ENERGY EFFICIENT HEED PROTOCOL IN WIRELESS SENSOR NETWORKS

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ABSTRACT

The aim of this paper is to develop an energy efficient HEED protocol to increase lifetime of the wireless sensor network. The purpose of Hybrid Energy Efficient Distributed Protocol is increase network lifetime by distributing energy consumption, so asto complete the process of clustering within a given number of iterations, and divide the network into organized and compact clusters. The main objectives of this paper are : division of network into clusters, Analyzing the performance of network using HEED,optimizing the formation of clusters and cluster head rotation process to increase network lifetime and comparison of the performance of EE-HEED with HEED

KEYWORDS—WSN; Clustering; Cluster head

I. INTRODUCTION

Wireless Sensor Network consists of a large number of very smallelectromechanical devices that communicate with each other through radio transmission. The job of the sensor nodes in wireless sensor networks is to gather information from the environment, the data collected is transmitted to the sink. A sensor node comprises of a sensor, microcontroller or processor, transceiver and battery. Usually the sensors are deployed in unattended environments; these nodes collect data and send to the base station with multi-hop protocol. The use of protocols is done to increase efficiency and lifetime of the network. The data gathered by sensor nodes is sent to base station where data is processed which further sends data to the computers with software at monitoring station. The data is analyzed at the monitoring station and the results are calculated. To make the Wireless sensor network operate for long time it needs an uninterrupted power supply i.e. a battery backup which doesn’t get exhausted. The other way is to decrease energy consumption by developing protocols for the way the nodes communicate with each other. Most of the energy is consumed in communication among the nodes, the goal is limit the unnecessary transmissions. This is done by dividing the networks into clusters. Each cluster has a cluster head which collects data from the nodes. There are various protocols which have different ways to select the cluster head.

A. LEACH PROTOCOL

Low Energy Adaptive clustering hierarchy is one of the most known protocols. LEACH is a distributed an hierarchical protocol with objective to improve the efficiency and network lifetime by distributing energy equally among the network sensor nodes. It has specific time period and phases such as setup phase and steady state phase. The clusters are formed at the setup phase and selection of cluster head id one randomly which facilitates the distribution of energy among the sensor nodes during communication. In the beginning of setup phase the the sensor node select a number between 0 and 1 to compare it with the threshold energy; if the chosen number is lower than threshold the sensor node is cluster head and the information is sent to the network about the CHs in the network. The cluster head is responsible for scheduling the nodes in the cluster with TDMA (time division multiple access). The steady state phase is the transmission phase in which data packets from nodes is sent to the cluster head which direct the data to base station directly. To prevent collision TDMA-CDMA MAC are used in LEACH.

B. HEED PROTOCOL

Hybrid Energy Efficient Distribution protocol was developed to overcome drawbacks in LEACH i.e. the random selection of cluster heads. It is multi-hop clustering algorithm for wireless sensor networks with objectives to:-

1) Extend network by reducing energy consumption
2) Reduce energy usage in formation of cluster heads
3) Reduce the processing cost of the data.

Clustering in HEED – As the battery is limited in a wireless sensor network, and to maximize it, the
network lifetime energy consumption should be reduced. Clustering is an effective technique to increase network lifetime and scalability. This topology involves grouping of sensor nodes into different clusters, each cluster selects a cluster head and the rest of the nodes are called member nodes. In HEED the member nodes does not communicate directly with base station. The cluster head collects data from the member nodes and forwards it to the base station thus limiting the number of transmissions. The base station is the collection node for the whole wireless sensor network. The clusterheads are selected according to following reasons:-

1) Residual Energy – The cluster heads are selected depending on the remaining energy levels.
2) Cost of intra cluster Communication – A node can come in range of multiple clusters, so the inclusion of node in the cluster will depend on the low intra cluster communication. The intra cluster communication cost will depend on the cluster size and power levels available for intra cluster communication. Each node has calculates its probability for becoming a cluster head.

**Clustering Parameters** – The basic parameters in clustering in WSN are :-

1) *Intra-cluster Communication* – The number of cluster heads is limited when the communication of wireless sensor nodes is limited. So multi-hop routing protocols is required to reduce energy consumption.
2) *CH mobility* – If the cluster heads are mobile then the assigning of nodes to clusters can be changes i.e. the nodes can shift to other clusters.
3) *Clustering method* – In LEACH the cluster heads are the sensor nodes, the clustering is done randomly without the coordination of all the nodes. In some protocols a centralized approach is followed in which few nodes divide the network and control the clusters and member nodes.
4) *Cluster head selection* – In some protocols the cluster heads are assigned randomly when the nodes are deployed. In HEED the CHs are selected based on residual energy level, scalability, connectivity etc.
5) *Multiple levels* – Multilevel clustering is developed to reduce energy consumption by the wireless sensor network. There is lot of room for improvement in multilevel hierarchy when the networks are very large and the communication within the network of utter importance.

## II. LITERATURE REVIEW

1) A. MeenaKowshalya et.al in [2] discusses about the clustering in wireless sensor networks. In this paper the heterogeneity of nodes to the performance of WSN is studied. In this paper they classified the protocols according to stability and energy efficiency of networks. The conclusion after the survey was that heterogeneous WSNs are more suitable for real life application as compared to homogenous approach.
2) Malika N. Halgamuge et.al tells about formation of energy optimized cluster for set of arbitrarily scattered wireless sensor networks. The sensor nodes communicate only with the cluster head. The sensor nodes send information to the cluster head which further sends it to the base station. The clustering is determined by energy minimization for all the sensors.
3) Vinay Kumar et.al proposed the clustering algorithms for heterogeneous networks in [5]. The method of data transfer is chosen in such a way that total energy which is consumed along with transmission is reduced. To support better collection of data and high scalability sensor nodes are regularly grouped into clusters. The paper presents survey on clustering of wireless sensor networks and taxonomy of clustering which are energy efficient of WSNs.
4) Nikos Dimokas in [4] explain two categories. The first category involves a specific number of nodes are responsible for transferring messages and due to this they cause energy to deplete faster. In second category uses the remaining energy of each node with a specific target to direct its choice whether it will select itself as a cluster head or not. It proposes a novel appropriated clustering protocol for wireless sensor networks depending on novel metric for portraying the significance of node. The results show that the protocol produces only few clusters allowing fewer message transfers thus enhancing the lifetime of network.
5) Tal Anker et.al in [8] shows the efficient clustering for improving the network performance in wireless sensor networks. The paper proposed a distributed interference algorithm for clustering, focussed around belief propagation. The cluster heads are selected based on extraordinary set of local and global parameter which increase network performance under limited energy. The results shows increase in throughput more than 40%. The research resulted in reliability of network, reduced cost of transmission and improved quality in data collection.
6) ManjuBala et.al in [12] this paper proposes improvement of HEED to help mobility in heterogeneous and homogeneous network. The
research was done on HEED, 2H-HEED, 3H-HEED and MH-HEED with arbitrary mobility in wireless network in terms of efficiency, throughput, lifetime and stability. The most efficient of all was the MH-HEED according to the results. The overall performance of network enhanced in case of BS-mobility.

III. ENERGY EFFICIENCY HEED PROTOCOL

The communication within the sensor nodes in a wireless sensor network is of utmost importance. The structure of wireless sensor network is like a tree like leaves as sensor nodes which send data to the root base station through multi-hop protocols. The limitation of energy restricts the scalability, lifetime, memory and connectivity of the network. The clustering is the technique to counter the limitation. Instead of increasing battery the clustering helps in reducing the consumption of energy. The energy distribution in the nodes is done by selecting a cluster head which collects data and sends it to the base station. Most of the energy is consumed in formation of clusters and then in cluster head selection and rotation. In LEACH every node can become a cluster head regardless of its energy level, so in this case when a node with less energy is selected as a cluster head it has the possibility to die out which can result in loss of information. HEED overcomes this problem in which cluster head is selected with comparisons of residual energy levels and the node with highest energy level is selected as a cluster head. But this doesn’t make much difference from LEACH in cluster formation phase and cluster head rotation. The objective of paper to reduce energy consumption to increase network lifetime is achieved with Energy Efficient HEED.

TOOL USED: In this research we used Network Simulator 2 (NS2) which is most widely used in networking simulations due to its real time environment. It helped analyzing the routing of packets between the nodes with animation. Components of NS2 are:-

1) NAM – Network Animator that visualizes ns output and xgraph tool.
2) Scenario Generator – Traffic and topology generators
3) Post processing – Tracing result analysis

The coding of the main file which is considered as input to the network simulator is done with tool command language (TCL). TCL is an interpreted scripted language mostly used to develop graphic interfaces with help to tool kit (TK). The type of files used are tc and awk in supporting TCL script. The compiler creates two files i.e. trace file and nam file by which various parameters can be analyzed. The trace files has the information about the consumption of energy of the nodes and the nam file gives information about routing of packets.

TECHNIQUE USED: The nodes are deployed using the random way point mobility model in which nodes are clustered near the centre of the simulation area and distance between nodes is shorter and performance is better. The total number of nodes deployed is 49. Node 0 is the first node and Node 48 is assumed to be the sink node where data is collected in the network. The nodes are grouped into 6 clusters shown in different colors in animation. The cluster formed are according to the position of the nodes. So we have divided the whole area into subareas of 300 * 300. The nodes lying in the sub area are considered to form a single cluster. In HEED the when the clusters are formed the nodes go for lead advertisement process in which the nodes send HELLO messages to each other and send their residual energy levels. The node with highest energy level is considered as the cluster head. In EE-HEED the process is optimized by using initiator node. The initiator is random node that is selected from each cluster. Such as from cluster 1 the node 9 is selected as initiator node, then the initiator node 9 sends hello messages to all the nodes in the cluster to which it belongs. The nodes send the acknowledgement of hello messages with the information about their energy levels. This way the initiator selects the priority of the nodes to become cluster head for example if node 3 has more energy level than node 5 then node 3 will be selected as a cluster head in first round and then node 5 as cluster head in second round and so on. After the cluster head selection every node gathers its data at the cluster head i.e. at node 3. In second cluster head is node 8 and the cluster nearest to the sink node has node 42 as cluster head. So the node 3 from cluster head passes its data to cluster head in 2nd cluster and so on to last cluster head 42 which further transfers to the sink node. After the completion of first phase the node which was second in order in the cluster head will be selected the cluster head such as node 5 in the first cluster. This way the data is gathered at cluster head which sends it to the nearest cluster head and so on until it reaches the sink node.

The objective of EE-HEED is to reduce the consumption of energy which is consumed during cluster head rotation in the basic HEED protocol. The initiator node helps in prioritizing the node which has the highest energy to become a cluster head and the second in energy level becomes the cluster head in second round. Hence the initiator decides the cluster head in subsequent rounds which saves energy in cluster head rotation phase.
Flowchart of the proposed method is as follows

```
Start

Deployment of the Nodes

Formation of Clusters

Selection of initiator node

Initiator decides the cluster head

Data gathered at cluster head

Cluster head forwards data to sink
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SIMULATION PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulator</td>
<td>NS2.35</td>
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<tr>
<td>Channel</td>
<td>Wireless Channel</td>
</tr>
<tr>
<td>Propagation Model</td>
<td>Two Ray Ground</td>
</tr>
<tr>
<td>No. of nodes</td>
<td>49</td>
</tr>
<tr>
<td>Dimensions of Simulated Area</td>
<td>1100m X 1100m</td>
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<tr>
<td>Queue</td>
<td>Drop Tail</td>
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<tr>
<td>Antenna</td>
<td>Omni-Directional</td>
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<tr>
<td>Routing Protocol</td>
<td>AODV</td>
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<td>Energy Model</td>
<td>Radio Energy Model</td>
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<tr>
<td>Initial Energy</td>
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</tbody>
</table>

SIMULATION RESULTS

The performance of the proposed algorithm is measured on basis of amount of energy consumed in cluster head selection and throughput. The energy consumption is calculated by computing energy consumed in total transmission and reception per successfully delivered bit. The energy is consumed in base HEED in sending hello signals to all the nodes in all the clusters and then only the cluster head is selected, this is done in every round. In EE-HEED all the nodes are informed of the cluster heads in the beginning after the clusters are formed. So in EE-HEED the energy is only consumed in sending hello messages once and informing cluster heads in first round. The initial energy available is 100 Joules. In HEED the energy consumed is 24 Joules and remaining energy is 76 Joules where as in our proposed algorithm: i.e. EE-HEED the energy consumed after 2 rounds of cluster head selection is 20 Joules that means remaining energy is 80 Joules. The throughput is defined as the total number of bits sent per second at the base station through all multi-hops in the network. The simulation results show that the throughput in the proposed Energy Efficient HEED has risen upto 175 Kbps as compared to HEED protocol which was 160 kbps. Hence energy efficiency and throughput shows that the proposed Energy Efficient HEED performs better than the base HEED. The unnecessary transmissions of informing residual energy levels in each phase is reduced which reduces consumption of energy.

Formula of throughput is

\[
\text{Throughput} = \frac{\text{Frames transferred} - \text{Frames failed}}{\text{Total time}}
\]

Proposed throughput in EE-HEED

Throughput in HEED
IV. CONCLUSION AND FUTURE

We have proposed an EE-HEED protocol which reduces energy consumption in the network and increases throughput. The concept has been shown by deploying nodes in 300 X300 m area. The concept has been justified with the comparison of performance metrics which are calculated in the simulation. Although the results are positive there is still scope in this research as there would be doubts if the nodes selected as cluster heads by the initiators are have lost more energy unexpectedly, the cluster might stop transmission when cluster head uses all its remaining energy and it would violate the concept of HEED which is selection of cluster head based on residual energy.

REFERENCES


