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Performance Evaluation of Heterogeneous-HEED Protocol for Wireless Sensor Networks

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Abstract: In this paper, the Hybrid Energy Efficient Distributed protocol for the heterogeneous wireless sensor network have been reported. The main requirements of wireless sensor network are to prolong the network lifetime and energy efficiency. Here, Heterogeneous- HEED: A Protocol for clustered heterogeneous for Wireless Sensor Network has been proposed to prolong the network lifetime. The simulation was carried out using Matlab software and the simulation results were compared with the existing system thus proving that the proposed work achieves longer lifetime and is efficient in managing the energy constraints of the network.

Keywords: WSN, Cluster head, HEED, Protocols, Sensors.

I. INTRODUCATION

A wireless sensor network (WSN) is a wireless network consisting of low-size and low-complex devices called as sensor nodes that can sense the environment and gather the information from the monitoring field and communicate through wireless links; the collected data is forwarded, via multiple hops relaying to a sink (also called as controller or monitor) that can use it locally, or is connected to other networks [1].

A sensor node usually consists of four subsystems i.e. sensing unit, processing unit, communication unit and power supply unit. In WSN, the sensor nodes are deployed in a sensor field. The deployment of the sensor nodes can be random (i.e. dropped from the aircraft), regular (i.e. well planned or fixed) or mobile sensor nodes can be used. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment.
Each sensor nodes collect the data and route the data to the base station.

All the nodes need not communicate at the same time and they can communicate only with the nearby nodes. The network has a routing protocol to control the routing of messages between the sensor nodes. The routing protocol also attempts to get messages to the base station in an energy-efficient manner. The base station is a master node. Data sensed by the network is routed back to a base station. The base station may communicate with the other sensor nodes.

HEED (Hybrid Energy Efficient Distributed Clustering) protocol is an energy efficient clustering protocol. It uses residual energy as primary parameter and node degree and distance to neighbors as secondary parameters. It extends the basic scheme of LEACH protocol. The clustering process is divided into a number of iterations, and in each iteration nodes that are not covered by any cluster head, it doubles the probability of becoming a cluster head. It cannot guarantee optimal elected set of cluster heads. H-HEED (Heterogeneous Hybrid Energy Efficient Distributed) is the modified version of the HEED protocol in terms of heterogeneity. Here the cluster head is selected based on the fraction of residual energy to the maximum energy possessed by the sensor nodes. Head to head communication takes place and different energy leveled networks have been created. Different levels of heterogeneity are used. In 2-level H-HEED, two types of sensor nodes, i.e. normal and advanced nodes are used. In 3-level H-HEED, three types of sensor nodes, i.e. super, normal and advanced nodes are used. In this heterogeneous approach, all the nodes are having different energy level [2]. The concept of 2-level H-HEED protocol is employed in this paper.
Rest of the paper is organized as follows: Section two deals with the proposed H-HEED protocols, in section three we discuss performance evaluation, experimental results are dealt in section four and finally we conclude with future research direction in section five.

II. H-HEED PROTOCOL

The proposed effective H-HEED protocol is illustrated in this section. This protocol works on four modules.

1) Deploying Sensor nodes randomly:

WSNs involve a large number of sensors ranging in the hundreds or even thousands. The first step involved in this phase is the plotting of sensor nodes in a 100*100 m square egion.100 nodes including the base station are deployed in a 2D plot. Initially, energy of about 5 joules each is assigned to the nodes. The probability to become CH and energy values is assigned.

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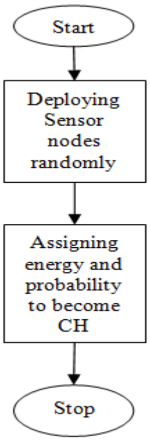


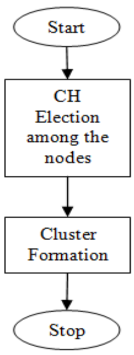
2) Cluster Head Election and Cluster Formation:

We have assumed that there are 100 sensor nodes, which are randomly dispersed within a 100 * 100 m square region. The assumptions made regarding the network model are given below:

(1) Nodes in the network are quasi-stationary.
(2) Nodes locations are unaware i.e. it is not equipped by the GPS capable antenna.
(3) Nodes have similar processing and communication capabilities and equal significance.
(4) Nodes are left unattended after deployment.

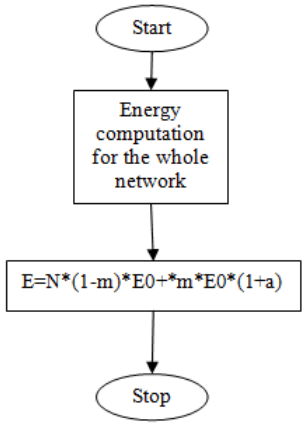
Cluster head selection is primarily based on the residual energy of each node. Since the energy consumed per bit for sensing, processing, and communication is typically known, and hence residual energy can be estimated. Intra cluster communication cost is considered as the secondary parameter to break the ties. A tie means that a node might fall within the range of more than one cluster head. [4]. When there are multiple CHs, the one with lower intra cluster communication are favored. The secondary clustering parameter, intra-cluster communication cost, is a function of (i) cluster properties, such as cluster size, and (ii) whether or not variable power levels are permissible for intra cluster communication. Each node sets its probability to become a cluster head.

3)Energy Computation:



In 2-level H-HEED protocol, two types of sensor nodes are used. They are the advanced nodes and normal nodes. Let us assume there are 'N' numbers of sensor nodes deployed in a region. E0 is the initial energy of the normal nodes, and m is the fraction of the advanced nodes, which own a times more energy than the normal ones. Thus there are m * N advanced nodes equipped with initial energy of E0, and normal nodes equipped with initial energy of E0. The total initial energy of the network is given by: *Energy = N*(1-m)*E0 + N*m*E0*(1+a) = n*E0*(1 + am) Where, E0 is the initial energy (0.5J).* [2]

So, this type of networks has 'am' times more energy and virtually am more nodes.



III. PERFORMANCE EVALUATION

From then on, we have proposed a set of performances measures. The most common evaluation measures are delay, delivery ratio, throughput and average energy. Throughput is the total no. of data packets sent per unit of time. It is the average rate of successful message delivery over a communication channel. Delay or Average latency is the average delay time of a packet between transmitting from the source and receiving at the destination. There are possible delays caused by buffering during route discovery latency and retransmission. Average Energy is the energy spent by the network. Packet delivery ratio is the rate between numbers of data packets received by the destination and the number sent by the source. It describes the percentage of the packets that reach the destination [2]. Performance of H-HEED protocol is compared with the existing protocol HEED. From that, we have found that H-HEED protocol's performance is more accurate compared to the existing protocol.

EXPERIMENTAL RESULTS

A. FIGURES AND TABLES

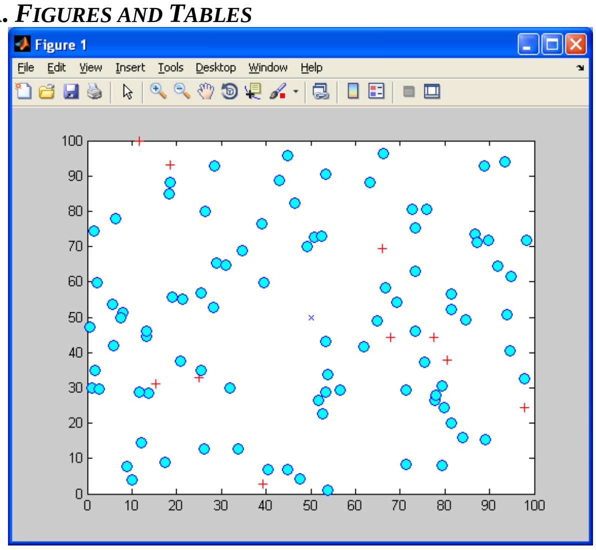


Fig 1: Random Deployment of sensor nodes

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Figure 1 represents the random deployment of sensor nodes. In this, two types of sensor nodes are shown. Normal nodes are shown in circular shape. Advanced nodes are shown as plus symbol.

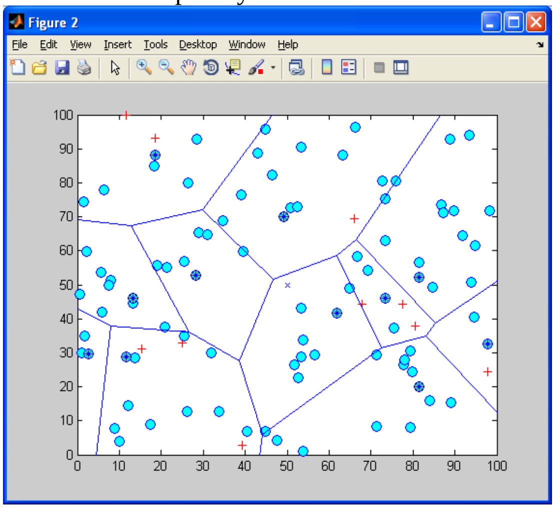

Fig 2: Cluster Formation

Figure 2 represents the cluster formation. Cluster heads are elected first. Then the nodes that are closest to the cluster head will be formed into groups.

Fig 3: Energy used by the network

Figure 3 represents the energy used by the whole network.

Table I: Delay

Protocol	Delay Vs No. of Rounds					
	0	1	2	3	4	5
HEED	2.3	3	3.3	3.8	4	4.5
H-HEED (Proposed)	0	1.5	2.3	2.7	3	3.5

Table II: Packet Delivery Ratio

Protocol	Packet Delivery Ratio Vs No. of Rounds					
	0	1	2	3	4	5
HEED	350	370	400	380	360	330
H-HEED (Proposed)	800	750	700	600	550	500

Table III: Throughput

Protocol	Throughput Vs No. of Rounds					
	0	1	2	3	4	5
HEED	1.1	1	1.05	1	0.95	0.9
H-HEED (Proposed)	1.6	1.5	1.55	1.55	1.45	1.4

Table IV: Average Energy

Protocol	Average Vs No. of Rounds					
	0	1	2	3	4	5
HEED	8	7.95	7.9	7.8	7.75	7.7
H-HEED (Proposed)	8	8.1	8	8.05	8.05	8.1

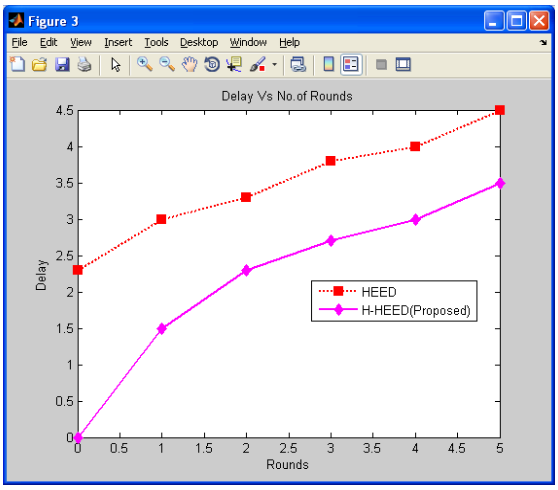

Fig 4: Delay Vs No. of Rounds

Figure 4 shows the delay for both existing (HEED) and proposed (H-HEED) protocols. For each round, the corresponding delay values are plotted. The delay is calculated in terms of the number of rounds and the delay by the system in delivering the data to the base station. The first graph shows the delay of the existing protocol and the second one represents the delay of the proposed protocol. It is clear that the delay in the proposed protocol is lesser than the existing protocol. Thus the proposed system effectively reduces the delay in delivering data to the base station.

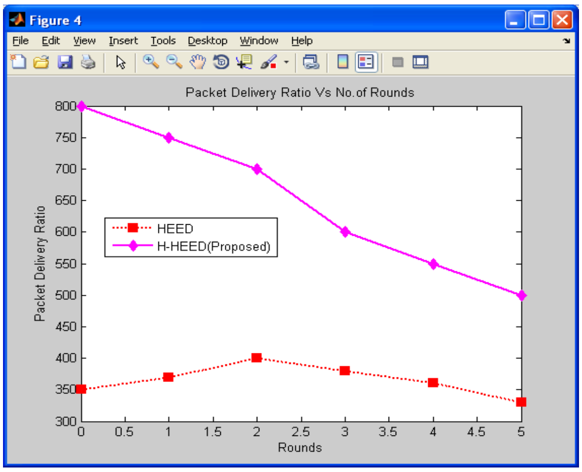

Fig 5: Packet Delivery Ratio Vs No. of Rounds

Figure 5 shows the packet delivery ratio for both existing (HEED) and proposed (H-HEED) protocol. The no. of packets delivered for each round values is plotted. The ratio between no. of packets sent by the source and no. of packets received by the destination gives the packet delivery ratio. The first graph shows the proposed protocol and the second one represents the existing protocol. It is clear that the packet delivery ratio of proposed protocol is

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higher than the existing protocol. Thus the proposed system effectively increases the packet delivery ratio.

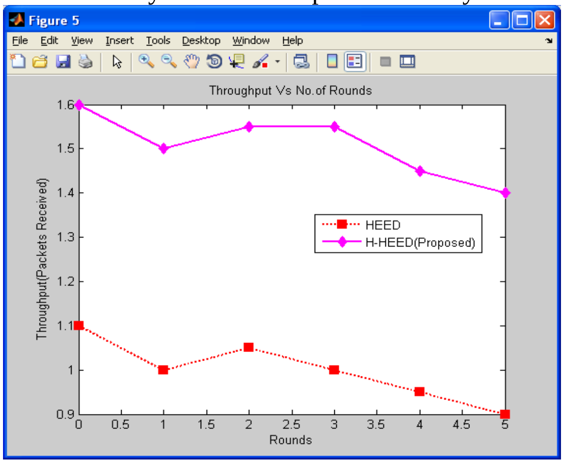

Fig 6: Throughput Vs No. of Rounds

Figure 6 shows the throughput for both existing (HEED) and proposed (H-HEED) protocol. For each round, the corresponding throughput values are plotted. Throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. This is the measure of how soon an end user is able to receive data. The first graph shows the proposed protocol and the second one represents the existing protocol. It is clear that the throughput of proposed protocol is higher than the existing protocol.

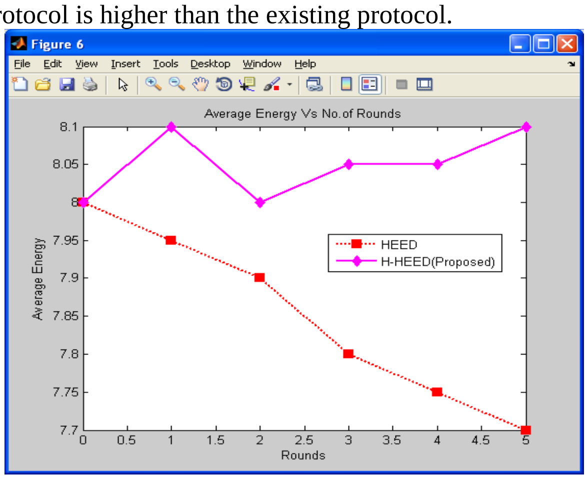

Fig 7: Average Energy Vs No. of Rounds

Figure 7 shows average energy for both existing (HEED) and proposed (H-HEED) protocol. The energy used by the system is calculated and the graph is plotted.For each round, the corresponding energy values are plotted. The first graph shows the proposed protocol and the second one represents the existing protocol. It is clear that the average energy of proposed protocol is higher than the existing protocol.

IV. CONCLUSION AND FUTURE ENHANCEMENT

In this paper, we have proposed a protocol called H-HEED protocol which improves network lifetime and energy. We have proved our idea by simulating a network of 100 nodes in MATLAB. While justifying our idea through results of our simulation we have considered the performance metrics like delay, throughput, average energy and packet delivery ratio. By using proposed technique we have increased the throughput, energy and number of packet in the network and we decreased the delay. Currently this protocol is implemented and tested in a simulation using MATLAB simulator. This work can be tested on real motes and then while considering real environment more mature results can be achieved.

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BIOGRAPHIES

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