AUTONOMIC MULTI-HOP COST-BASED ENERGY EFFICIENT BALANCED ROUTING STRUCTURE FOR WIRELESS SENSOR NETWORKS

Navnita Sakharkar
MTech. (Scholar)

Kusum Sharma
Assistant Professor

Anil Kumar Pandey
Assistant Professor

RSR Rungta College of Engineering & Technology, Bhilai, Chhattisgarh, INDIA

Abstract: WSN is highly interested area of research in nowadays. when particular purpose needs to achieve in a non-reachable area by human there, we placed sensing devices in wireless mode. But the problem is sensors has a limited resource as memory, energy, bandwidth. In network various nodes, cluster head, one sink. Furthermore, hot spots in a WSNs emerge as locations under heavy traffic load. Nodes in such areas quickly drain energy resources, leading to disconnection in network services. Cluster based routing algorithms in WSNs have recently gained increased interest, and energy efficiency is of particular interest. A cluster head (CH) represents all nodes in the cluster and collects data values from them. To balance the energy consumption and the traffic load (hotspot) in the network, the CH should be rotated among all nodes and the cluster size should be carefully determined at different parts of the WSNs. From past research [18 and 19], We have considered the problem of hop-based communication, network overhead, stability issues, location awareness, appropriate utilization of network heterogeneity, optimum election probability, cost, localization issues, multi-hop communication and higher energy consumption within local regions of network along with total lifetime of network etc. This research work proposed an optimum cluster based solution for routing in WSN, our protocol utilize node location, sensor density, distance of nodes from BS, distance between individual sensors, energy values (residual energy, initial energy, average energy, total network energy), connectivity density etc. for global decision within network (Optimum election of Heads). Optimum value of cost function will be decided through our proposed multi-objective Genetic Algorithm. In this paper we purpose energy efficient protocol which is based on LEACH.

Keywords: Wireless sensor network; Energy efficient routing; Heterogeneous network; Network Stability; Location Based Routing; Connectivity Density; Distance from BS; Energy Distribution, Optimum Network Design; Multi-hop communication.

1. Introduction

I. Overview:

Beyond the established technologies such as mobile phones and WLAN, new approaches to wireless communication are emerging being the ad-hoc and sensor networks one of the most notorious and interesting for their potential applications.

The interest in the research and development of WSNs is due to their numerous advantages in front of other wireless technologies. They are easier, faster and cheaper to deploy than wired networks or other forms of wireless networks. They have a large coverage area and longer range. In addition, they have higher degree of fault tolerance than other wireless networks since a failure of one or few nodes does not affect the operation of the network. Another feature of these networks is that they are mostly unattended to, and finally, they are self-configuring or self-organizing.

Sensor devices in WSNs monitor the same event and report on them to the base station. Therefore, one good approach is to consider that sensors located in the same region of the network will transmit similar values of the attributes. This fact notices inherent redundancy in the node transmissions that may be used by the routing protocol.

I. TYPES OF WSN:

No.	NW Type	Description
1	Proactive networks	It provides a snapshot of the relevant parameters at regular intervals. They are well suited for applications requiring periodic data monitoring
2	Reactive networks	react immediately to sudden and drastic changes in the value of a sensed attribute. They are well suited for time critical applications.
3	Hybrid networks	not only react to time-critical situations, but also give an overall picture of the network at periodic intervals in an energy efficient manner. It enables the user to request past, present and future data from the

		network in the form of historical, one-time and persistent queries respectively.

II. CHALLENGES:

- Due to energy constraints, a sensor node can but communicate directly with other sensors within a limited distance, Multi-hop communication is required. In order to enable communication between sensors out of each other's communication range, sensors form a multi-hop communication network. Utilizing clustering algorithm to form a hierarchical network topology is the accustomed realizing scenario of network management and data aggregation for WSNs, and clustering facilitates the distributed control of the network. Moreover, clustering nodes into groups not only saves energy but also reduces network contention when nodes communicate their data over shorter distances to their respective cluster-heads.
- Tree based structures developed through graph theory is limited with the real time position and resource status of individual device. Therefore, clustering or grouping of wireless devices is necessary in current research area.
- Wireless sensor networks are quite diverse from general wireless networks due to various constraints and highly application unambiguous nature of WSNs. Consequently, WSNs pose different research challenges. In wireless communication system, the representations for signal strength drop over a distance are well developed. Effects of signal reflection, scattering and fading are well understood.
- In a tangible WSN, cost and other application specific issues affect the communication properties of the system. For example, radio communication in WSN is of low power and petite range compared to any other wireless communication network. The system performance characteristics vary considerably in WSN even though the same basic doctrines of wireless communication network are used in WSN.
- The size, power, cost and their trade-offs are fundamental constraints in WSNs. Bearing in mind the basic differences with the wireless communication systems, many issues have been identified and investigated. Energy awareness is critical, especially in situations where it is not imaginable to replace sensor node batteries so it is essential design issue in wireless sensor networks.
- Most sensor network applications aim at monitoring or detection of phenomena likes office building environment control, wildlife habitat monitoring, and forest fire detection. Network Efficiency is a key consideration when deploying Wireless Sensor Networks. We had seen in literatures that an efficient encroachment is needed from a long time in routing schemes of wireless sensor network and this is considered to be a major problem in wireless sensor network.
- The base problem area considers that the Network Head near the base station also forward or relay the data from other cluster heads along with its own sensed data (all clusters need to communicate with the base station, but long-distance wireless communication consumes more energy), and as we all know, too many members in a cluster may bring about excessive energy consumption in management and communication.
- As NH is closer to the base station, so energy consumption is higher as NHs relay data from other cluster heads (cluster data) also. Moreover, there's No clear way presented in base paper that how much NH should take to get optimum results.
- This research work introduces the problem of electing cluster heads based on ranking and cluster formation. We propose that, the cluster formation is totally depends upon the head selection within network. Furthermore, network density is more important as compare to any other parameter, and distance from base station should use to elect the head so as to provide longevity to the network besides forming clusters with it. Also, election of head from certain constraints need some optimization scheme for appropriate and optimum election of heads in network.
- Base paper algorithm considers the stability issues based on NH and the location and distance of the nodes, trying to build a more balanced clustering structure. This research work introduces the problem of electing cluster heads (NH are also introduced after electing heads) and cluster formation.
- The election probability of NN, IN and AN are different in base paper but this is the worst concept proposed by the author because there's no criteria of distinguish between these types of nodes (way of detection of nodes attributes).
- The basic idea of Base work is based on the network heterogeneity in terms of energy distribution and selection of cluster heads are depends upon the ratio of energy heterogeneity and some constant parameters but for optimum election of cluster heads we should consider some other parameters or real time attributes like density of network, distance of a node from base station, location, residual energy with respect to networks average energy, initial supplied energy with respect to total energy, distance from other nodes etc.
- During communication period, CHs were sending only their distance to BS information to the other CHs for NH selection. But at a certain stage, CHEERS binds every node to send to the BS a message when it has depleted energy enough to reach half of a reference energy value. The BS then broadcasts this information. Every node receives this information and knows the first half death has occurred in the network. This process should be autonomic as it increases the overall energy dissipation in proposed network environment.
- Scheme Proposed in base paper is completely a multi-hop communication scheme, It means after NH are elected from number of CHs, a CH is not able to communicate directly with BS whether it is closer to BS than NH.
- The concept of normal node, intermediate node and advanced node is failed if network is homogeneous. Furthermore, after a certain period if all high residual energy nodes are dead due to overload, we are not able to elect NH from CHs. Hence, past works fails to follows a distributed approach to build hierarchical structure in self-organizing mode without central control.
- In base paper, the selection of head node is not dependent on its previous selection as a head. But, Number of times a sensor node u become head is $H(u)$ should be directly proportional to election probability. Means, if a node becomes cluster head earlier, then its chances to become a head increases. This concept should be use to increase the stability of network.
- It is clear that, concept of NH decreases the stability of network widely and author introduces a cost-based criterion (based on residual energy level) to control the variation in energy.
- Furthermore, Base work does not introduce any criteria for the size of clusters (number of member nodes in associated with a head node within a cluster). This also affect the results.

- Base paper used the concept of heterogeneity before starting of communication. But as we know after stating communication, every sensor transmits different data to different distances. Hence there will be a difference of values of energy for every sensor node after stating the communication.
- Author proposed a multi-hop communication scheme but there's no plan of considering the connectivity density of network. Means, availability of connected hops to the base station is very important to control the loss of packets.
- In base work the probability P of selection for head is considered to be a fixed user defined value. Means certain variation in value of P can change the results. As a system designer, our aim is to find the optimum value of P at which results are maximum and problems are minimized (we should use some optimization algorithm to define this optimum value of probability).
- Base work uses an Additive mathematical expression for the selection of head node, but relations doesn't put on a direct impact on selection.
- x represents the proportion of the intermediate nodes in n number of nodes defined by specific application, but the load balancing criteria dependent upon these parameters and affect the selection of head completely. Most importantly, this x unbalanced the selection criteria of normal and advanced nodes.
- The cluster head gathers the cost of all member nodes, and then selects the node with minimum cost as the next head node. In this way, the communication costs are increased. The re-electing of cluster head occurs in the 'old' cluster, in this case if an elected head doesn't have sufficient energy, then packets of whole cluster are dropped.
- The base work written that, the simulation result shows that the algorithm is feasible and has superior performance. In addition, the scenario they propose is scalable and works for different network sizes. But, the reality is they didn't show thorough results in details. Results are presented only in terms of lifetime. No other parameters are used to represent the quality of service.
- In base work, the head selection is a load balancing architecture as per the author but after analysing we can conclude that it is a local decision. Decision should not be taken with respect to an individual sensor. In base work, residual energy of a sensor is compared with its own initial energy for the head selection.
- In many work, how much number of head which can be elect in a single round can also be a problem. The base work not consider this problem.
- Concept of localization consume more energy rather than Euclidean distance calculation expression for distance calculation between nodes.
- Energy awareness is critical, mainly in situations where it is not imaginable to replace sensor node batteries so it is essential design issue in wireless sensor networks. We should take care of each and every aspect related to network resources for better survivability.

2. LITERATURE REVIWE

i) DIRECT TRANSMISSION

In Direct Communication Protocols, any node can send information to the BS directly. When this is applied in a very large network, the energy of sensor nodes may be drained quickly. Its scalability is very small. SPIN is an example of this type of protocol.In the case of Flat Protocols, if any node needs to transmit data, it first searches for a valid route to the BS and then transmits the data.Nodes around the base station may drain their energy quickly. Its scalability is average. Rumour Routing is an example of this type of protocol.

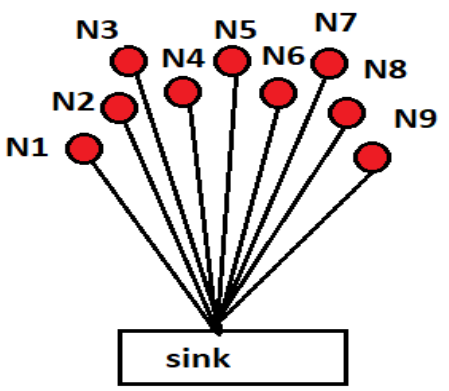
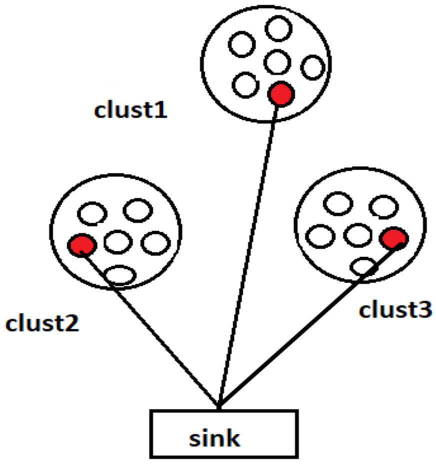


FIG: DIRECT TRANSMISSION

ii) CLUSTER BASED.

According to the clustering protocol, the total area is divided into numbers of clusters. Each and every cluster has a cluster head (CH) and this cluster head directly communicates with the BS. All nodes in a cluster send their data to their corresponding Cluster Head. The Threshold sensitive Energy Efficient sensor Network (TEEN) is an example of a clustering protocol.



iii) RADIO ENERGY DISSIPUTION MODEL

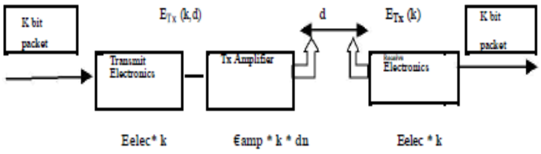


Fig. 2 Radio energy dissipation model

$$E_{TX}(k,d) = \{K \times E_{elec} + K \times \epsilon_{fs} \times d^2, \text{ if } d \leq d_0$$
$$K \times E_{elec} + K \times \epsilon_{mp} \times d^4, \text{ if } d \geq d_0 \text{ - - -}$$
(Eqn1)

iv) LIMITATIONS OF PREVIOUS PROTOCOL

1]W.R. Heinzelman, A.P. Chandrakasan, and H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks", Proceedings of the 33rd Hawaii International Conference on System Sciences (IEEE), January 2000.

The basic idea of LEACH has been an inspiration for many subsequent clustering routing protocols. The main objective of LEACH is to select sensor nodes as CHs by rotation, so the high energy dissipation in communicating with the BS is spread to all sensor nodes in the network. Any node that served as a CH in certain round cannot be selected as the CH again, so each node can equally share the load imposed upon CHs to some extent. Utilizing a TDMA schedule prevents CHs from unnecessary collisions. Cluster members can open or close communication interfaces in compliance with their allocated time slots to avoid excessive energy dissipation.

Limitations in LEACH as follows.

It performs the single-hop inter-cluster, directly from CHs to the BS, routing method, which is not applicable to large-region networks. It is not always a realistic assumption for single-hop inter-cluster routing with long communication range. Besides, long-range communications directly from CHs to the BS can breed too much energy consumption. Despite the fact that CHs rotation is performed at each round to achieve load balancing, LEACH cannot ensure real load balancing in the case of sensor nodes with different amounts of initial energy, because CHs are elected in terms of probabilities without energy considerations. Sensor nodes, with lower initial energy, that act as CHs for the same number of rounds as other sensor nodes, with higher initial energy, will die prematurely. This could bring about energy holes and coverage problems. Since CH election is performed in terms of probabilities, it is hard for the predetermined CHs to be uniformly distributed throughout the network. Thereby there exist the elected CHs that are concentrated in one part of the network and some nodes that have not any CHs in their vicinity. The idea of dynamic clustering brings extra overhead. For instance, CH changes and advertisements may diminish the gain in energy consumption.

[2] A. Manjeshwar and D.P. Agarwal, "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks" In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, 2001.

- Threshold sensitive Energy Efficient sensor Network protocol (TEEN), proposed by Anjeshwar and Agrawal, is a hierarchical protocol whose main goal is to cope with sudden changes in the sensed attributes such as temperature. The protocol combines the hierarchical technique in line with a data-centric approach. The nodes sense their environment continuously, but the energy consumption in this algorithm can potentially be much less than that in the proactive network, because data transmission is done less frequently. Based on the two thresholds, data transmission can be controlled commendably, *i.e.*, only the sensitive data we demand can be transmitted, so that it reduces the energy transmission consumption and improves the effectiveness and usefulness of the receiving data. TEEN is complement for reacting to large changes in the sensed attributes, which is suitable for reactive scenes and time critical applications.

Limitations in TEEN as follows:

- It is not suitable for periodic reports applications since the user may not get any data at all if the values of the attributes may not reach the threshold;
- There exist wasted time-slots and a possibility that the BS may not be able to distinguish dead nodes from alive ones, because only when the data arrive at the hard threshold and has a variant higher than the soft threshold did the sensors report the data to the BS;
- If CHs are not in the communication range of each other the data may be lost, because information propagation is accomplished only by CHs.

[3] Arati Manjeshwar, Dharma P. Agrawal, "APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks", Parallel and Distributed Processing Symposium. Proceedings International, IPDPS 2002

- The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN), introduced by Manjeshwar and Agrawal, is an extension to TEEN and aims at both transmitting periodic data and reacting to time critical events.
- APTEEN, on the other hand, is a hybrid protocol that changes the periodicity or threshold values used in TEEN according to the requirement of users and the type of the application.
- APTEEN is based on a query system which allows three types of queries: historical, on-time, and persistent which can be used in a hybrid network.
- Moreover, QoS requirements are introduced for the on-time queries and minimum delay is achieved by a TDMA schedule with a special time slot assignment manner.
- The distinctive feature of APTEEN is to switch between proactive and reactive modes to transmit data. All nodes sense the environment continuously, but only those nodes which sense a data value at or beyond the hard threshold permit transmitting. The characters and advantages of APTEEN include: APTEEN combines both proactive policies, which is alike that of LEACH, and reactive policies, which is alike that of TEEN. Accordingly, it is suitable in both proactive and reactive applications; It embodies a lot of flexibility by setting the count-time interval, and the threshold values for the energy consumption can be adjusted by changing the count time as well as the threshold values.

The main Limitations of APTEEN are as follows:

- There exists additional complexity required to implement the threshold functions and the count time;
- Actually, both TEEN and APTEEN share the same drawbacks of additional overhead and complexity of cluster construction in multiple levels, implementing threshold-based functions, and dealing with attribute-based naming of queries—APTEEN more than TEEN.

[4] Stephanie Lindsey, Cauligi S. Raghavendra, "PEGASIS: Power-Efficient Gathering in Sensor Information Systems", Aerospace Conference Proceedings, 2002. IEEE (Volume: 3)

- Power-Efficient Gathering in Sensor Information Systems (PEGASIS), proposed by Lindsey *et al.*, is an improvement of LEACH. The main idea of PEGASIS is for each node to only communicate with their close neighbours and take turns being the leader for transmission to the sink.
- In PEGASIS, the locations of nodes are random, and each sensor node has the ability of data detection, wireless communication, data fusion and positioning. Energy load is distributed evenly among the sensor nodes in the network.
- The nodes are organized to form a chain, which can either be concentratedly assigned by the sink and broadcast to all nodes or accomplished by the nodes themselves using a greedy algorithm.
- During the process of chain formation in PEGASIS, it is assumed that all nodes have global knowledge of the network and the greedy algorithm is employed. The chain construction is commenced from the furthest node from the sink and the closest neighbour to this node will be the next node on the chain.

Some Limitations in PEGASIS:

- It is the necessity of having a complete view of the network topology at each node for chain construction and that all nodes must be able to transmit directly to the sink. Thus, this scheme is unsuitable for those networks with a time varying topology;
- It is assumed that each sensor node can be able to communicate with the sink directly, but nodes usually use multi-hop communications with the sink in practical cases.
- Furthermore, long-range communications directly from the node to the sink can breed too much energy consumption;
- The communication manner suffers from excessive delays caused by the single chain for distant nodes and a high probability for any node to become a bottleneck;
- It is a difficult task for all nodes to maintain a complete database about the location of all other nodes in the network, furthermore the network is not very scalable because all nodes must have global knowledge of the network and employ the greedy algorithm.

[5] O. Younis and S. Fahmy, "HEED: A hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," IEEE Trans. Mobile Computing, vol. 3, no. 4, Dec. 2004.

Hybrid Energy-Efficient Distributed clustering (HEED), introduced by Younis and Fahmy, is a multi-hop WSN clustering algorithm which brings an energy-efficient clustering routing with explicit consideration of energy.Different from LEACH in the manner of CH election, HEED does not select nodes as CHs randomly. The manner of cluster construction is performed based on the hybrid combination of two parameters. One parameter depends on the node's residual energy, and the other parameter is the intra-cluster communication cost. In HEED, elected CHs have relatively high average residual energy compared to MNs.Additionally, one of the main goals of HEED is to get an even-distributed CHs throughout the networks. Moreover, despite the phenomena that two nodes, within each other's communication range, become CHs together, but the probability of this phenomena is very small in HEED.

There are some limitations with HEED as follows:

- The use of tentative CHs that do not become final CHs leave some uncovered nodes.
- As per HEED implementation, these nodes are forced to become a CH and these forced CHs may be in range of other CHs or may not have any member associated with them. As a result, more CHs are generated than the expected number and this also accounts for unbalanced energy consumption in the network;
- Similar to LEACH, the performing of clustering in each round imposes significant overhead in the network.
- This overhead causes noticeable energy dissipation which results in decreasing the network lifetime;
- HEED suffers from a consequent overhead since it needs several iterations to form clusters. At each iteration, a lot of packets are broadcast.
- Some CHs, especially near the sink, may die earlier because these CHs have more work load, and the hot spot will come into being in the network.

[6] L. Qing, Q. Zhu, and M. Wang, “Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks,” Computer Commun., 2006.

Distributed energy-efficient clustering protocol (DEEC), proposed by Qing *et al.*, is a distributed clustering algorithm similar to HEED. The main objective of DEEC is to improve HEED by building balanced cluster sizes and optimize the intra-cluster topology using location awareness of the nodes. Both DEEC and HEED share some similarities including no assumptions about network size and density, and considering residual energy in the process of CH election. Every node implements DEEC individually and the algorithm ends after several iterations that are implemented in a distributed manner. Different from LEACH and HEED, DEEC creates a multi-level structure for intra-cluster communication and limits a parent node's number of children. Moreover, the only locally calculated parameter weight is defined for CH election in DEEC. After locating the neighbouring nodes in its area, each node calculates its weight.

Some Limitations of DEEC are summarized as follows:

Similar to LEACH, single-hop inter-communication, directly from CHs to the BS, is performed in DEEC.Thus DEEC may result in significant amount of energy consumption, and is not applicable to large-region networks. In the process of cluster formation, the iterative nature in both DEEC and HEED produces a relatively high control message overhead compared to other protocols.

3. Of Autonomic Cost-Based Multi-hop Energy Efficient Balanced Routing Structure For Wsn

I. INTRODUCTION:

The objective of this proposed work is to deal with scrutinizing the initialization and routing strategy of previous energy efficient clustering protocol for wireless sensor networks maintaining the power awareness of network, for efficient transmission in wireless sensor networks. The proposed work emphasis on wireless sensor network to be energy-efficient in order to elongate the battery lifetime and network lifetime as a consequence. In most application scenarios the replacement of failed or depleted network nodes is not an option since they are placed in hazardous zones. Thus it is extremely important that nodes consume the minimum amount of energy in order to increase the lifetime of the network as much as possible, i.e. the time the application is still working properly.

The proposed work focuses on wireless sensor network to be energy-efficient in order to elongate the battery lifetime and network lifetime as a result. In most application scenarios the replacement of failed or depleted network nodes is not an option since they are placed in hazardous zones. Thus it is enormously important that nodes consume the minimum amount of energy in order to increase the lifetime of the network as much as possible, i.e. the time the application is still working appropriately. The Proposed work is going to develop some routing strategies which will fairly overwhelmed the previous work done in the field of routing in wireless sensor networks. In points, we can describe the main objective as

- Design a protocol for more Load balancing of energy in network architecture. Utilize location of sensors, connectivity density (availability of sensors near head with respect to average sensor distance) and distance from the base station for optimum election of cluster head and cluster formation.
- Use some intelligence to improve the selection of communication heads in Multi-hop communication and clustering. We should use residual energy with respect to average energy in network to make the selection global.
- Increased connectivity and reduced delay in routing and Adaptive clustering based on network density. Minimal cluster count, increase throughput and intelligent optimization of clustering solution. Maximal network longevity and stability period in almost all worst circumstances.

ii. ARCHITECTURE OF PROTCOL

a. Multi-Hop Communication

Proposed work rejected the concept of network heads as it increases the overall network overhead and energy dissipation, this work uses a novel concept of optimum connected path calculation which is use when a CH is far away from the BS and it will utilize the connected path to forward data to serving base station. This path is only use if we are getting the value of cost function optimum for routing. Heads are elected only if they are closer to BS.

b. Stability

It is well-known that; a network is only stable if the communicating devices/nodes survives for a longer period. In order to increase the lifespan of network, the election of heads should be optimum in terms of energy and other real-time geographical parameters. Moreover, the clustering or *election probability should be directly proportional to more stable nodes or nodes which are already elected as head earlier and having a sufficient amount of energy.*

c. Sleep Mode

Sleep-mode is basically a power-saving mode of operation in which devices or parts of devices are switched off until needed. We have used it in proposed work to save energy. Broadcasting of additional messages from nodes should be avoided in proposed Work.

d. Distance Vector Calculation

To avoid extra energy dissipation in node localization (distance calculation) process, proposed Work uses Euclidean distance formulation for calculation of distance between individual devices and distance of devices from the Base Station.

Let assume that position of node in cell is (x_n, y_n). It can be well-defined distance between node i & the other node (x_c, y_c) as:

$$D_{[i]} = \sqrt{(x_c - x_n)^2 + (y_c - y_n)^2}$$

e. Global Decision

In proposed Work, There's No criteria for selection probability for individual nodes, a global selection strategy is used to select a node as cluster head whether it is advanced node with higher energy or a normal node with lower energy.

f. *Autonomic Process*

The Clustering and Cluster head selection process is completely autonomic based on Optimum cost calculated by genetic algorithm. Also, the objectives or fitness function of cost is depending upon some efficiency attributes like energy, location, distance etc.

g. Cluster formation

For very member sensor which is not a cluster head, we have to compare its distance from all the CHs. Next we have to find out the minimum distance CH and minimum distance cluster for the allotment of member node. Hence, size of cluster is optimum and is depends upon real-time position and capability of network nodes.

h. One Protocol One formulation

Proposed routing procedure follow a systematic procedure to overcome multi-objective problems proposed in [18], this work doesn't introduce many expressions for selection of nodes. This should be done on the basis of location, distance, capability and cost of individual nodes. For example, *Zain Murtaza* in [18] propose a concept of network head which are selected from number of cluster heads and CHs are selected from advanced nodes to perform a multi-hop communication practice, these NH are selected from CHs closer to BS and close link with other CHs with better residual energy level. Broadcasting of energy level then cost of communication and other things are calculated by author after this procedure. To make the process simplest, we have selected CHs, which already have a higher residual energy globally and which are closer to BS, which are also closer to other CHs and that too in a denser area with more member's nodes around and this process is autonomic for each round.

III. WORKING OF PROTOCOL

The operation of LEACH -AC is broken up into rounds, where each round begins with a set-up phase, when the clustersare organized, followed by a steady-state phase, when data transfers to the base station occur. In order to minimize overhead, the steady-state phase is long compared to the set-up phase.

1. Advertisement Phase

Initially, when clusters are being created, each node decides whether or not to become a cluster-head for the current round. This decision is based on the suggested percentage of cluster heads for the network (determined a priori) and the number of times the node has been a cluster-head sofa. This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold(n), the node becomes a cluster-head for the current round. The threshold is set as:

$$T(s) = \begin{cases} \dfrac{p}{1 - p\left(r \bmod \left(\frac{1}{p}\right)\right)} & \text{if } s \in G \\ 0 & \text{otherwise} \end{cases}$$

where P = the desired percentage of cluster heads (e.g.,
P = 0:05), r = the current round, and G is the set of nodes that have not been cluster-heads in the last 1-P rounds. Using this threshold, each node will be a cluster-head at some point within 1-P rounds. During round 0 (r = 0), each node has a probability P of becoming a cluster-head. The nodes that are cluster-heads in round 0 cannot be cluster-heads for the next 1-P rounds. Thus, the probability that the remaining nodes are cluster-heads must be increased, since there are fewer nodes that are eligible to become cluster-heads. After 1-P1 rounds, T = 1 for any nodes that have not yet been cluster-heads, and after 1-P rounds, all nodes are once again eligible to become cluster-heads. Future versions of this work will include an energy-based threshold to account for non-uniform energy nodes. In this case, we are assuming that all nodes begin with the same amount of energy and being a cluster-head removes approximately the same amount of energy for each node. Each node that has elected itself a cluster-head for the current round broadcasts an advertisement message to the rest of the nodes. For this "cluster-head-advertisement" phase, the cluster-heads use a CSMAMAC protocol, and all cluster-heads transmit their advertisement using the same transmit energy. The non-cluster-head nodes must keep their receivers on during this phase of set-up to hear the advertisements
of all the cluster-head nodes. After this phase is complete, each non-cluster-head node decides the cluster to which it will belong for this round. This decision is based on the received signal strength of the advertisement. Assuming symmetric propagation channels, the

cluster-head advertisement heard with the largest signal strength is the cluster-head to whom the minimum amount of transmitted. energy is needed for communication. In the case of ties, a random cluster-head is chosen.

2. Cluster Starting Phase

After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits this information back to the cluster-head again using a CSMA MAC protocol. During this phase, all cluster-head nodes must keep their receivers on.

3. Schedule Formation

The cluster-head node receives all the messages for nodes that would like to be included in the cluster. Based on the number of nodes in the cluster, the cluster-head node creates a TDMA schedule telling each node when it can transmit. This schedule is broadcast back to the nodes in the cluster.

4. Data Transmission phase

Once the clusters are created and the TDMA schedule is fixed, data transmission can begin. Assuming nodes always have data to send, they send it during their allocated transmission time to the cluster head. This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster-head advertisement). The radio of each non-cluster-head node can be turned off until the node's allocated transmission time, thus minimizing energy dissipation in these nodes. The cluster-head node must keep its receiver on to receive all the data from the nodes in the cluster. When all the data has been received, the cluster head node performs signal processing functions to compress the data into a single signal. For example, if the data are audio or seismic signals, the cluster-head node can beamform the individual signals to generate a composite signal. This composite signal is sent to the base station. Since the base station is far away, this is a high-energy transmission. This is the steady-state operation of LEACH networks. After a certain time, which is determined a priori, the next round begins with each node determining if it should be a cluster-head for this round and advertising this information,

5. Multiple Clusters

The preceding discussion describes how the individual clusters communicate among nodes in that cluster. However, radio is inherently a broadcast medium. As such, transmission in one cluster will affect (and hence degrade) communication in a nearby cluster. each cluster communicates using different CDMA codes. Thus, when a node decides to become a cluster-head, it Chooses randomly from a list of spreading codes. It informs all the nodes in the cluster to transmit using this spreading code. The cluster-head then filters all received energy using the given spreading code. Thus, neighbouring clusters' radio signals will be filtered out and not corrupt the transmission of nodes in the cluster.
Efficient channel assignment is a difficult problem3, even when there is a central control centre that can perform the necessary algorithms. Using CDMA codes, while not necessarily the most bandwidth efficient solution, does solves the problem of multiple-access in a distributed manner.

6. Hierarchical Clustering

The version of LEACH described in this paper can be extended to form hierarchical clusters. In this scenario, the cluster-head nodes would communicate with "super-cluster head" nodes and so on until the top layer of the hierarchy, at which point the data would be sent to the base station. For larger networks, this hierarchy could save a tremendous amount of energy. In future studies, we will explore the details of implementing this protocol without using any support from the base station, and determine, via simulation, exactly how much energy can be saved.

4. Simulation Result & conclusion

i. Performance parameters:

Both LEACH and AMHCB are simulated using MATLAB. The parameters taken into consideration while evaluating AMHCB and LEACH are as follows.

- Round Number vs Number of Dead Nodes (with variation of probability)
- Round Number vs Average Energy of Each node (with variation of probability)
- Round Number vs Number of Dead Nodes (with variation of number of nodes)
- Round Number vs Average Energy of Each node (With variation of number of nodes)

To simplify the simulation of these protocols few assumptions are made. They are as follows:

- Initial energy of nodes is constant.
- Nodes are static
- Nodes are assumed to have a limited transmission range after which another equation for energy dissipation is used

- Homogeneous distribution of nodes.

Details of the simulation environment are mentioned in Table 1, given below:
Table 1: Simulation Details

No.	Components	criteria
1.	Simulation Area	100*100
2.	Base Station Location	(150,50)
3.	Channel Type	Wireless Channel
4.	Energy Model	Battery
5.	Transmission Amplifier Efs Emp	10*0.000000000001 0.0013*0.000000000001
6.	Data Aggregation Energy	5*0.000000001
7.	Transmission Energy, ETx Receiving Energy, ERX	50*0.000000001 50*0.000000001

ii. Simulation result while comparing with leach:

a) Simulation of protocols at 0.05 probability

The below set of results represent the simulation of both LEACH and AMHCB protocols at 0.05 probability that is the percentage of total nodes which can become cluster head is 5% of the total number of nodes.

Implementation Results of Protocols for 0.5 Probabilities with number of Dead node vs round no.

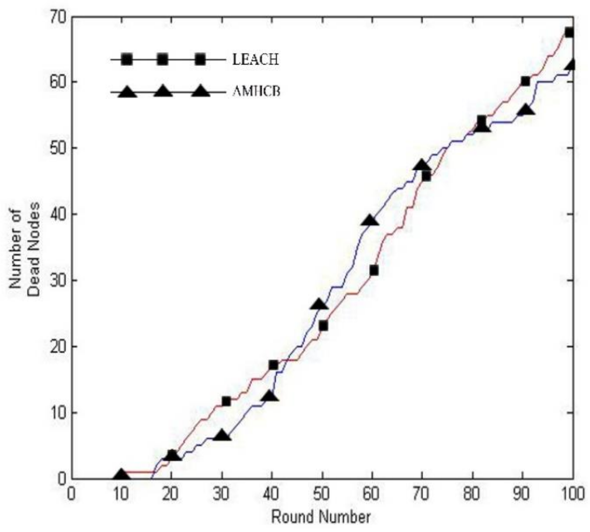


Fig:1 100N

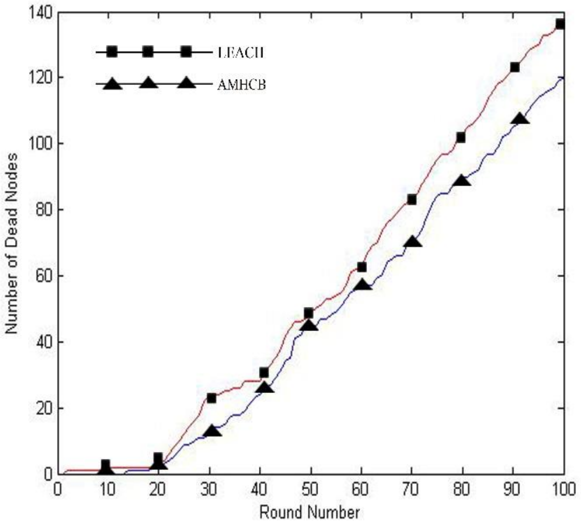
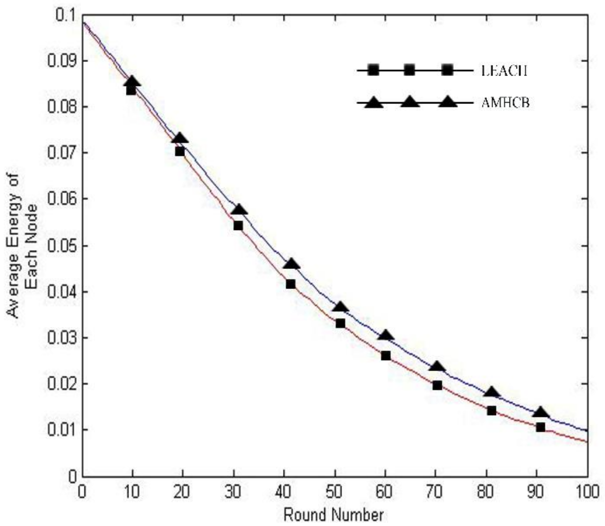


Fig:2 200N



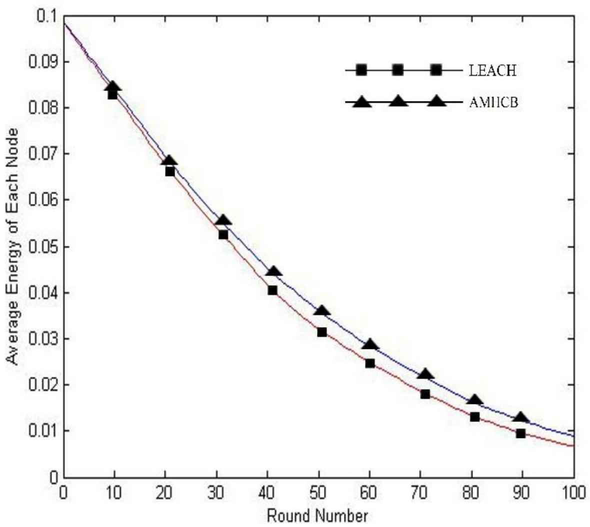


Fig:4 200N

Implementation Results of Protocols for 0.5 Probabilities with average energy of each node vs round no.

b) Simulation of Protocols at 0.1 probability

The above set of results represent the simulation of both LEACH and AMHCB protocols at 0.1 probability that is the percentage of total nodes which can become cluster head is 10% of the total number of nodes.

Implementation Results of Protocols for 0.1 Probabilities with number of Dead node vs round no.

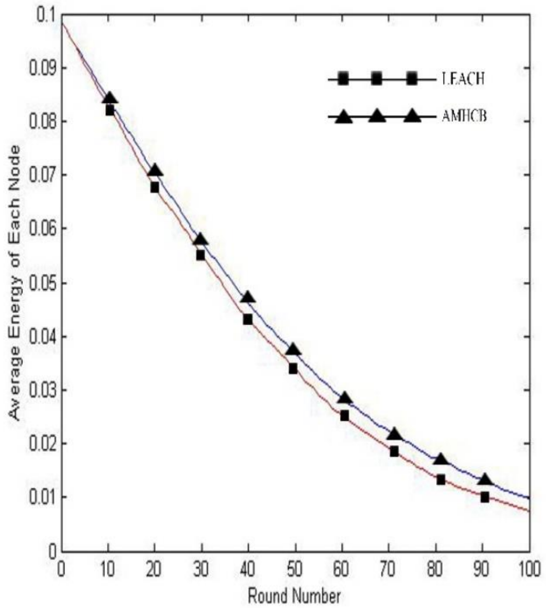


Fig:5 100N

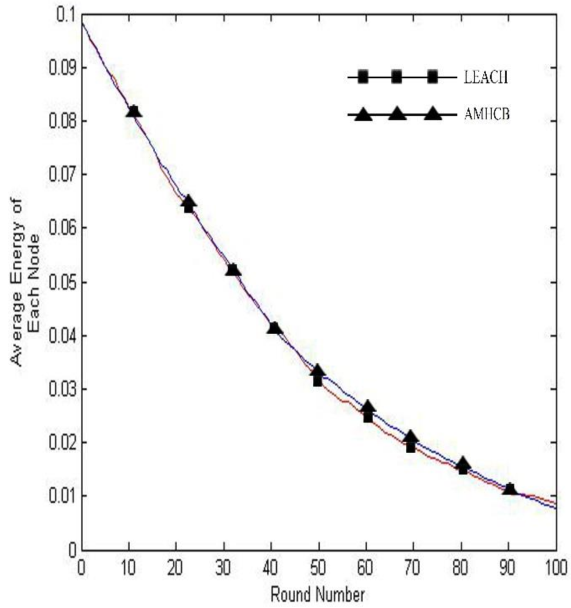


Fig:6 200N

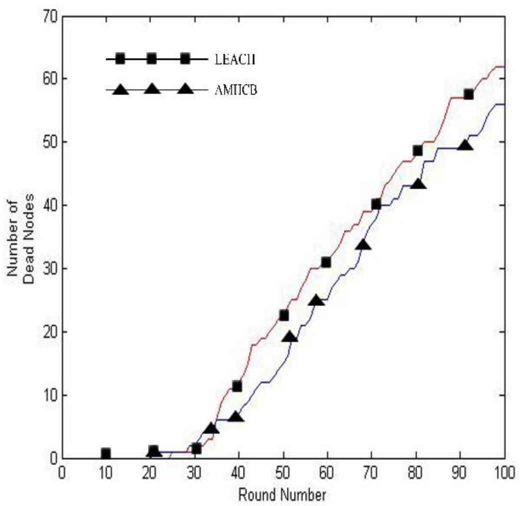


Fig:7 100N

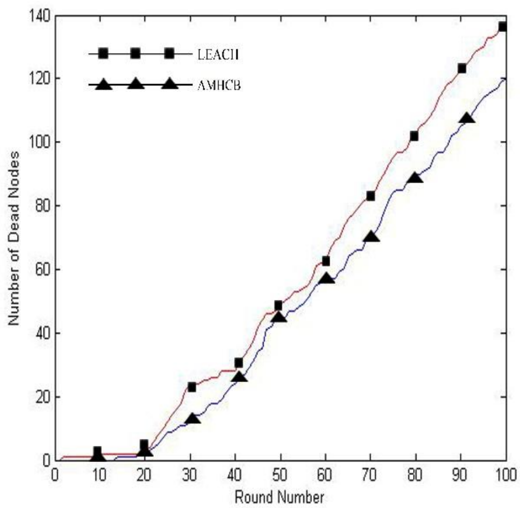


Fig:8 200N

Implementation Results of Protocols for 0.1 Probabilities with average energy of each node vs round no.

c) Simulation of Protocols at 0.2 probability

The below set of results represent the simulation of both LEACH and AMHCB protocols at 0.2 probability that is the percentage of total nodes which can become cluster head is 20% of the total number of nodes

Implementation Results of Protocols for 0.2 Probabilities with number of Dead node vs round no.

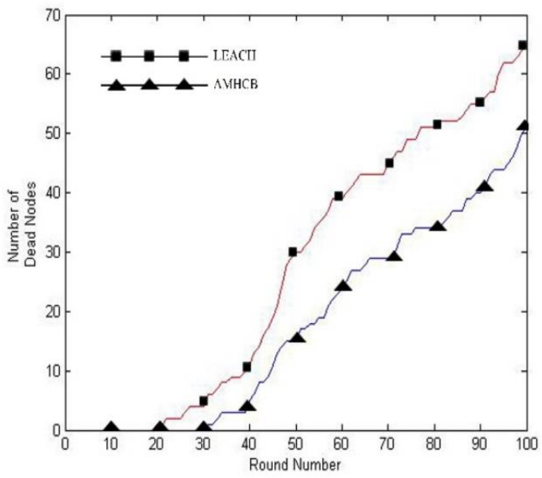


Fig:9 100N

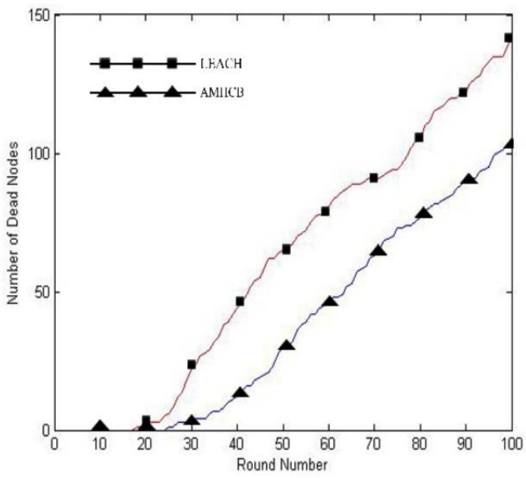


Fig:10 200N

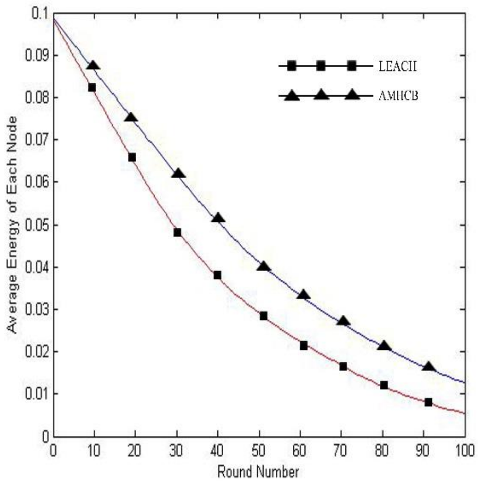


Fig:11 100N

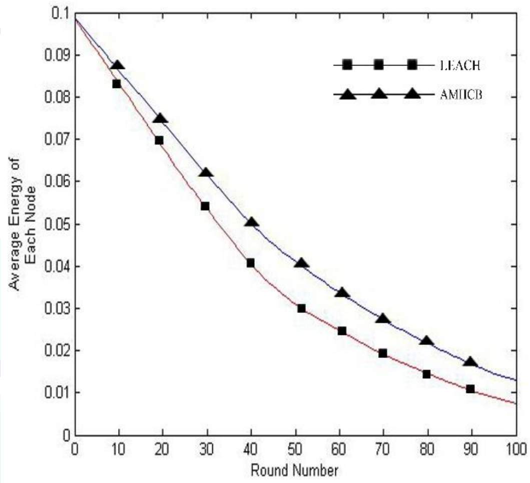


Fig:12 200N

Implementation Results of Protocols for 0.2 Probabilities with average energy of each node vs round no

d) Conclusion:

- Figures 1 and 2represent the comparison of LEACH and AMHCB protocols for the number of dead nodes against the round number elapsed for 100 and 200 nodes respectively. From Figure 2 we observe that, the number of dead nodes with the simulation of LEACH protocol is almost as comparable to number of dead nodes in AMHCB protocol. However as the number of nodes increase, we observe from Figure 2 that AMHCB results in lesser number of dead nodes after the completion of 100 rounds when compared to LEACH.
- Figures 3 and 4 represents the average energy of each node as the round progresses for LEACH and AMHCB protocols. In Figure 3 the average energy of each node after 100 rounds is almost equal for both AMHCB and LEACH whereas AMHCB performs better in Figure 4.
- Figures 5 and 6 represents the comparison of LEACH and AMHCB protocols for the number of dead nodes against the round number elapsed for 100 and 200 nodes respectively for a cluster head probability of 0.1. In all the figures we can observe that after a total of 100 rounds the number of dead nodes resulting from AMHCB protocol is less than the number of dead nodes resulting from LEACH protocol.
- Figures 6 and 7 represents the average energy of each node as the round progresses for LEACH and AMHCB protocols for the cluster head selection probability of 10% or 0.1. We observe from the figures that the average energy of each node using AMHCB protocol after 100 rounds is better in all scenarios of different nodes when compared to LEACH.
- Figures 8 and 9 represents the comparison of LEACH and AMHCB protocols for the number of dead nodes against the round number elapsed for 100 and 200 nodes respectively for a cluster head probability of 0.2. We observe in Figure 8 with a simulation of a total of 50 nodes that the number of dead nodes after 100 rounds is 29 and 30 respectively for LEACH and AMHCB protocols. LEACH protocol performs slightly better than AMHCB when the number of nodes is 5 , whereas as the number of nodes increases, we observe from Figure 8 that AMHCB outperforms LEACH in all the scenarios.

- Figures 9 and 10 represents the average energy of each node as the round progresses for LEACH and AMHCB protocols for the cluster head selection probability of 20% or 0.2. From Figure 10, we observe that the average energy of each node curve for both AMHCB and LEACH is very close after 100 rounds, where in AMHCB energy is slightly better than LEACH. From Figures 9 and 10 we observe that the energy gap of the curves of AMHCB and LEACH vary significantly with AMHCB outperforming LEACH protocol.

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