COMPARISION BETWEEN CLUSTER BASED ENERGY EFFICIENT PROTOCOL FOR WIRELESS SENSOR NETWORK

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ABSTRACT

This paper deals with criterion used to measure communication protocol efficiency in Wireless Sensor Networks. As energy is a crucial characteristic of those networks, it is necessary to pay attention both to the energy consumption and to the distribution of energy consumption, when using communication protocols, so as to increase the lifetime of the whole network. Our aim is to present and discuss criterion designed to analyze communication protocol effectiveness. Clustering routing protocol provides an effective method for prolonging the lifetime of a wireless sensor network. But most of the researches care less about the communication between Cluster Head (CH) nodes and Base Station (BS). This paper proposed a Multi-hop Cluster based Routing Protocol comparison for wireless sensor network. In this Paper we compare the cluster based routing protocol LEACH and HEED. Simulation results show that the HEED protocol offers a better performance than LEACH clustering routing protocols in terms of network lifetime and energy consumption.

Keywords: *Wireless Sensor Network, LEACH and HEED Protocol Energy Efficient, Multi-hop Clustering. Sensor nodes.*

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1. INTRODUCTION

Wireless Sensor Networks (WSNs) are formed by hundreds or thousands of nodes that gather information and forward it to base station node. Distinguished from traditional wireless networks, sensor networks are characterized of severe power computation, and memory constraints [1]. As the wireless nodes in a WSN are usually driven by power sources (e.g. batteries) which are irreplaceable, energy resource of sensor networks should be managed wisely to extend the lifetime of sensors. Routing protocol is one of the core technologies in the WSN. Due to its inherent characteristics, routing is full of challenge in WSN [2]. Clustering is a well-know and widely used exploratory data analysis technique, and it is particularly useful for applications that require scalability to hundreds or thousands of nodes [3]. For large-scale networks, node clustering has been proposed for efficient organization of the sensor network topology, and improves the network lifetime. We consider a network of energy-constrained sensors that are deployed over a geographic area for monitoring the environment. Among the sources of energy consumption in a sensor node, wireless data transmission is the most critical. Within a clustering organization, intra-cluster communication can be single hop or multi-hop, as well as inter-cluster communication. Low Energy Adaptive Clustering Hierarchy (LEACH) [4] is the first clustering protocol that was proposed for reducing power consumption. It forms clusters by using a distributed algorithm, each node has a certain probability of becoming a cluster head per round, and the task of being a cluster head is rotated between nodes. A non-CH node determines its cluster by choosing the CH that can be reached with the least communication energy consumption. In the data transmission stage, each cluster head sends an aggregated packet to the base station by single hop. Hybrid Energy-Efficient Distributed (HEED) [5] clustering approach, is one of the most recognized energy-efficient clustering protocols. It extends the basic scheme of LEACH by using residual energy and node degree or density. In HEED, the initial probability for each node to become a tentative cluster head depends on its residual energy, and final heads are selected according to the intra-cluster communication cost. The clustering process is divided into a number of iterations, and terminates within a constant number of iterations. HEED achieves fairly uniform distribution of cluster heads across the network. Although the protocols above reduce energy consumption on forwarding paths to increase energy efficiency.

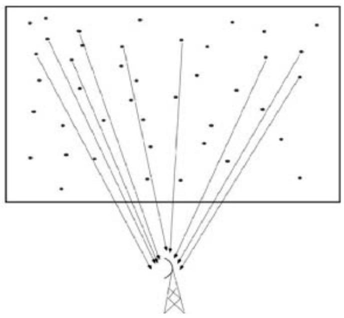
In LEACH and HEED protocols the basic difference is that while find out the cluster node in a network we use the maximum energy at the node. While in HEED protocol we use maximum energy of the node and as well as the minimum distance between the node and the base station. In this way we balance the energy consumption over the network. Many researches dedicate to energy efficient routing of WSNs [7-10], but most of them care less about the communication between Cluster Head (CH) nodes and Base Station (BS). In this paper, we compare the LEACH and HEED Clustering Routing Protocols.

The remainder of this paper is organized as follows. Section 2 introduces a single-hop clustering and multihop routing protocol, Section 3 describes the LEACH and HEEDS protocol. Section 4 contains performance evaluation of our scheme throughout simulations results and section 5 shows the conclusion.

2. CLUSTERING ROUTING PROTOCOLS

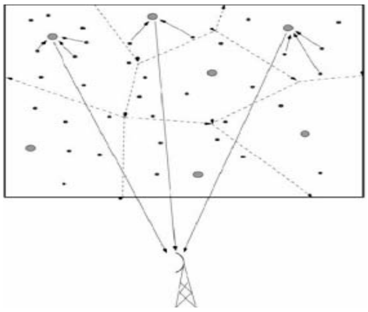
2.1 Single Hop Protocol:

Employ clustering techniques in routing protocols can hierarchically organizing network topology and to increase the lifetime of a wireless sensor network. A single-hop clustering routing protocol can reduce the communication overhead by selecting a CH to forward data to base station via one hop. As shown in Fig. 1 [4], the transmission range will be decreased obviously with clustering. Many single-hops clustering routing protocol have been proposed like LEACH, HEED as discussed.



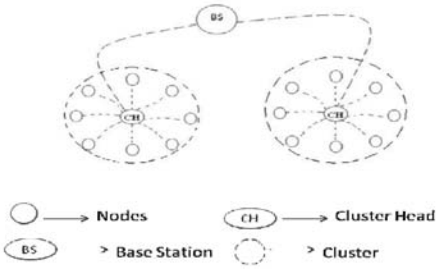
(a) Single hop without clustering

HEED protocol is a distributed single-hop clustering routing protocol for Wireless Sensor Networks, which selecting CHs based on both residual energy of each node and communication cost. It has the advantages in increasing the network lifetime and having a constant algorithm complexity.



(b) Single hop with clustering

Figure 1. Clustering Routing Protocols



In steady state phase, the clusters are formed and the corresponding cluster head is selected. After the cluster head receives the data it can be aggregated and the data can be transmitted to the base station. Research on application-specific protocol architecture for wireless micro Sensor networks by W.B.Heinzelman, proposed a solution that, In LEACH-C [4], during the set-up phase each node sends information about its current location to the sink. In order to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. The sink computes average node energy, and determines which nodes have energy below this average. This solution minimize the amount of energy for transmit their data to cluster head. After the cluster head and associated cluster (the node which have energy below the average energy) 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, that node seems to be an cluster head, otherwise the node determines its TDMA slot for data transmission and goes sleep until it's time to transmit data. 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.

2.2 Multi-hop Routing Protocol:

To increases the network lifetime and well balances the energy consumption, we adopt an energy-driven method to rotate cluster-head, and propose a Multi-hop Clustering Routing Protocol for long range transmission in the wireless sensor networks.

3. LEACH PROTOCOL:

LEACH-distributed or LEACH [2] is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. LEACH makes some assumptions about both the sender nodes and the underlying network, being some of them very strong. LEACH assumes that all sensor nodes can adapt their transmission range. Furthermore, energy consumption during transmission scales exactly with the distance and every sensor node is able to reach a base station (BS). Moreover, nodes support several MAC layers and perform signal-processing functions. LEACH uses a distributed algorithm to determine the cluster heads in the set-up phase whereas in the steady phase nodes send their data according to the time schedule provided by their cluster heads. This operation of LEACH is divided into rounds as shown in figure 2.

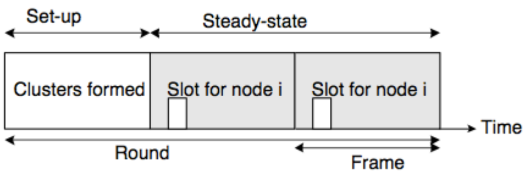


Figure 2

When clusters are created, each node *n* autonomously decides if it will be a cluster head for the next round. The selection is stochastic and each node determines a random number between 0 and 1. If this number is lower than a threshold *T (n)*, the node becomes a cluster head. *T (n)* is determined according to the equation:

$$T_1(n) = \frac{P}{1 - P * (r \bmod \frac{1}{P})},$$

For nodes that have not been cluster head in the last 1/*P* rounds, otherwise *T1 (n)* is zero. Here *P* is the desired percentage of cluster heads and *r* is the current round. Using this algorithm, each node will be a cluster head exactly once within 1/*P* rounds. After 1/*P* – 1 rounds, *T1 (n)* = 1 for all nodes that have not been a cluster head. When a node has elected itself as a cluster head, it broadcasts an advertisement message telling all nodes that it is a cluster head. Non-cluster heads use these messages from the cluster heads to choose the cluster they want to belong for this round based on the received signal strength of the advertisement message.

3.1 HEED Protocol:

The clustering process is triggered repeatedly after every clustering process time and network operational interval. At each node, the clustering process requires a number of iterations called *Niter*. Every step should be long enough to receive messages from any neighbour within the cluster range. Also it is set an initial percentage of cluster heads among all nodes in the network called *Cprob*. It is only used to limit the initial cluster head announcements. Before executing HEED, a node sets its probability of becoming a cluster head, *CHprob*, as follows:

$$CH_{prob} = C_{prob} * \frac{E_{residual}}{E_{\max}},$$

.

Where *Eresidual* is the estimated current residual energy in the node and *Emax* is a reference maximum energy (corresponding to a fully charged battery), which is typically identical for all nodes. During any iteration *i*, *i* < *Niter*, every uncovered node elects to become a cluster head with probability *CHprob*. After step *i*, the set of tentative cluster heads, *SCH*, is updated and a node *vi* selects its cluster head to be the node with the lowest cost in *SCH*. Every node then doubles its *CHprob* and goes to the next step. If a node elects to become a cluster head, it sends an announcement message where the selection status is set to *tentative_CH*, if its *CHprob* is less than 1, or *final_CH*, if it's *CHprob* has reached 1. A node considers itself covered if it has heard from either a *tentative_CH* or a *final_CH*. If a node completes HEED execution without selecting a cluster head that is *final_CH*, it considers itself uncovered, and announces itself to be a cluster head with state *final_CH*. A *tentative_CH* node can become a regular node at a later iteration if it finds a lower cost cluster head. The inter-cluster communication to allow all the cluster heads to send the data they have aggregated from their cluster members is not explained, but there are some statements and requirements over it. The communication among the cluster heads to allow all the data to reach the base station should be based on a multi-hop approach.

HEED uses two clustering parameter to select CH: one is residual energy, and the other is communication cost. The communication cost is defined as an average minimum reach ability power, which means the minimum power levels required by all nodes within the cluster range to reach the CH. The communication cost held by CHs is used to let a node which belong to several CHs choose the best one. In HEED, each node must be mapped to exactly one cluster, and each node belongs to its only CH within one hop. After a clustering process, each node can either elect to become a CH due to a probability or join a cluster according to CH messages. A HEED process can be divided into three steps [4]: (1) initialize: firstly, set an initial percentage of CHs among all nodes. A node which is selected to be an initial CH will broadcast its cost to nodes within its cluster range other nodes will then choose their own CHs. A node may belong to two or more CHs at the beginning, but it can select an optimal one in iteration processing by comparing the costs of these CHs. Furthermore, each node also computers a probability of becoming a CH when finds not any CHs due to its residual energy. (2) Iteration processing: After initializing, nodes will go to the iteration process. In each iteration step, every node which detects no CH elects to become a CH with probability mention above. After one iteration, a set of tentative CHs is known for nodes, and then they select the tentative CHs with the lowest cost as their CHs. When a node elects to become a CH, it'll send an announcement message to notice its neighbours. After that, all nodes double the probability and go the next iteration until the probability to be value 1 or the iteration time exceeds. If a node hears from no CH, it elects itself to be a CH and inform to its neighbours. (3) Finalize: Once a node complete iteration, it implies that the node has chosen its suitable CHs with high residual energy and low cost, and then joins to the cluster. Meanwhile, every node elect to be final CH will pronounce its cost to nodes within cluster. HEED uses the clustering approach by considering the residual energy and has a constant iteration number, so it can Increase the network life time and suit for large network. However, one-hop clustering routing protocols only perform well in a case when the CH close to base station. When a CH locates far from the base station, it may consume more energy to forward data to the base station via one hop. Actually, there are hundreds or thousands of nodes in large WSN, so some of CHs may distribute far away from base stations. Therefore, it may save more energy when letting a farther CH forward data to a base station through other closer CHs via multiple hops.

4. SIMULATION ASSUMPTIONS:

We have used MATLAB software in our simulation evaluation. Considered an area of x-axis and y-axis of 100*100 meter.Etx and Erx are (Electrical=Etx=Erx) EDA (Data Aggregation Energy).Further Parameter assumption given below in the table:

Assumption Table:

Parameter	Values
Field Area	100*100 m
No. of Nodes (n)	100
Initial energy	0.5 j
Eelec	50 *nJ=bit*
Efs	10 *pJ=bit=m2*
Emp	0.0013 *pJ=bit=m4*
Dcrossover	87m
EDA	5 *nJ=bit=signal*
Packet size	4000 *bits*

4.1 Leach Simulation Results:

The first Figure 1 shows the All dead nodes, figure 2 shows the All Alive nodes, Figure 3 shows the number of data packets transfer from cluster head to base station and finally figure 4 shows the total number of cluster formed. All these figures are shown below.

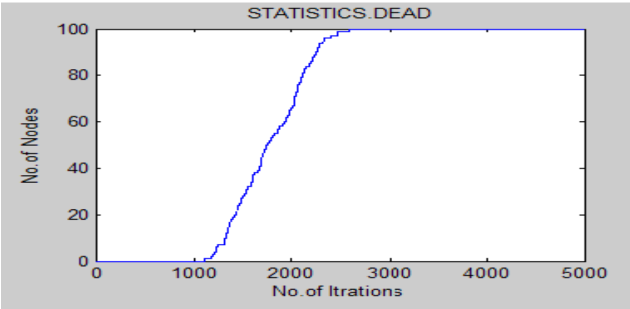


Figure 1

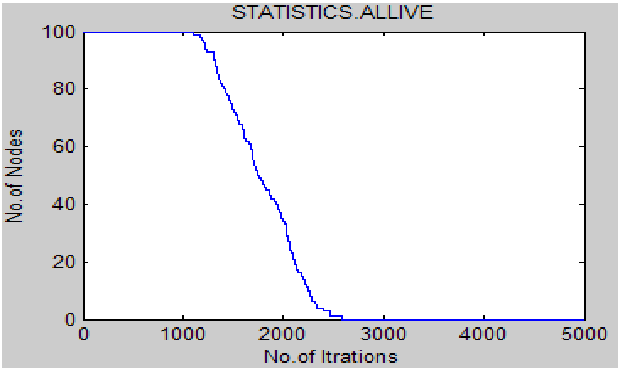


Figure 2

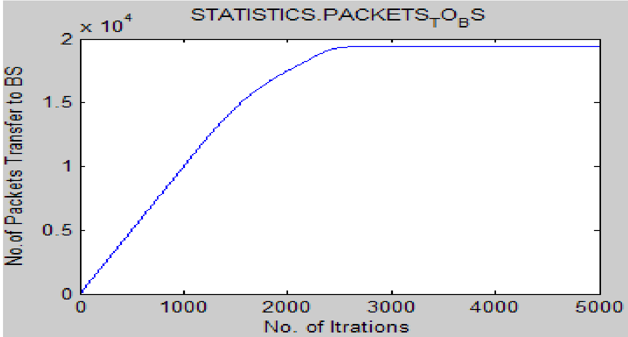


Figure 3

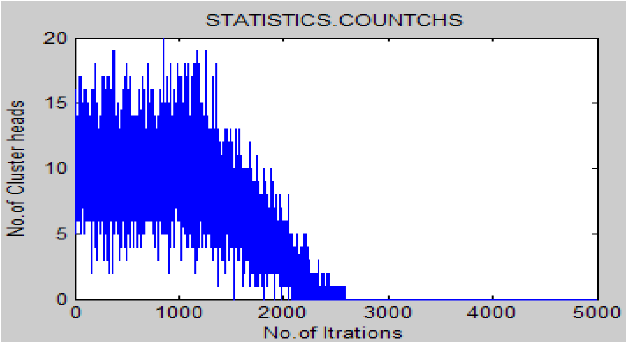


Figure 4

4.2 HEED PROTOCOL RESULTS:

The first Figure 5 shows the All dead nodes, figure 6 shows the All Alive nodes, Figure 7 shows the number of data packets transfer from cluster head to base station and finally figure 8 shows the total number of cluster formed. All these figures are shown below.

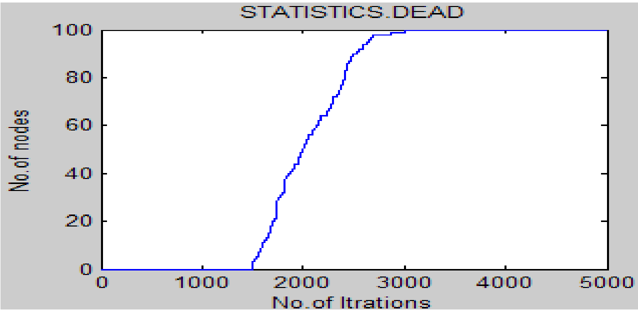


Figure 5

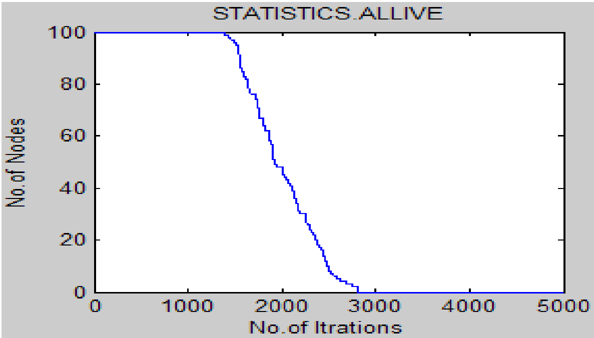


Figure 6

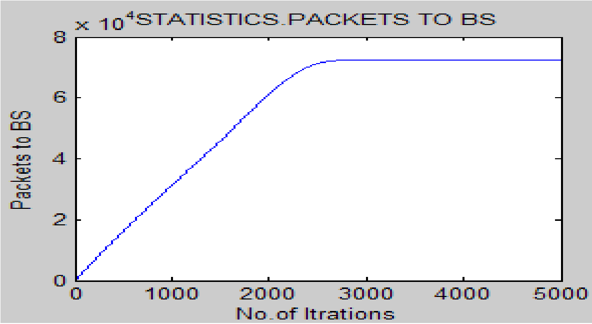


Figure 7

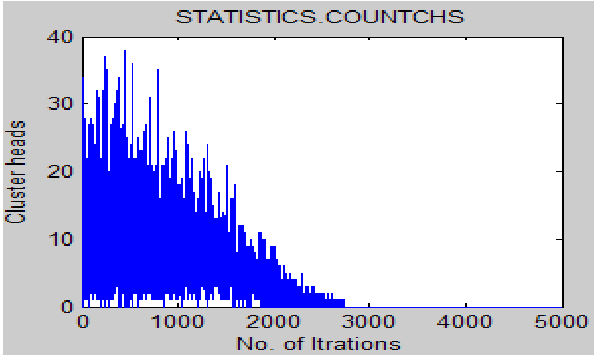


Figure 8

4.3 Statistics Comparison Results of LEACH and

HEED Protocols:

Cluster Based Protocols	First Dead	Tenth Dead	All Dead	Packet to CH	Packet to BS
HEED	1495	1593	3008	130784	73741
LEACH	1075	1337	2496	158891	19361

5. CONCLUSION AND FUTURE SCOPE

After the comparing analysis we observed that the HEED routing protocol is more energy efficient routing protocol for wireless sensor network as comparisons to LEACH protocol in the form of energy consumption and cost of sensor nodes. Further in future we use the movable nodes to compare and analyzed these protocols.

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