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A Survey on Clustering Protocols for Energy efficiency of sensors nodes in Wireless Sensor Network

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***Abstract*-Recent advancement in wireless communications and electronics has enabled the development of Clustering routing protocols in wireless sensor network. The Wireless sensor networks can be used for various application areas (e.g., health, military, home).For different application areas; there are different technical issues that researchers are currently resolving. In this review paper, we examine currently proposed clustering algorithms for Wireless Sensor Networks. We will briefly discuss the operations of these algorithms, as well as draw comparisons on the performance between the various schemes. Specifically, we will examine the performance in terms of the power and quality aspects of these schemes. This review paper should provide the reader with a basis for research in clustering schemes for Wireless Sensor Networks.**

***Index Terms* - Clustering algorithms, Energy efficient clustering, Network lifetime, Wireless sensor networks.**

I. INTRODUCTION

A wireless sensor network is a collection of sensor nodes interconnected by wireless Communication channels. Each Sensor node is a small device that can collect data from its surrounding area, carry out simple Computations, and communicate with other Sensors or with the base station (BS). [2] Such networks have been realized due to recent advances in micro-electromechanical systems and are expected to be widely used for applications such as environment monitoring, home security, and earth quake warning. Wireless sensor networks consist of a large number of low power multifunctional sensor nodes with sensing, limited computation and Wireless communications capabilities. Recent advances in sensor technology have enabled the development of small, low-cost and low power sensors that can be connected via a Wireless networks.[5] In wireless sensor networks, Sensors are densely deployed so that it can be Applicable to a variety of fields that include surveillance, military, national security, and chemical or biological detection. Many routing protocols have been proposed for wireless sensor networks. The main goal the routing protocols in wireless sensor networks is to find ways for improvement of energy efficiency and reliable transmission of sensed data to the Sink. Almost all of the routing protocols can Be classified according to the network structure as flat, hierarchical, or location based. And hierarchical routing protocols can be classified again according to the clustering tactics as distributed or centralized fashion. For example, LEACH (Low-Energy Adaptive Clustering Hierarchy), HEED (Hybrid Energy-Efficient Distributed clustering) use distributed tactics and LEACH-C (LEACH-Centralized) use centralized tactics. The main goal of cluster-based routing protocol is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a cluster and by performing data aggregation and fusion in other to decrease the number

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of transmitted messages to sink and transmission distance of sensor nodes.

II.CLUSTERING

The grouping of sensor nodes into clusters has been widely pursued by the research community in order to achieve the network scalability objective.[6] Every cluster would have a leader, often referred to as the cluster-head (CH). Although many clustering algorithms have been proposed in the literature for ad-hoc networks, the objective was mainly to generate stable clusters in environments with mobile nodes. Many of such techniques care mostly about node reach ability and route stability, without much concern about critical design goals of WSNs such as network longevity and coverage. Recently, a number of clustering algorithms have been specifically designed for WSNs. These proposed clustering techniques widely vary depending on the node deployment and bootstrapping schemes, the pursued network architecture, the characteristics of the CH nodes and the network operation model. A CH may be elected by the sensors in a cluster or pre-assigned by the network designer. A CH may also be just one of the sensors or a node that is richer in resources. The cluster membership may be fixed or variable. CHs may form a second tier network or may just ship the data to interested parties, e.g. a base-station or a command center.

III.CLUSTERING OBJECTIVE

Many protocols have been proposed for energy-efficiency in WSN in the last few years. Clustering based schemes are believed to be the most energy efficient routing protocols for wireless sensor networks. As defined previously, Clustering is grouping of similar objects or the process of finding a natural association among some specific objects or data. [5] The structure of a general cluster scheme is shown in the following Figure1. In each cluster, one node is elected as the cluster-head (CH) while the rest of the nodes are member nodes. Member nodes in their respective clusters sense the ambient conditions in the environment and transmit the measured data to their corresponding cluster-head.

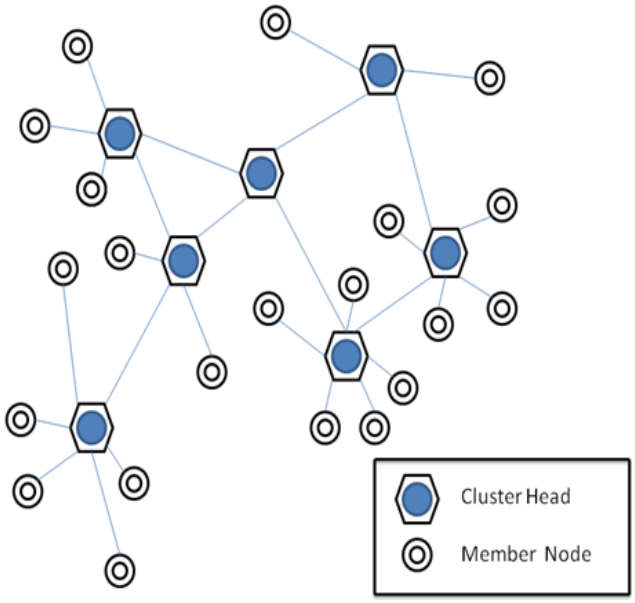

Figure1.Clustering in Sensor Network

Cluster-heads handles the responsibilities to collect data from their member nodes, to aggregate them, and finally to forward the aggregated data either to neighboring cluster-head (multi hop) or directly (single hop) to sink/base station. Clustering leverages the advantages of small transmit distances for most of nodes, requiring only a few nodes to transmit far distances to the sink/base station. Thus clustering along with the reduction in energy consumption improves the network life-time. Along with clustering, the concept of hierarchical clustering also plays a very important role in developing energy efficient schemes for WSN.Clustering has many objectives which are:

1. Allows Aggregation
2. Limits data transmission
3. Load balancing
4. Fault-tolerance
5. Increased connectivity and reduced delay
6. Minimal cluster count
7. Maximal network longevity
8. Facilitates the reusability of the resources
9. Gives impression of smaller and stable networks
10. Reduces network traffic and contention for the channel

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11. Forms virtual backbones for inter cluster routing using CHs and gateway nodes

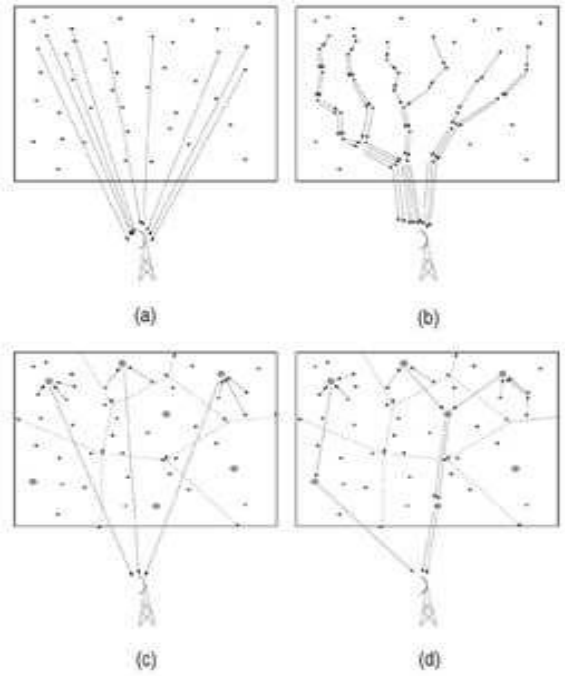

Figure2: Sensor information forwarding with and without clustering and aggregation (a) Single hop without clustering (b) Multihop without clustering (c) Single hop with clustering(d) Multihop with clustering.

In figure 2(a) Show single hop without Clustering, there is sensor direct communicate with the base station but in figure 2(b) sensors communicate first with other sensor nodes and finally communicate with base station, there is without clustering all sensor nodes communicate with base station. In figure 2(c) Clustering is shown, there is a area is divided into many clusters and every cluster has a cluster head, all sensor nodes communicate with cluster head first and then cluster head of every cluster communicate with base station, there is cluster head communicate with base station directly. In figure 2(d) all cluster head communicate with each other and finally send data to base station. Hierarchical clustering is an efficient way for lowering energy consumption within a cluster. It is mainly a two-level routing where one level is used to select cluster heads and other is for routing. Lower energy consumption within a cluster is achieved by data aggregation and fusion to decrease the number of transmittable messages. Also clustered Network allows coverage of large area of phenomenon and additional load balancing without degrading the performance of the network.

IV.CLUSTERING PROTOCOLS

A. LEACH-Distributed

Low-Energy Adaptive Clustering Hierarchy (LEACH) was proposed by Heinzelman [1] and is one of the first cluster-based routing approaches for WSNs. LEACH has inspired many subsequent cluster-based routing schemes. The main goal of LEACH is to select sensor nodes as cluster heads by rotation, so that high energy dissipation in communicating with the base station is spread to all sensor nodes in the network. The nodes organize themselves into local clusters, where one node acts as the local base station or cluster head. LEACH also performs local data compression, reducing the amount of data sent from the clusters to the base station, which further reduces energy dissipation and enhances system lifetime. Sensors elect themselves as local cluster heads with a certain probability at any given time. These cluster-head nodes then broadcast their status to all the other sensors in the network. The sensor nodes then determine which cluster they want to join by choosing the cluster head that requires the minimum communication energy. After all the nodes are organized into clusters, each cluster head creates a schedule for the nodes in its cluster. Once the cluster head has the data from its nodes, the cluster head aggregates the data and then transmits the data to the base station. This is a high-energy transmission because the base station is far away. Because being cluster head drains the battery of that node, the cluster heads are not fixed, so that energy usage can be spread over multiple nodes. The operation of LEACH breaks down into rounds. Each round has two phases: the setup phase and the steady-state phase. During the setup phase, clusters are organized; during the

steady-state phase, data transmission is performed. LEACH is a totally distributed approach and requires no global information.

Advantages of LEACH

(1) Each node has an equal chance to become a cluster head but cannot be selected as cluster head in a subsequent round so the load is shared between nodes.

(2) Because LEACH uses Time Division Multiple Access (TDMA), it keeps cluster heads from unnecessary collisions.

(3) LEACH can avoid a lot of energy dissipation by opening and closing members' communication interfaces in conformity with their allocated time slots.

Limitations of LEACH

(1) Because LEACH uses single-hop communication, it cannot be deployed in networks spread over large distances.

(2) Because cluster heads are elected only on the basis of probability, not taking energy into consideration, LEACH cannot provide actual load balancing.

(3) Because cluster heads are elected on the basis of probability, uniform distribution cannot be ensured. So, there is a chance that the elected cluster heads are concentrated in one part of the network and some nodes might not have any cluster heads in their vicinity.

(4) The idea of dynamic clustering brings extra overhead.

B. HEED

Hybrid Energy-Efficient Distributed (HEED) clustering was introduced by Younis and Fahmy.[2] The main goal of HEED is to prolong network life. The main difference between HEED and LEACH is cluster head election; cluster head election in HEED is not random. The construction of clusters is based on residual energy of the node and intra-cluster communication cost. Cluster heads have higher average residual energy than the member nodes. The communication technique of HEED is the same as LEACH.

Advantages of HEED

(1) HEED is a fully distributed cluster-based routing technique.

(2) HEED achieves load balancing and uniform cluster head distribution due to lower power levels of clusters.

(3) HEED achieves high energy efficiency and scalability by communicating in a multi-hop fashion.

Limitations of HEED

(1) Energy consumption is not balanced because more cluster heads are generated than the expected number.

(2) As with LEACH, massive overhead is created due to multiple rounds.

(3) HEED also has additional overhead owing to several iterations being done to form clusters.

C. PEGASIS

Power-Efficient Gathering in Sensor Information Systems was proposed by Lindsey *et al*.[12] and is an improved version of LEACH. The main idea behind PEGASIS is that each node communicates only with its close neighbors and becomes the leader for transmission to the sink, one by one. The nodes are randomly located, and each sensor node has capabilities for data detection, wireless communication, data fusion, and positioning. Energy load is evenly distributed among all the sensor nodes in the network. In PEGASIS, the

nodes are organized into a chain, which can either be assigned by the sink and then broadcast to all the nodes or accomplished by the nodes themselves using a greedy algorithm. If the nodes form the chain themselves, the nodes can first get the location data of all nodes and locally form the chain using the same greedy algorithm.

Advantages of PEGASIS

(1) PEGASIS has the ability to outperform LEACH because it reduces the overhead due to dynamic cluster formation, and decreases the number of data transmissions due to the chain of data aggregation.

(2) The energy load is distributed uniformly in the network. To make sure that the fixed sensor node is not selected as the leader and thus to prevent the

subsequent early death of this sensor node, all sensor nodes take turns acting as leader.

Limitations of PEGASIS

(1) PEGASIS is not suitable for networks with time-varying topologies. In PEGASIS, it is essential to have a complete view of the topology at each and every node for chain construction.

D. LEACH-Centralized

Low-Energy Adaptive Clustering Hierarchy-Centralized was proposed by Heinzelman [13].LEACH offers no guarantee about the placement and/or number of cluster heads. In, an Enhancement over the LEACH protocol was proposed. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the cluster heads throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location and residual energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy, and determines. The sink finds which nodes have energy below this average. Clusters using the simulated annealing algorithm to solve the NP-hard problem of finding k optimal clusters. This algorithm attempts to minimize the amount of energy for the ordinary nodes to transmit their data to the cluster head. Once the cluster heads and associated clusters are found, the sink broadcasts a message that obtains the cluster head ID for each node. If a cluster head ID matches its own ID, the node is a cluster head; otherwise the node determines its TDMA slot for data transmission and goes sleep until it's time to transmit data. The steady-state phase of LEACH-C is identical to that of the LEACH protocol. Although LEACH and LEACH-C protocols act in a good manner, they also suffer from many drawbacks like the following.

(i) CHs' selection is random, which does not take into account the residual energy of every node or need the support of BS.

(ii) The high frequency of reclustering wastes a certain amount of energy.

(iii) It cannot cover a large area.

(2) It is assumed by PEGASIS that every sensor node is able to communicate with the sink directly, whereas in real life nodes use multi-hop communications to communicate with the sink.

(3) Communication has very long delays, which can cause a node to become a bottleneck.

(4) The network is not very scalable because all the nodes must have global knowledge of the network and use the greedy algorithm.

(iv) CHs are not uniformly distributed, where CHs can be located at the edge of the cluster.

E. EEPSC

Energy-Efficient Protocol with Static Clustering) was proposed by Amir Sepasi Zahmati [6] and it is a hierarchical static clustering based protocol, which eliminates the overhead of dynamic clustering and engages high power sensor nodes for power consuming tasks and as a result prolongs the network lifetime. In each cluster, EEPSC chooses the sensor node with maximum energy as the cluster-head (CH); thus, not only there is always one CH for each cluster, but also the overhead of dynamic clustering is removed. EEPSC is a modified version of the Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol presented in LEACH uses the paradigm of data fusion to reduce the amount of data transmitted between sensor nodes and the base station. Data fusion combines one or more data packets from different sensors in a cluster to produce a single packet. It selects a small number of CHs by a random scheme which collects and fuses data from sensor nodes and transmits the result to the base station. LEACH uses randomization to rotate the CHs and achieves a factor of 8 improvement compared to the direct approach before the first node dies.

The main difference between EEPSC and LEACH are described below:

(i) EEPSC benefits a new idea of using temporary-CHs and utilizes a new setup and responsible node selection phase.

(ii) EEPSC utilizes static clustering scheme, therefore eliminates the overhead of dynamic clustering

V. COMPARISON BETWEEN CLUSTERING PROTOCOLS

Table 1 Highlight the comparison between cluster-based routing protocols on the basis of energy efficiency, cluster stability, scalability, delivery delay, load balancing.

Protocol Name	Cluster Stability	Scalability	Delivery Delay	Energy Efficiency	Load Balancing
LEACH	Medium	Very Poor	Very Small	Very Poor	Medium
HEED	High	Medium	Medium	Medium	Medium
PEGASIS	Poor	Very Poor	Very Large	Poor	Medium
LEACH-C	High	High	Medium	Medium	Medium
EEPSC	High	High	Very Large	High	High

Table 1: Comparison between clustering protocols

VI. CONCLUSIONS

In this paper we have examined the current state of proposed clustering protocols. In wireless sensor networks, the energy limitations of nodes play a crucial role in designing any protocol for implementation. In this paper, we present an overview of cluster-based routing algorithms in WSNs. We discuss the advantages and taxonomy of cluster-based routing algorithms in WSNs. In addition, we compare different approaches on the basis of various performance measures. It is clear that the different cluster-based routing algorithms mentioned above can be used to improve the performance of WSNs.

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