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ASH-HEED Protocol for Heterogeneous Wireless Sensor Networks

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ABSTRACT: The Wireless SensorNetwork (WSN) consisting of a large number of sensors are effective for gathering data in a variety of environments. Sensors are usually randomly deployed where battery replacement or recharge is difficult or even impossible to be performed. In this paper, we first completely analyze the basic distributed clustering routing protocol LEACH (Low Energy Adaptive Clustering Hierarchy).The classical schemesconsider that all nodes are deployed with same amount of energy. Here we consider a heterogeneous medium, i.e. each node is provided with varying power levels called Heterogeneous - Hybrid Energy Efficient Distributed Protocol (H-HEED). Heterogeneity can be implemented by various parameters here we consider node energy as the basic parameter. Transmitting data from each node of the sensor field may lead to high power consumption and unreliable network lifetime. In order to avoid this we go for clustering and election of cluster heads. Cluster head alone transmits the aggregate data of the cluster. Theformation of the clusters and cluster head selection are done bycomparing the residual energy of the individual inevery round this improves the lifetime to a considerable level. Also we introduce a node scheduling scheme in HEED. The nodes are classified into ACTIVE and SLEEP nodes. The best solution for energy –saving is to making the nodes in sleep mode with results in power consumption.Finally the simulation result demonstrates that proposed work achieves longer lifetime and more effective data packets in comparison with the HEED and LEACH protocol**.**

KEYWORDS: Wireless Sensor Network (WSN), Network Lifetime, Heterogeneity, LEACH, H-HEED.

I. INTRODUCTION

Wireless sensor networks are wireless networks in which collection of nodes are gathered together which workscooperatively and gathers information from environment conditions in variousregions[16].Wireless sensor networks are most emerging ubiquitous technology. There is a exponential growth in usage of sensor networks in various fields of application of such as health monitoring, robotic explorations, tracking rival forces habitat monitoring, surveillance friendly forces ,control applications, ecologicalscrutiny ,estimating the traffic flows[6] [8] [9]semiconductor technology .A node in sensor network consists of CPU for data processing, memory for data storage, battery for energy and transceiver for receiving and sending signals or data one node to another node. [1, 2] Sensor network are battery dependent, mostly unattended, knotty to replace the batteries or impossible to replace the batteries and are generally deployed in the environments through aircrafts.

The sensor nodes are deployed in a sensor field. The deployment of the sensor nodes can be random, regular or mobile sensor nodes can be used and also as advancement in recent technology results in production of stumpy cost sensor mote distributionwhich results in great accuracy and consistency. The difference in deployment of sensor mote distance may be tenfeet. The positions of sensor nodes need not to be determined in prior. This characteristic of sensor networks result in disaster relief applications. [1].The very first noticeable sensor network application was the usage of SOSUS which was used during the cold war to track the submarines [15].

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The base station may communicate with the remote Controller node via Internet or Satellite Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Power control is needed to efficiently make use of the limited energy resources in order to minimize the energy consumed by the sensor nodes and thus prolong network lifetime. [3, 4].

The remainder of the paper is organized as follows. We briefly review related work. Section II describes the applications of WSN.Section III describes the related works Section IV,V describes the Network Initialization in the H-HEED protocol, cluster and cluster head formation,Section VI shows the heterogeneous WSN model of H-HEED. Section VII shows the implementation of Active and Sleep nodes. Section VIII shows the simulation results by comparing with the preceding methods.

II.APPLICATIONS

The advancement in recent technology such as sensing, micro-electro-mechanical systems(MEMS), analog and digital signal processing, real time applications, wireless communications and networking, in the past decade the wireless sensor network technology has a significant impact in the twenty-first century[10][11].

Data gathering is a crucial operation of sensor network .WSNs enable the consistent monitoring of a variety of environments such as applications that include surveillance, home security, chemical, biological detection, medical monitoring, and machine failure analysis. The otherapplications of wireless sensor network are environmentalsensing,habitat monitoring, inventorymanagement, vehicle tracking, battlefield management, etc. Furthermore, WSNs are also deployed al fresco in hefty sensor fields to support precision agriculture,smart interactive places,detecting and controlling the spread of wild fires in forest areas, and to detect structural faults [13,14].

Few of these applications are field experiments, few are commercial products, and few are advanced research projects that use sensor networks as a tool. [12]

III.RELATED WORKS

There are number of routing algorithms among this LEACH [6] Low Energy Adaptive Clustering Hierarchy protocol proposed in the year2000, is themainly popular hierarchical routing algorithms for sensor networks.

The conformist protocol for routing is clustering. The idea behind the LEACH is the formation ofself organized clustergroup with single Cluster Head (CH) based on the signal strength. In LEACH the CH are elected for each round so as to save the energy .CH are selected independently without communication overhead. In addition to save the energy data's are compressed and transmitted to consume energy. The energy is also consumed by following a schedule created by the CH, in which all the cluster sensor motes except CH move to sleep mode for all time except the transmit time.

The sensor node becomes eligible CH for the current round when the number is less than the following threshold
The threshold

$$T(n) = \begin{cases} \frac{p}{(1-p*(r \bmod 1/p)} & if\ n \in G(1) \\ 0 & otherwise \end{cases}$$

where p is the desired percentage of cluster heads (e.g. 0.05), r is = the current round, and G is the rest of nodes that have not been CH in the last 1/p rounds. The elected cluster head motes are not permanent. In LEACH there is no guarantee that CH is evenly distributed.

The Hybrid Energy Efficient Distributed clustering Protocol (HEED)[5]protocol projected in the year 2004 follows a general distributed hybrid energy clustering approach to prolong the network life time. In HEED every node acts as

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source and also as a server.Intra cluster communication is considered to increase energy efficiency and network life time. HEED uses single hop communication among CH and cluster group nodes.CH are selected based on their residual energy. The CH selection depends on hybrid of residual energy as primary parameter and communication cost as secondary parameter to achieve power balancing. HEED utilizes the iterative cluster formation algorithm. In HEED sensors assign themselves a "Cluster Head Probability" and communication cost. The CH probability is a function of nodes residual energy and communication cost is a function of neighbour'sproximity. Using CH probability, the sensor motes decide themselves whether to advertise themselves for this iteration.

In H-HEED [11] some percentage of nodes are equipped with heterogeneity. In the H-HEED the sensor motes are assigned with different levels of energy levels which prolongs the network life time. In the 2-level H-HEED two energy level sensor motes are used .These two energy level sensor motes are named as advance and normal nodes . There are 30% of advance nodes and others are normal nodes in the network. The energy levels of advance nodes are 150% greater than normal nodes.

In the 3-level H-HEED three energy level sensor motes are used and in multilevel various energy levels sensor motes are used.These three level sensor motes are named as super, advance and normal nodes. The advance node equipped in the network remains same as that like 2-level H-HEED .There are 20% of super nodes in 3-level H-HEED .The energy level of of super nodes will be 150-300% higher than that of normal nodes .The H-HEED out performs better than HEED and LEACH.

IV.NETWORK INITIALIZATION OF ASH-HEED

In this section, we describe our network model which includes some of the initialization of the sensor motes and initial setting of energy parameters. Thereforeit is necessary to generate a random distribution of these nodes in the L * L m^2 of the region. Random 100- node topology for a 100 * 100 m^2. Sink is located at (50, 50). Fig. 1 demonstrates the wireless sensor network initialization.

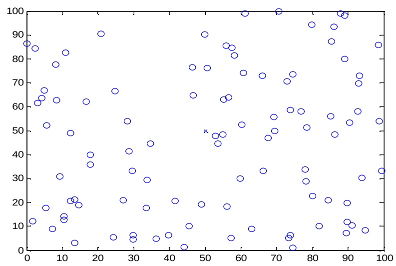

Fig.1 Random deployment of nodes

V.CLUSTER AND CLUSTER HEAD FORMATION

Sensor node are densely deployed in wireless sensor network in the physical environment which produces very similar data in close by sensor node and transmitting such type of data is more or less redundant. Compact data's are transmitted which are gathered from various distributed sensor in the network. This results in reduction of traffic in whole network. Clustering is a process of grouping the sensor nodes .The data congregated from the cluster group are compressed and send to the destination.

Issues of clustering in wireless sensor network: (a) how many sensor nodes should be taken in a single cluster Selection procedure of cluster head in an individual cluster? (b) Heterogeneity in a network, it means user can put some power full nodes, in term of energy in the network which can behave like cluster head and simple node in a cluster work as a cluster member only. Many protocol and algorithm have been proposed which deal with each individual issue. Following assumptions are made regarding the network model is:
1. Nodes in the network are quasi-stationary.
2. Nodes locations are unaware i.e. it is not equipped by the GPS capable antenna.

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3. Nodes have similar processing and communication capabilities and equal significance.
4. Nodes are left unattended after deployment

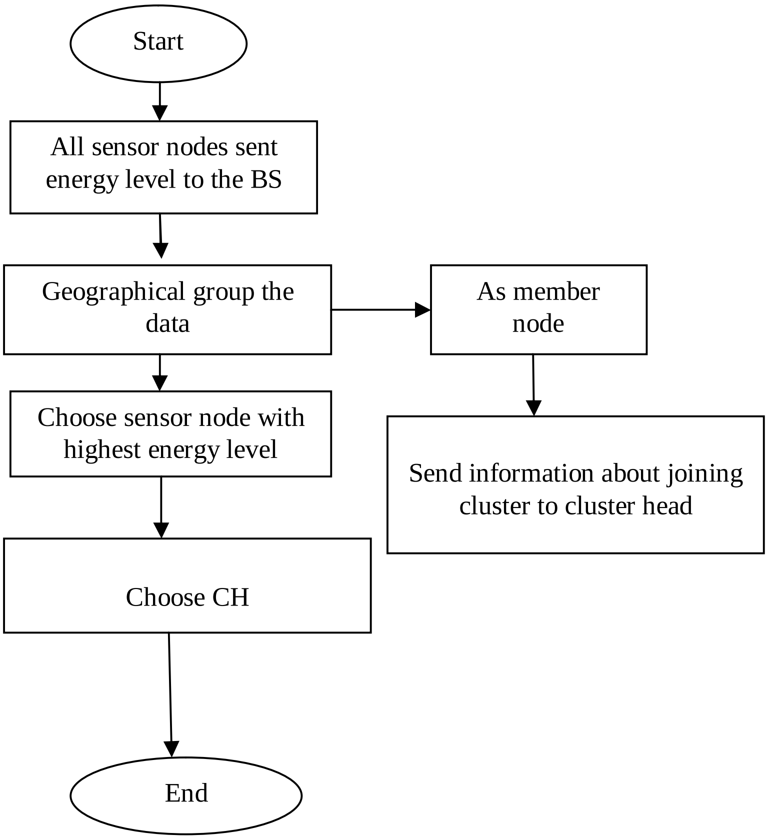

Fig.2 Cluster head selection process

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. If the power level used for intracluster communication is fixed for all nodes, then the cost can be proportional to (i) , if the requirement is to distribute load among cluster heads, or (ii) , if the requirement is to create dense clusters. This means that a node joins the cluster head with minimum degree to distribute cluster head load or joins the one with maximum degree to create dense clusters. Each node performs neighbour discovery, and broadcasts its cost to the detected neighbours. Each node sets its probability of becoming a cluster head, CH_{prob}, as follows:

$$CH_{prob} = \max\left(C_{prob} * \left(\frac{E_{residual}}{E_{max}}\right), P_{min}\right) \quad (2)$$

VI.HETROGENOUS WSN MODEL

In this section we describe our model of a wireless sensor network with nodes heterogeneous in their initial amount of energy. We particularly present the setting, the energy model, and how the optimal number of clusters can be computed. Let us assume the case where a percentage of the population of sensor nodes is equipped with more energy resources than the rest of the nodes. Let mbe the fraction of the total number of nodes n, which are equipped with α times more energy than the others. We refer to these powerful nodes as advancednodes, and the rest (1-m)*nas normalnodes. We assume that all nodes are distributed uniformly over the sensor field.

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2 level H-HEED:

In 2-level H-HEED protocol, two types of sensor nodes, i.e., the advanced nodes and normal nodes are used. Let us assume there are 'N' numbers of sensor nodes deployed in a field. *E0* is the initial energy of the normal nodes, and mis the fraction of the advanced nodes, which own atimes more energy than the normal ones. Thus there are m * *N* advanced nodes equipped with initial energy of, $E_o * (1 + a)$ and (1-m)*E_0 normal nodes equipped with initial energy of *E0*. The total initial energy of the network is given by:

$$E_{total} = N * (1 - m) * E_0 + N * m * E_0(1 + a)$$

$$= N * E_0 * (1 + am) \quad (3)$$

3-level H-HEED:

There are three types of sensor nodes, i.e. the super nodes, advanced nodes and the normal nodes. Let *m*be the fraction of the total number of nodes *N*, and *m0* is the percentage of the total number of nodes *N * m* which are equipped with β times more energy than the normal nodes, called as the super nodes, the number is *N * m *m0*. The rest *N *m * (1-m0)* nodes are having a times more energy than the normal nodes, being called as advanced nodes and the remaining *N * (1-m)* nodes are the normal nodes. *E0* is the initial energy of the normal nodes. The energy of the each super node is$E_o(1 + \beta)$ and the energy of each advanced node is$E_0(1 + a)$

The total energy of the network is given by:

$$E_{total} = N * (1 - m) * E_0 + N * m * (1 - m_0) * E_0(1 + a) + N * m * m_0 * E_0(1 + \beta) (4)$$

$$E_{total} = N * E_0(1 + m * (a + m_0 + \beta)) (5)$$

So, the total energy of the network is increased by the factor of $1 + m * (a + m_0 * \beta)$

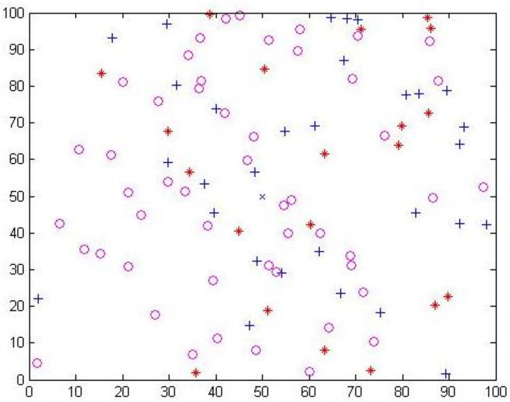

Fig.3 Deployment of 3 level H- HEED

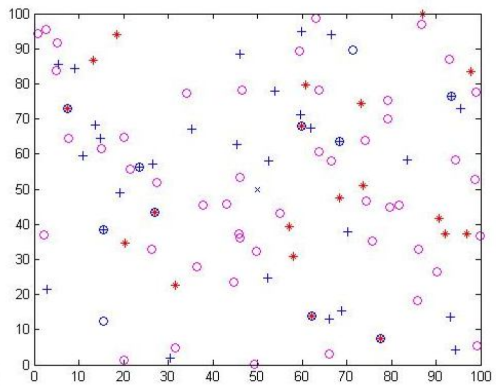

Fig.4 Cluster head selection in 3 levels H-HEED

+ = Advanced node , O = Normal node , * = Super node, ⊕ =cluster head

VII.ACTIVE AND SLEEP NODES

In this node scheduling the total available residual energy is equally distributed and the cluster head also elected as per the residual energy comparison. Only thing is whenever the node is under sleep mode in each cluster it consumes very small energy. Here the total rounds are increased by doing both changing of sleeping and active modes and the available energy is distributed in a balanced manner. By properly doing the node scheduling in each cluster with proper time interval, the total energy consumed is low and the total lifetime of the wireless sensor network is increased near to 50%, when compared with the normal LEACH.

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VIII.SIMULATION RESULTS

The simulation is done in MATLAB. Let us assume the heterogeneous sensor network with 100 sensor nodes are randomly distributed in the 100m*100m area. The base station is located at the centre (50, 50). We have set the minimum probability for becoming a cluster head (*pmin*) to 0.0001 and initially the cluster head probability for all the nodes is 0.05. The parameters used in our simulation are listed in the Table 1.

Parameters	Values	Parameters	Values
Sink	At(50,50)	Energy consumed by the amplifier to transmit at a short distance, E_{fs}	10 pJ/bit/m^2
Threshold distance, d_0	70 m	Energy consumed by the amplifier to transmit at longer distance, E_{mp}	0.0013 pJ/bit/m^4
Cluster radius	25 m	Data Aggregation Energy, E_{DA}	5 nJ/bit/signal
Energy consumed in the electronics circuit to transmit or receive the signal, E_{elec}	50 nJ/bit	Message Size	4000 bits

Table.1 Simulation parameters

In the analysis, we use the same energy model as proposed in [6]. In the process of transmitting an l-bit message over a distance d, the energy expended by the radio is given by:

$$E_{TX(l,d)} = E_{TX-elec}(l) + E_{TX-amp}(l,d)$$

$$= f(x) = \begin{cases} lE_{elec+}lE_{fs}d^2 \\ lE_{elec+}lE_{fs}d^4 \end{cases} (6)$$

And to receive the message, the radio expends:

$$E_{RX}(l) = E_{RX-elec}(l)$$

$= lE_{elec}(7)$

There are other factors like collision, noise, and physical obstacles may affect the received power are ignored. We have introduced the advanced nodes to the HEED protocol, so as to assess the performance of HEED protocol in the presence of heterogeneity. Let us consider the case for 2-level H-HEED, 30% of the nodes are advanced nodes (m=0.3) and equipped with 150% more energy than normal nodes (a=1.5). For 3-level H-HEED, 30% of the nodes are advanced nodes and 20% of the nodes are super nodes are equipped with 150% and 300% more energy than the normal nodes (a=1.5 and b=3, m=0.5 and m0=0.4). For multilevel H-HEED, each node in the sensor network is randomly assigned different energy between aclosed set [0.5, 2]

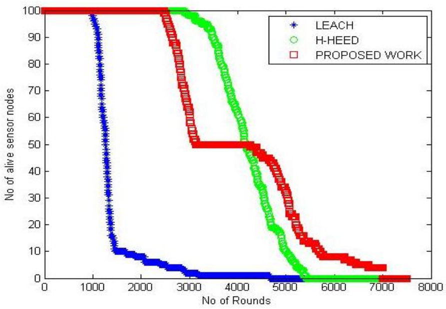

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Fig.5 Simulated output

In Fig. 5, a detailed view of the behaviour of HEED and H-HEED protocol is illustrated; it shows the number of alive nodes per round. The number of nodes death in HEED is more than H-HEED over the same number of rounds. The number of normal nodes dies very fast and as a result the sensing field becomes sparse very fast. On the other hand, due to the higher energy than the normal nodes the advanced nodes and super nodes die slowlyBut in multi-level H-HEED, all the sensor nodes are having different energy as a result nodes will die randomly. In this we can say that multi-level H-HEED prolongs lifetime and shows better performance than other level of H-HEED and HEED protocol. Figure 5 represents the total remaining energy of the network in each round. In this both HEED and H-HEED, the energy depletes very fast at constant rate. We can conclude that both 3-level H-HEED and multi-level H-HEED is more energy efficient.

IX.CONCLUSIONS

In this paper, H-HEED protocol is proposed along with active and sleep node implementation for heterogeneous wireless sensor network. Different level of heterogeneity: 2-level and 3-level are introduced in terms of the node energy with active and sleep mode. We have evaluated the performance of the proposed H-HEED with HEED protocol using MATLAB 7.10. It is observed that there is significant improvement in the lifetime in case of H-HEED protocol in comparison with HEED protocol because the number of rounds is maximum with H-HEED.

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