A New Approach of Unequal Clustering in Wireless Sensor Networks

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***Abstract*—Energy conservation is a central parameter for design of WSNs. In major scenarios, the nodes nearer to the base station are quickly devastated by entire network traffic. Such nodes' energy fades rapidly, the network gets partitioned causing frequent topology variations. In general, sensor network possess equal size clusters throughout the network, which on other go cause elimination nodes on cluster formation due to coverage issues. This locates into hot spot problem. In this paper, we address equal clustering problem to resolve energy conservation. The proposed work presents an unequal clustering approach that enhances the network life time at low cost of energy in wireless sensor networks.**

Keywords: Wireless Sensor Networks, Unequal Clustering, Energy efficient Routing.

I. INTRODUCTION

Wireless Sensor Networks are deployed in area where human intervention is impossible like habitat monitoring, landslide and forest fire detection etc. Fundamental issues in design of WSNs are expanding the network lifetime and high energy consumption because the nodes are battery operated. The tiny sensors are powered with limited battery which cannot be recharged. To overcome these critical demands, numerous techniques were proposed in recent times on network protocols, in network data fusion algorithms, energy aware routing and locating optimal sink location, etc.

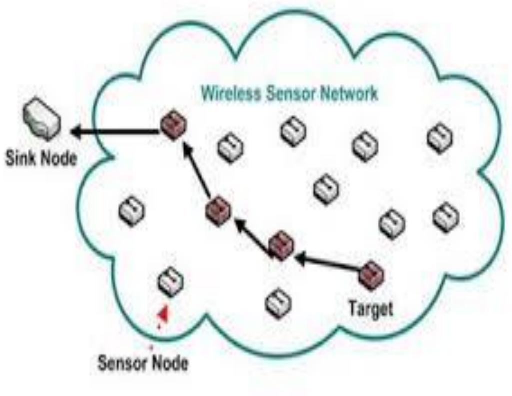

Fig 1. Wireless Sensor Network

This paper converge to an idea on energy efficient unequal clustering algorithm and inter-cluster routing which equalizes the energy utilization of the network using least distance multiple hop technique and improves the network lifetime. Existing algorithms employ different techniques in association with energy efficient routing using multiple data sink and cluster formation.

Gooals need to be concentrated on network protocol design are:

- Prolonging the lifetime of the Wireless sensor network by evenly distributing energy consumption.
- Selecting cluter-heads in a constant iteration process.
- Minimization of overhead.
- Formation of well-distributed cluster heads and compact clusters.

II. RELATED WORK

Different cluster-based routing protocols for WSNs aim at balancing the energy consumption of nodes at different locations of network.

A. LEACH:

LEACH [1, 2] is the first energy- efficient hierarchical clustering algorithm for WSNs proposed for reducing power consumption. The operation of LEACH breaks down into rounds, with two phases. During the setup phase, clusters are structured; during the steady state phase, data transmission is performed. LEACH achieves minimized communication cost between sensors and their CHs and turning off non-CH nodes as much as possible [3]. LEACH becomes unstable during the set-up phase due to non-deterministic duration of setup phase. LEACH uses single hop routing where each node can transmit directly to the CH and the BS. Therefore, it is not applicable to networks deployed in large scale applications.

B. TL-LEACH:

Two-Level LEACH (TL-LEACH)[4] is a proposed extension to the LEACH algorithm. It utilizes two levels of cluster heads (primary and secondary) in addition to the other simple sensing nodes. In this algorithm, the primary cluster head in each cluster communicates with the secondary, and the corresponding secondary communicate with the nodes in their sub-cluster. Data-fusion is also performed as in LEACH.

C. IBLEACH:

Intra-balanced LEACH (IBLEACH)[5], extends LEACH protocol by balancing the energy consumption in the network, and energy gap between the CHs and CMs by calculating the overhead energy for the CHs and CMs. This protocol provides energy consumption balancing over all sensor nodes in each cluster. Here, the IBLEACH is divided into rounds and each round is divided into three phases, Setup, Pre-Steady and the Steady State as shown in figure 2. In the pre-steady phase it calculates the cluster workload (includes the aggregation of data from cluster members and sending the aggregated data to the BS) in one frame, then elect CM that can handle the aggregation processes through all frames in the round. If not exist such node, elect CMs that can handle the aggregation processes for each frame in the round and the CH will handle the aggregation process for frames that do not have aggregators.

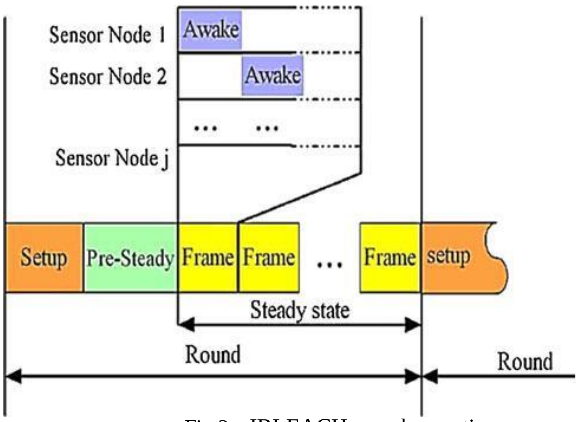

Fig 2. IBLEACH round operation

Some algorithms address this constraint through unequal clustering, has been proposed by researchers, e.g. EEUC [3], UCA [5] EECS [6],etc.

D. EECS:

In Energy Efficient Clustering Scheme(EECS) [6], a distance-based cluster formation method is proposed to produce clusters of unequal size in single hop networks. A weighted function is introduced to let clusters farther away from the base station have smaller sizes,thus some energy could be preserved for long-distance data transmission to the base station.

E. UCA:

In unequal Clustering Algorithm(UCA)[7], author propose balance the energy consumption among cluster heads. Clusters closer to the sink have smaller sizes than those farther away from the sink,thus cluster-heads closer to the sink can preserve some energy for the purpose of inter-cluster data forwarding. Furthermore,the Minimum Energy Consumption (MEC) multi-hop routing protocol for the inter-cluster communication.

F. UCS:

Unequal Clustering Size (UCS)[8], model analyze an approach where the network is organized into clusters of different sizes. The energy consumed on intra-cluster communication changes proportionally with the number of nodes within a cluster, while the energy spent on inter-cluster communication (i.e., forwarding data from other clusters) is a function of the expected load from the clusters further away. Therefore, by changing the number of nodes in every cluster with respect to the expected relay load, can maintain more uniform energy consumption among the cluster heads, so that the total energy dissipated for every cluster head is similar, achieving uniform energy dissipation.

G. EEUC:

Energy-efficient unequal clustering (EEUC)[9], proposed to balance the energy consumption among clusters, in which the cluster sizes near the sink node are much smaller than the clusters far away from the sink node in order to save more energy in intra-cluster communications and inter-cluster communications. Here, it prolongs the network lifetime and to balance the load among the nodes.

Protocol being a distance based scheme, hence requires every node to have global knowledge relating to the sink node. It resolves the hot spot issues by placing cluster size proportional to the distance to base Station. It is disadvantageous on multi hop network, the extra global data aggregation adds overheads to all sensors and degrades the network performance.

H. EEHC:

Energy Efficient Hierarchical Clustering (EEHC)[10] is a distributed, random clustering algorithm for WSNs. Cluster heads aggregate data and report to the base-station. This technique is divided into two phases; initial and extended. In the first stage, also called single-level clustering, each sensor node attempts to CH on its own probability p. These CHs are named as the volunteer CHs. Nodes within k hops of a CH receive this announcement. Nodes that receive such announcements and not a CH joins the closest cluster head. Forced CHs are nodes that are neither CH nor belong to a cluster. No announcements reach them on a preset time interval t, they may be k hops away, the node becomes forced CH. The second phase, called multi-level clustering builds h levels of cluster hierarchy. The algorithm ensures h-hop connectivity between CHs and the base station. In inter-cluster communication, follows over LEACH[1], dissipating energy of nodes near base station.

Famous strategy for eliminating the first wave nodes of base station was to configure the clusters structure such that the clusters that closer to BS has smaller radius than the outer ones. This idea can derived from Shu et al.[11].

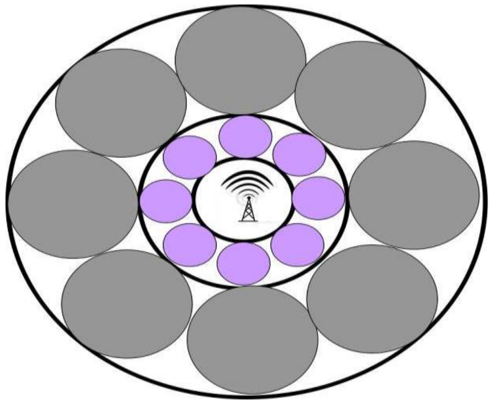

Fig 3. Cluster Distribution

We analyze an approach where network is organized into varying size clusters. Cluster head spends its energy both on inter-cluster and intra-cluster communication. The energy consumed on intra-cluster communication changes proportionally with the number of nodes within a cluster, while the energy spent on inter-cluster communication is a function of the expected load from the clusters further away. Therefore, by changing the number of nodes in every cluster with respect to the expected relay load, uniform energy consumption can be maintained among the cluster heads, so that the total energy dissipated for every cluster head is similar. The criteria above again would prove energy balancing over the network through shortest distance relay scheme.

III. PROPOSED PROTOCOL

The proposed work makes an energy management technique to unequal clustering in WSN. A set of nodes are randomly deployed as the network topology shown in figure 3.

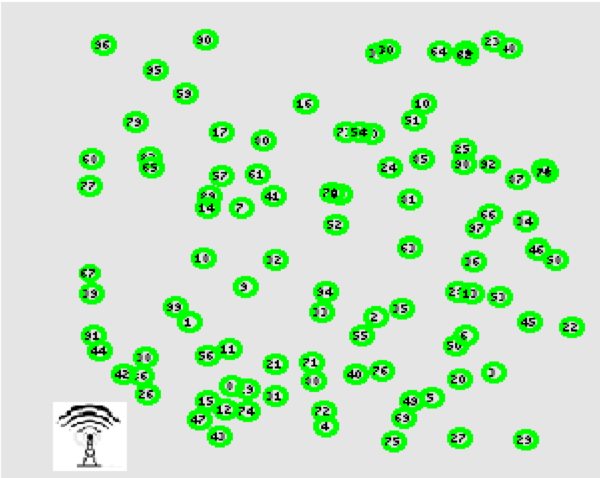

Fig 3. Random Topology

Different from other approaches, we employ a transmission control technique. Control coverage parameter, RSSI can be used for cluster formation. The algorithm of proposed protocol is shown in figure 5.

Cluster Head Selection:

Initially, based on the distance from base station, the waves of different range are considered for clustering. Each node in the network generates a random number and estimates its eligiblity to become cluster head based on probability. Node satisfying the criteria joins the competition to become cluster head. Every node has a competition scope for formation of cluster.

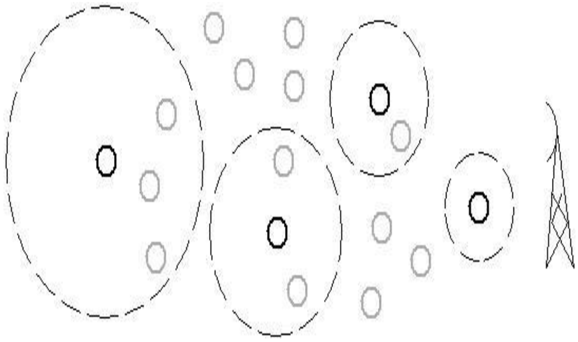

Fig 3. Node Scope

Node Scope:

Nodes placed near to the base station on first hop are considered first wave nodes which may usually drain quickly. When the cluster head selection is being done, the nodes that occur as highest energy of all nodes' energy, possibly becomes the primary cluster head, gaining the ability to make transmissions to base station. Nodes having higher energy being less compared to primary head becomes secondary cluster head that aggregates the transmitted data from the cluster nodes.

Cluster Head Rotation:

Based on predefined percentage, CHs rotation is done. When the CH's energy gets lower than any other node in the cluster, a request for CH rotation is made. Identifying the node that has highest energy, the cluster head rotation process begins. CH drops as there are nodes in the cluster possessing higher energy node than itself and hence, declares higher energy node as next cluster head.

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Final Process:

After the efficient cluster head selection procedures, nodes sense data. Data is then gathered at the heads and transmitted to the base station through TDMA schedule as like LEACH process.

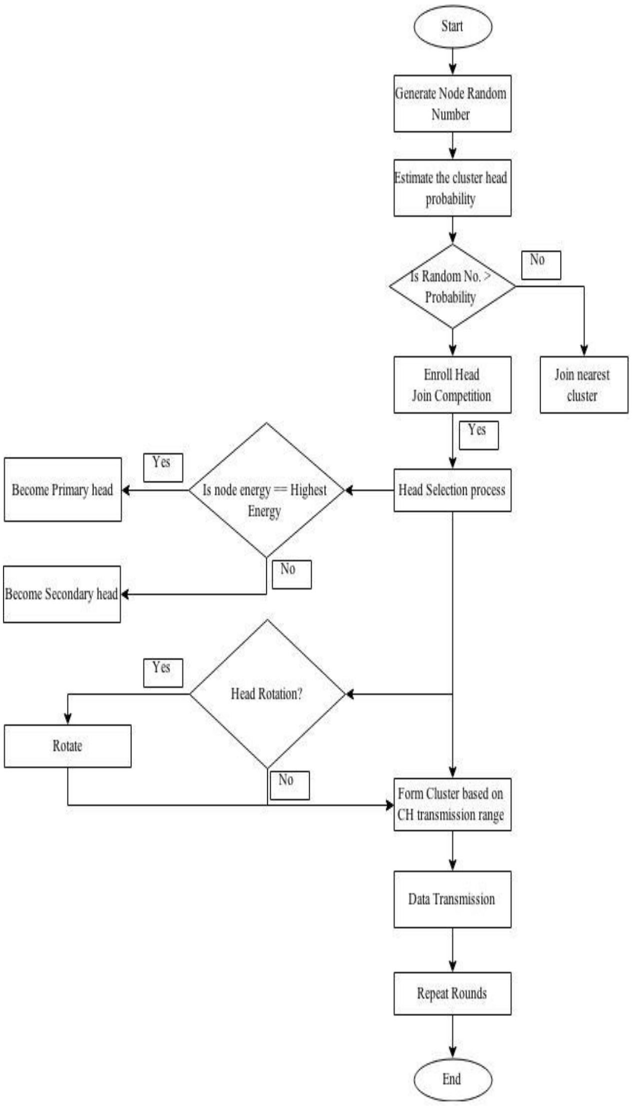

Fig 4. Algorithm of proposed work

IV. RESULTS

Compared to LEACH protocol, the algorithm would perform better as the secondary nodes may perform the cluster operations, reducing the burden of primary cluster heads. Primary nodes may sustain long reducing the need for frequent cluster head rotations.

Obtained network performance was compared to LEACH protocol in terms of Energy consumption and Network lifetime. Comparison results of both protocol are shown in figures below.

Figure 6 shows reduced energy consumption performance of the proposed protocol being higher than the LEACH protocol.

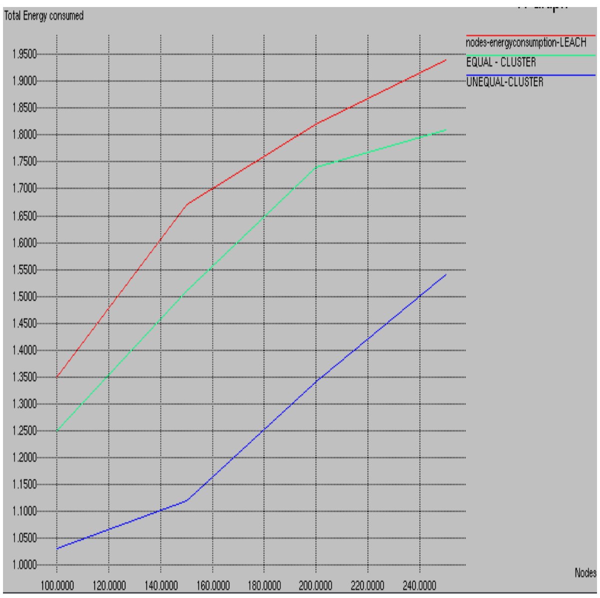

Fig 5. Energy Consumption Performance

Figure 7 shows proposed protocol having reduced rate of dead nodes as the network operates, increasing the life time when compared to LEACH protocol.

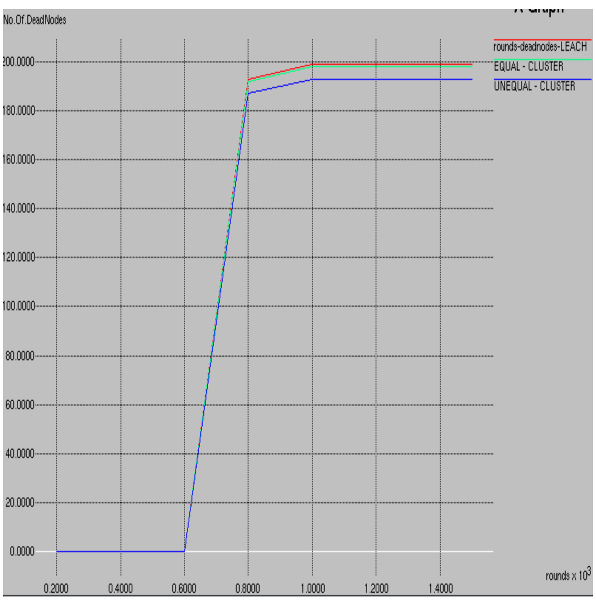

Fig 6. Network Lifetime Performance

From the above outputs, it can also be inferred that the network performance was increased through unequal clustering than equal clustering.

V. CONCLUSION

In the work presented, an improvement over LEACH protocol was obtained through unequal clustering and reducing the burden of cluster heads. This obtains increased network lifetime. An extension can be made through circular clustering obtaining an high performance network that could eliminate hot spot issues in future.

VI. REFERENCES

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