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Review on Energy Aware Clustering Based Routing Protocols in Wireless Sensor Networks.

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ABSTRACT

Wireless Sensor Networks (WSN) have a broad range of applications because they are suitable for most of the environments. They can be operated independently in critical places where the human presence is not possible or hazardous. Since the network lifetime depends on the batteries, where replacing or charging of batteries are not possible, so it is essential to find energy efficient routing protocols for WSN. There are various types of routing protocols such as location aware routing protocols, clustering based routing protocols, multipath routing protocols, hierarchical routing protocols, hybrid routing protocols, mobility based routing protocols, and etc. Among them, Clustering is a process where the sensing area is divided into clusters in order to control the energy level of the sensor nodes. Clustering techniques will reduce the energy conservation and increase the lifetime of the network in WSN. In this paper, we review various energy aware routing protocols based on clustering along with their merits and demerits.

Keywords: Wireless Sensor Networks, Clustering, Energy aware routing, Network lifetime.

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INTRODUCTION

A WSN consists of a huge number of sensor nodes that has a capability of sensing, processing and communicating. Frequently the sensed data by the sensor nodes are reported to the Base Station (BS) for further processing. The sensor nodes are equipped with less cost, small size batteries which can't be replaced or charged. The scope of the WSN is to observe the critical environment with easy deployment of the sensor node. The communication in WSN is based on single hop or multi hop method [1]. In single hop method, the sensor nodes directly communicate with BS where as in multi hop method the sensor node communicate with BS through intermediate nodes. In the past decade, many researchers have been carried out to address the issue of energy preservation. The sensor nodes energy plays a vital role in the network, if the energy is exhausted, then that sensor node will not be able to communicate in the future and the data can't be obtained. If the sensor node does not have sufficient energy for sending and receiving data, then the sensor node enters into a sleep state. When the sensor node yields required amount of energy it enters into awake state. Energy is consumed more during communication than the other task, such as sensing and processing. Many routing protocols have been developed to improve energy efficiency [2], based on the energy the network lifetime is extended. Initially WSN has been developed for defense and gradually it has extended its application in environmental or habitat monitoring, inventory tracking, smart space, medical monitoring, etc. The major advantages of WSN are the low cost, its organization and the ability to sense [3]. The major difference between WSN and traditional wireless network sensors are considerable to energy conservation. The performance of the WSN mainly depends on the network lifetime. Network lifetime defined as the span between the deployment of the network and when the first node dies. An alternative definition is that the all the sensor nodes run out of energy [4]. The faulty sensor nodes cannot be able to communicate with the BS, therefore these faulty sensor nodes should be identified and removed at the right time from the data collection process in order to improve the quality, but it is not possible in large scale WSN [5]. So many studies that have been carried out in the area of designing a routing protocols in order to preserve energy of the sensor node and to prolong the network lifetime. To preserve the sensor nodes energy, clustering is one of the best technique in WSN. Fig 1, shows the structure of typical clusters in WSN. Clustering provides energy efficient resource distribution and helps in maintaining the energy control. Routing protocol based on clustering provides huge advantages like scalability, load balancing, collision avoidance, less energy consumption, etc. Sensor nodes are grouped together and forms a cluster, each cluster has a Cluster Head (CH) and the data are transferred to BS from CH. BS is a location through some medium the sensed data are transferred to the user. The communication between the sensor nodes can be either single-hop or multi-hop communication. Both the mechanism has disadvantages, in single-hop communication, there is wastage of energy if the distance increases and in multi-hop communication suffers from energy hole. The cluster can be classified as equal size and unequal size cluster. The procedure for clustering is (i) CH Selection, where the CH is elected from the sensor node based on the energy. (ii) Re-clustering, here the clustering should be performed periodically, in case of the wide network. (iii) Relay Selection, in general CH will be far from the BS so the intermediate node transmits the collected data to BS. (iv) Routing, where the next hop will be selected for transmission. (v) Hotspot dispute, the collected data will be sent to the BS the clusters around the BS will become a hotspot [6]. The main advantages of clustering techniques are i) It reduces the travelling distance of the data sent by the sensor node, where the most amount of energy can be preserved, ii) The redundant data are limited in the network where the CH performs the data aggregation process, where the energy will be preserved and consume bandwidth effectively. In this paper, we are going to discuss about various energy aware routing protocols based on clustering WSN.

This paper deals with the following sections: Section II will provide Challenges in WSN routing. Section III will provide an overview of various Energy Aware clustering protocols. We will conclude this paper with Section IV.

CHALLENGES IN WSN

i. Energy: Energy of the sensor node plays a vital role in WSN, which extends the network lifetime.
ii. Computation: The data are collected from the sensor nodes and processes to the base station.
iii. Communication: To enable the contact of sensor nodes at all ranges.

iv. Scalability: To increase the number of nodes and adaptation towards the changes made in topology.
v. Fault Tolerance: Tolerance towards overcoming the failure in sensor nodes.
vi. Power Consumption: One of the major dispute faced by WSN is the high consumption of sensor nodes.

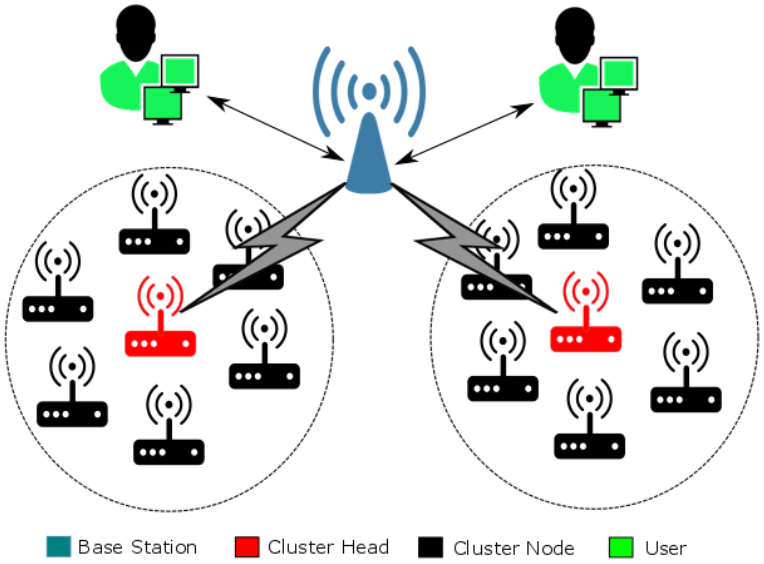

Fig 1: A typical clusters in WSN

ENERGY AWARE CLUSTERING PROTOCOLS

Various energy aware routing protocols based on clustering and their merits and demerits are discussed in this section.

The author [7,9] proposed LEACH (Low Energy Adaptive Clustering Hierarchy) that takes place in two different phases, one is set phase, which is for organizing the networks into clusters, and the other is the steady phase which is for data dissemination. The nodes in LEACH are independent in decision making for becoming CH. Each node selects a random number and compares with the threshold value, if the threshold value is higher than the number the node becomes CH. The chances of becoming CH for all nodes are of equal chances, where one CH cannot become CH for the second time. LEACH cannot be used for larger networks, which is the main drawback, as it uses a single hop communication.

In [8] the author discussed certain protocols, E-LEACH (Enhanced Low-Energy Adaptive Clustering Hierarchy), which overcomes LEACH by two main challenges, where it assumes that the nodes will have the general information about other sensors remaining energy. E-LEACH has come up with an algorithm for selecting CH for different energy level sensor nodes. The other is the number of CHs can be raised to the square root of total sensor under assumptions. This leads to the total energy consumption; other aspects are similar to LEACH. LEACH-C (LEACH Centralized) is for solving the issues created by LEACH. The phases are similar to LEACH. The role of sensor nodes is to send the location and energy information to BS. Based on the information the clusters are formed by the BS and select the CH and CH members, which is the setup phase, and another phase is similar to LEACH. LEACH-F (LEACH with Fixed cluster) is a type of protocol in which the cluster formation is static, which rotates among the same nodes in the same cluster. It uses the same algorithm used in LEACH-C. The drawback is the scalability, as nodes cannot be introduced in clusters, but it controls the overhead.

TL-LEACH (Two Level Hierarchy LEACH) is discussed in [10] from the name it defines two levels of CHs, primary and secondary CH. The algorithm takes place in two steps for communication from source to

destination. The node sends the data to secondary cluster heads of the primary cluster heads. The data are sent to the base station from primary CH, other functions are similar to LEACH. The author [11] came up with PEGASIS (Power Efficient Gathering in Sensor Information System), rather than clusters, it forms chains for transmission of data, which is an additional advantage than LEACH. Data transformation is done node by node until reaching the base station. The nodes fuse the data and sends to the neighbor next to the BS, this starts from the distant node to verify the sink of close neighbors. When the node dies, a chain is formed to bypass the dead nodes. The advantage of PEGASIS is network lifetime, which is twice higher than LEACH.

In [12] propose TEEN (Threshold sensitive Energy Efficient sensor Network Protocol) is the fusion of hierarchical and data centric approach. This method is to reduce the transmission numbers from ordinary node to cluster head. After the cluster formation, it broadcasts two threshold values to ordinary sensors called the hard threshold, which denotes the minimum value beyond which the transmitter should on and send the data to cluster head. Moreover, soft threshold is the smallest change in value, which again turns on the transmitter and sends the sensed value to CH. This method saves more energy by reducing transmission numbers between CHs and ordinary sensor nodes. The greatest disadvantage is dead node detection, where due to the non-detection of dead nodes the reason cannot be analyzed because of the node dead or the threshold value is not met. Same author discussed about APTEEN (Adaptive Periodic TEEN) is for overcoming the drawbacks of TEEN, which is based on the LEACH and TEEN features. It finds the data collection, periodically and in critical events. The results of simulation discusses that the energy dissipation in between LEACH and TEEN.

The paper [13] furnishes information regarding HEED (Hybrid Energy-Efficient Distributed clustering*)* It is an advancement of LEACH and it's based on the cluster head selection method which is not random. It achieves uniform cluster head distribution, load balancing and distributed routing. The demerit is its unawareness of heterogeneity and more cluster head formation. The author [14] explain about REACH-IN (Regional Energy Aware clustering with Isolated Node). According to this type of routing the CH selection is done based on the remaining energy and the average energy of the particular region that belongs to the sensor nodes. If the distributed clustering algorithm is not designed properly it causes the node to become lonely from the CH. Such separated nodes consume more energy, to extend the network lifetime. REAC-IN is compared with existing protocols like LEACH (Low Energy Adaptive Clustering Hierarchy) [7], HEED (Hybrid Energy Efficient Distributed) [13], DEEC, were REAC-IN gives 40% of network lifetime when compared with the remaining protocols [15]. This improves the lifetime performance of the network and the issues in isolated node will be rectified.

FSC (Fan Shaped Clustering**)** is one of the protocol reviewed in [6] which is developed for saving energy. In this protocol, the large scale network is partitioned into FSC, In CH selection, where CH is selected for each cluster, if there is no CH then re-clustering is accomplished. In FSC re-clustering takes place in each layer,but not on the entire network. Relay node selection, through which the packets are forwarded. Routing, Nodes collects the data and forward to the CH where the received data are forwarded to sink node. The partition of FSC leads to some benefits, Re-clustering is limited which reduce the signalling cost. Routing is robust and simple. CH is introduced in the central area of the network, which increase the performance and reduce the re-clustering frequency. FSC is compared with the HEED protocol [13]. In HEED protocol, the residual energy is 10% of the original energy and only one third of the nodes will be alive, but in FSC 40% of energy is left and 42% of nodes will be alive. Even the collection rate is more in FSC than HEED. Therefore, in FSC energy saving packet collection rate is much better than HEED protocol. The future work can be done by analyzing the parameters such as density, size of the network etc.

The author [16] proposed LEACH-E-D (Low Energy Adaptive Clustering Hierarchy-Energy-Distance), the selection of CH depends on two parameters, residual Energy and Average distance, first parameter is based on residual Energy, the temporary cluster head will be selected it ensure that CH has more energy than other nodes. Second parameter is based on the Average distance of the temporary cluster (final cluster head). Simulation is carried out with respect to the parameters like number of nodes, network size, base station location, no.of.CH, initial node power, energy consumption. This LEACH-E-D is compared with LEACH, which shows that the energy is balanced and the entire network lifetime is extended.

The author [17] came up with Improved EADUC (Energy Aware Distributed Unequal Clustering) which is frequently used to solve the Energy hole issue in multi hop communication in WSN, which is expanded to

improve the WSN life span. In EADUC, location of BS and the energy are vital parameters for clustering, to improve the process of EADUC, selection of the cluster head includes the number of nodes in the neighborhood along with the above parameters. The radii of the neighbor clusters give the best energy when compared to EADUC. For the selection of next hop node, the energy cost is defined instead of distance information, where the same cluster is retained for some round, which leads to a reduction in overhead cluster. The simulation parameters are the network area, location of the BS, the amount of nodes, the energy of the node at the beginning and packet size. In Improved EADUC 90% of the sensor nodes are alive depicting the performance of the network.

In order to improve the energy efficiency [18] discussed about two major issues Hotspot and energy hole are to be taken into account. In EESSC (Energy Efficient Semi Static Clustering) the energy of sensor nodes is taken into consideration, packet head is included to update the information during message transmission. On comparison of EESSC with the existing Hierarchical routing algorithm the energy efficiency of the sensor node is higher.LNC (List of Nodes in Cluster) is maintained according to which the CH will be rotated , and the re-clustering mechanism is used to optimize the distribution of cluster. H-CERP (Hybrid Clustering Energy Aware Routing Protocol) is designed to form an efficient cluster with the reduced CH count, it uses multi hops to communicate with the base station via the gateway node was proposed in [19]. The redundant data are eliminated by the CH so the energy is preserved between base station and CH; this protocol extends the network lifetime nearly 10% when compared to other algorithms like LEACH, PEGASIS. Further, this protocol can also be modified for the heterogeneous and homogeneous network.

EECS (Energy Efficient Clustering Scheme) is reviewed in [20], in a given round to become CH the candidates compete with each other, which involves broadcasting residual energy to neighboring candidates. In a case when given code does not find a node with more energy it then becomes CH. In EECS, the sizing is based on the distance from BS, whereas in LEACH clusters are formed based on the distance between the node and the related CH. The higher the distance to BS takes more energy for transmission than the shorter distance, which produces low overheads and distribution being uniform in CH. There are some demerits of EECS, in EECS the CH has the extra burden of performing transmission because of single-hop communication. EECS requires a good knowledge about the distances and an add on burden is the global data aggregation of all the sensor nodes.

The author [21] discussed HUCA (Hierarchical Unequal Clustering Algorithm) where this protocol is based on unequal clustering, all the sensor nodes are static after deployment and each node know its location by using GPS. Initially, all sensor nodes have the same amount of energy and the BS is located away from sensing field. It consists of three phases i) Grid formation, where the network field is divided into three horizontal grids, which is based on the BS's longitude distance. There will be more number of CH near to the BS which assures same amount of energy consumption among the CH. ii) CH Election, initially the CH is elected randomly where each node selects a number between 0 to 1. The node which has the greatest value among the neighbor node that is elected as CH. iii) Data collection, CH collects the data from its member and forward it to the next grid, which is nearer, then the grid, which is close to BS will act as a router and forwards the data. This protocol is compared with LEACH, where it reduces 11% of energy than LEACH. In paper [22] the author found LCC (LEACH-Centralized with Chain) to be an improved version of LEACH; it forms super clusters with the CH nodes. Similar to LEACH, CH nodes are selected. The LCC selects a leader among super cluster members by means of greedy approach.The leader group the data from CH nodes and transmit the data directly to the BS.

In paper [23] the author examine certain protocols like EEGTP (Energy Efficient Graph Theory Protocol) where the communication between BS nodes is in a multi hop manner. The super aggregator collects all the data from CH and send to BS. And next protocol is EECDC (Energy Efficient Coverage Aware Data Collection) as an initial step form the MIS and selects the sensor node. Communication is about inner and intra steps. This intercommunication is controlled between sensor nodes to BS in multi hop manner[24]. Followed by EAUCF (Energy Aware Unequal Clustering using Fuzzy logic) [25] it uses a multi hop routing with unequal clusters. When equal and unequal clustering are compared the unequal delays the first node time. Based on the distance, residual energy and node degree are used for selecting the coverage distance. The fuzzy logic approach and unequal clustering are combined which is advantageous.

CONCLUSION

In recent years, WSN has gained world-wide attention due to the progress made in many areas such as intrusion detection, environment or habitat monitoring, inventory tracking, smart space, medical monitoring, etc., but the energy of the sensor nodes is limited so the efficient utilization of energy is essential for WSN. Clustering the sensor nodes not only preserve the energy, but also reduce the network contention. This paper summarizes various energy aware routing protocols based on clustering, which is used in WSN, since it is a massive and upcoming area of research. This paper covers both the merits and demerits of certain protocols.

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