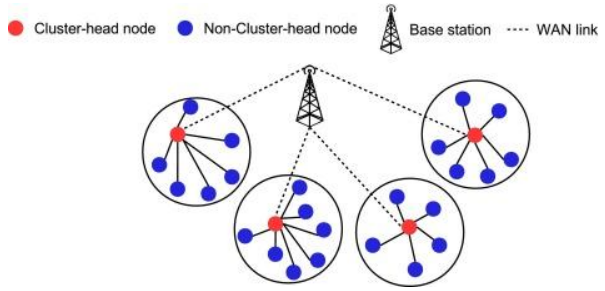

Figure 2: Clustering Mechanism

Another clustering algorithm, Linked Cluster Algorithm (LCA) was mainly implemented to evade the communication collisions among the nodes by using a TDMA time-slot. It uses a single-hop scheme, attains high degree of connectivity when CH is selected randomly. With an objective to figure overlapping clusters with maximum cluster diameter of two hops, CLUBS was implemented in WSNs. The clusters are formed by local broadcasting and its convergence depends on the local density of the sensor nodes. This algorithm can be implemented in asynchronous environment without losing efficiency. The main hitch is the overlapping of clusters, clusters having their CHs within one hop range of each other, thereby both clusters will collapse and CH election process will restart. Fast Local Clustering Service (FLOC) achieves re-clustering in constant time and in a confined manner in large scale networks, exhibits double-band nature of wireless radio-model for communication.

According to Energy Efficient Clustering Scheme (EECS), all CHs can communicate in a straight line with base station. The clusters have variable size, such that those nearer to the CH are bigger in size and those farther from CH are smaller in size. It is proved to be energy efficient in intra-cluster communication and excellent improvement in the total network lifetime. Energy Efficient Unequal Clustering mechanism (EEUC), was anticipated for uniform energy consumption within the network. It forms unequal clusters, with an supposition that each cluster can have variable sizes. Based on nodes' residual energy, connectivity and a unique node identifier, the cluster head selection is done in Distributed Efficient Clustering Approach (DECA). It is extremely energy efficient, as it uses fewer messages for CH selection. The main problem with this algorithm is that high possibility of incorrect CH selection which leads to discarding of all the packets sent by the sensor node. In order to select CH based on weight: a blend of nodes' residual energy and its distance to neighboring nodes, Distributed Weight-based Energy-efficient Hierarchical Clustering (DWEHC) has been proposed [19-22]. It generates well balanced clusters, independent on network topology or dimension. Hybrid Energy-Efficient Distributed Clustering (HEED) [2] is a well distributed clustering algorithm in which CH selection is made by taking into account the residual energy of the nodes as well as intra-cluster communication cost leading to prolonged

network lifetime.

3. OFFSPRING OF LEACH

Low Energy Adaptive Clustering Hierarchical Protocol (LEACH): [1] uses the following techniques to accomplish the design goals: randomized, self-configuring, adaptive cluster formation, local control for data transfers, low-energy media access control and application specific data dispensation. LEACH protocol has various rounds and each round has two phases: setup phase and steady state phase. In set up phase, it provides cluster formation in adaptive manner and in the steady state phase data transfer takes place. LEACH uses a TDMA to reduce inter-cluster and intra-cluster collisions. The energy utilization of the information gathered by the sensors node to reach the BS depends on the number of cluster heads and radio range.

LEACH-F: In this algorithm the number of clusters will be permanent throughout the network lifetime and the cluster heads are rotated within the cluster. Steady state phase of LEACH-F is alike as that of LEACH. LEACH-F may or may not offer energy saving and this protocol does not provide flexibility to sensor nodes' mobility.

LEACH-C: LEACH cluster formation algorithm has the disadvantages of having no guarantee about the number of cluster head nodes. Since the clusters are adaptive, there is deprived clustering set-up during a round. However, by using a central control mechanism to form clusters can produce better clusters by distributing the cluster head nodes throughout the network.

LEACH-B: This algorithm operates in the following phases: cluster formation, cluster head selection and data transmission. Every sensor node chooses its cluster head by evaluating the energy dissipated in the pathway between the last receiver and itself. It provides better energy efficiency in comparison with LEACH.

LEACH-ET: The cluster will adjust only when one of the following conditions is satisfied: Energy consumed by anyone of the CHs reaches energy threshold (ET) in one round, every sensor node should have the knowledge of the energy threshold (ET) value. During the initial phase, if anyone of the cluster head nodes dies, it should have the energy dissipated value and compares the dissipated value with the energy threshold (ET) value.

Energy–LEACH: This mechanism provides improvement in selection of cluster heads of LEACH protocol. It makes residual energy of a node as the main factor which decides whether these sensor nodes turn into the cluster head or not in the next round. E-LEACH helps a large in the cluster head election procedure.

TL-LEACH: This algorithm works in three phases: cluster-head casing, cluster setup and data transmission phase. This protocol is an improvement of LEACH where some of the cluster heads elected during setup phase in LEACH are chosen as the level-2 cluster heads (CHs), which communicates with the base station.

MH-LEACH: This protocol improves the communication mode from a single hop to multi hop between cluster head and base station. In LEACH, every cluster head directly communicates with sink ignoring the distance between the sink and the cluster head. The modified form, MH LEACH protocol adopts an optimal path between the base station and cluster head; thereby multi hop communication takes place among cluster heads.

ACHTH–LEACH: ACHTH–LEACH was proposed to improve the shortcomings of LEACH. The clusters are set up on the basis of Greedy k-means algorithm. The cluster heads are elected by considering the residual energy of sensor nodes, which may adopt two hop transmissions to reduce the energy spent on forwarding data to the BS. The performance of ACHTH-LEACH can be further improved if some parameters and threshold values are optimized.

MELEACH-L: This is an energy-efficient multi-channel routing protocol for wireless sensor networks. With the aim of controlling the size of each cluster and separating CHs from backbone nodes, MELEACH-L manages the channel assignment amid neighboring clusters and co-operation among CHs during data collection [11-15].

4. THE PROPOSED ALGORITHM

The proposed clustering algorithm is well distributed, where the sensor nodes are deployed randomly to sense the target environment. The nodes are divided into clusters with each cluster having a CH. The nodes throw the information during their TDMA timeslot to their respective CH which fuses the data to avoid redundant information by the process of data aggregation. The aggregated data is forwarded to the BS. Compared to the existing algorithms, the proposed algorithm has two distinguishing features. First, the proposed algorithm uses variable transmission power. Nodes nearer to CH use lesser transmission power and nodes far away from CH use extra power for transmission from nodes to CH or vice versa, which can lessen considerable power. Second, CH sends one message for every cluster nodes but many existing algorithms transmits numerous messages for cluster-setup.

5. CLUSTERING MECHANISM

The main activity in a WSN is to effectively select a CH. This is achieved by using various techniques. In the proposed algorithm, CH selection is accomplished with the use of the following parameters (figure 3).

A. *Highest Coverage*

In a network of N nodes, each node is assigned an exclusive Node Identity (NID) represented by n, where n=1, 2, 3…., N. The NID just serves as recognition of the nodes and has no relationship with location or clustering. The CH will be placed at the center and the nodes will be organized in to several layers around the CH and these layers are assigned with Layer Number (LN). LN is an integer number beginning from zero. CH gets LN0, nodes adjacent the CH in the next layer are assigned LN1, and so on. In LEACH, the coverage of a sensor node is not taken into account. This is essentially

significant when a sensor network is used for remote monitoring applications [16-18]. The nodes with highest coverage between the cluster nodes are given highest priority to become a CH. Basically HEED was proposed to avoid random selection of CHs. Though LEACH was more energy efficient, the main drawback is the arbitrary selection of CH. In HEED, the selection of CH is essentially based on residual energy and communication cost of the nodes. Here the lack of the parameter coverage leads to a main drawback. To overcome these problems, coverage among the nodes is considered to be one of the main parameter in the proposed algorithm.

B. *Highest Remaining Energy*

Remaining energy is defined as to energy remaining within a particular node after some number of rounds. This is generally considered as one of the main parameter for CH selection in the proposed algorithm. LEACH uses much energy for communication among nodes and CHs. It tries to distribute the loading of CHs to all nodes in the network by switching the cluster heads periodically. Due to two-hop structure of the network, a node far from CH will have to consume additional energy than a node nearer to CH. This introduces an uneven distribution of energy among the cluster members, disturbing the total system energy and remaining energy.

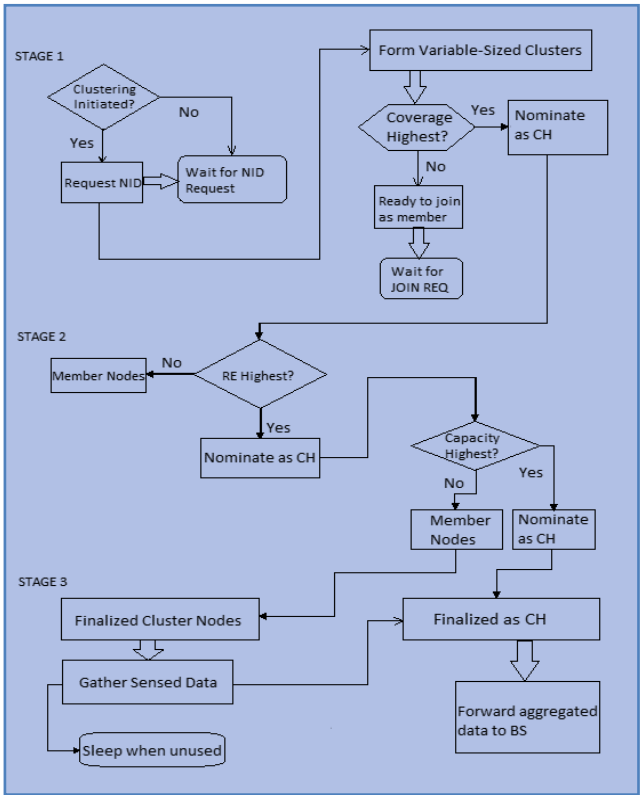

Figure 3: Cluster formation in the proposed algorithm

Node death rate is also directly proportional to the remaining energy. It is the measure of the number of nodes die over a time period, from the beginning of the process. When the data rate increases the node death rate also increases. The networks formed by LEACH show periodical variations in the data collection time. This is due to the selection function dependent on the number of data collection process. Since the CH selection of LEACH is a function of the number of completed data collection processes, the number of cluster varies periodically. The same process prevails also in HEED due to enlarged data collection. This increases the node death rate. Hence, remaining energy is considered as one of the important parameter for CH selection in the proposed algorithm.

C. *Highest Capacity*

Capacity of a node is the measure of the amount of data processing it can handle compared to other nodes. A node with highest capacity is given priority to become a CH. LEACH uses more energy for communication between nodes and CHs. It tries to distribute the loading of CHs to all nodes in the network by switching the cluster heads from time to time. The uneven distribution of energy among the cluster members is avoided in HEED as the CH selection is based on residual energy and communication cost. A node with highest residual energy and communication cost becomes a CH, thus the random selection of CH is avoided. But in the repetition phase, a number of iterations are carried out in order to find the communication cost and selecting a node with better communication cost. This is a peculiar drawback of HEED. In the proposed algorithm, fewer communication energy is required. It uses the concept of variable-transmission power in which the transmission power is variable from the lower edge to the higher edge based on the layers. Also in the proposed algorithm, separation among the layers is optimized to use optimum power for each layer. Hence the node with highest capacity is selected as a CH.

6. CONCLUSION AND FUTURE WORK

The sensed data is collected, processed and then routed back to the desired end user through a designated sink point, referred as the base station (BS). It has become feasible to construct multifunctional sensor nodes with advanced capabilities. Such sensor nodes are relatively of smaller size, lower cost and lesser power consumption. This paper gives a brief introduction on clustering process in wireless sensor networks. A study on the well evaluated distributed clustering algorithm Low Energy Adaptive Clustering Hierarchy (LEACH) and its followers are described artistically. To overcome the drawbacks of these existing algorithms a distributed clustering model has been proposed for clustering the wireless sensor nodes. Based on the degree of capacity (DOC), the algorithm has been formulated to form efficient clusters in a wireless sensor network. The proposed distributed clustering algorithm can show much improvement in communication energy. The performance of the proposed algorithm can show a drastic improvement in the total energy of the wireless sensor system. Nevertheless, the proposed algorithm can greatly minimize the node death rate and thus have

prolonged network lifetime. In future, the algorithm will be simulated and compared with two or three existing distributed clustering algorithms.

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