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A POWER EFFICIENT ROUTING SCHEME IN WSN: IMPLEMENTING GREEN NETWORKS WITH EAMMH PROTOCOL

Sakshee Srivastava

Communication Engineering, Galgotias University,

ABSTRACT: *Wireless Sensor Networks consist of small nodes with sensing and computation, communication capabilities. Wireless network are highly dependent on specific application and are constrained by energy, storage capacity and power. To increase the lifetime of networks, energy awareness is essential consideration if we analyze routing protocols. Routing protocols of sensor networks are responsible for maintaining the routes in the network. Wireless sensor networks are generally battery limited deployed in remote and crucial areas where continuous monitoring is essential. One of the main design issues for such a network is conservation of the energy available in each sensor node. Increasing network lifetime is important in wireless sensor networks. Wireless distributed sensor network consists of randomly deployed wireless sensors having low energy assets. These networks can be used for monitoring in a variety of environments. Major problem of these networks is energy constraint and lifetime, so, to overcome these problems different routing protocols and clustering techniques have been introduced. The proposed scheme describes a new way to select the Cluster head. Analysis shows that the extended version or enhanced LEACH protocol balances the energy expense, saves the node energy and hence prolongs the lifetime of the sensor network. Also a comparison between LEACH, proposed scheme (extended version) and Energy aware multi-hop multi-path hierarchy protocol (EAMMH) is presented.*

I. INTRODUCTION

Sensor networks have emerged as a promising tool for monitor the physical world, networks of battery powered wireless sensor network that can sense, process and communicate. A WSN consists of a large number of low cost, low powers and multifunctional wireless sensor network have been widely used in the industry, traffic, environmental protection, military and many other fields. Especially in the absence of the existence of the back bone of network, such as the dangerous region that man cannot get there, the battle field, and other destructive areas .These sensor nodes communicate over short distance via a wireless medium [1].

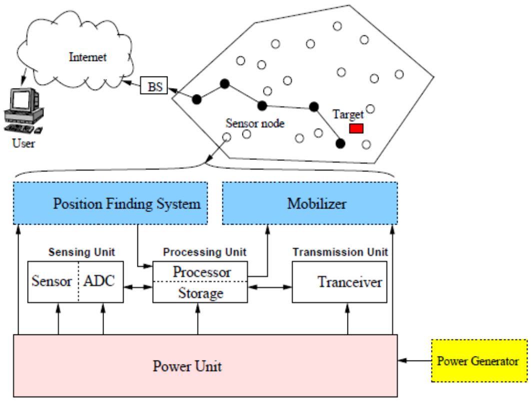


Fig.1 Components of Sensor Nodes and scattered Sensor nodes

A sensor network is a network of many tiny disposable low power devices, called nodes. The tiny sensor nodes,which consistof sensing, data processing and communicating components. As shown in fig.1,each node consists of four components: power unit and central processing unit (CPU).sensor unit and communication unit. They are assigned with different tasks. The important requirements of WSN are: Use large number of sensors, Low energy consumption, Self organization capability, and Querying ability. Key issue in wireless sensor networks is maximizing the network lifetime and the amount of data transferred successfully during the network lifetime. In sensor networks, the data transport model is such that a base station, typically is located at the boundary of or beyond the field from where the sensors sense/measure data [3]. Researchers have proposed numerous routing protocols to improve performance of different application in a wireless sensor network. Out of these, clustering algorithms have been of much interest as they well balance several key factors of Wireless Sensor Networks operation simultaneously [1]. Choosing one arbitrary node to act as servicing node for several sensor nodes than each trying to reach Gateway node can extend network lifetime and bring down energy utilization considerably. This process of choosing one node to act as servicing node for several neighbor nodes is known as 'clustering'.

II. NETWORK ARCHITECTURE AND DESIGN OBJECTIVES

Different architectures and design constraints have been considered for sensor networks. The performance of a routing protocol is related to the architectural model [2].

2.1 Network Architecture

Sensor network consists of three main components .these are the sink, monitored events and sensor nodes. Routing messages from moving node more challenging since route stability is more important factor, in addition to energy , bandwidth etc.

2.2 Node deployment

Another consideration is the topological arrangement of nodes. The arrangement of sensors is either deterministic or self organizing. In self organized systems, the sensor nodes are scattered randomly creating a path in an ad hoc manner. However in deterministic system, the sensors are manually placed and data routed through predetermined paths. The position of the sink or cluster head is also crucial in terms of energy and performance.

2.3 Energy deliberation

The process of setting up the routes is greatly influenced by energy considerations. Most of time sensors are scattered randomly over an area of interest.

2.4 Node capabilities

All sensor nodes are assumed to be homogenous, having equal capacity in terms of computation, communication and power. Set of sensors raises multiple technical issues related to data routing.

2.5 Data Latency and Over Head

These are considered as the important factors that influence routing protocol design. Data aggregation and multi hop relays cause data latency. Some routing protocols create excessive overheads to implement their algorithms, which are not suitable for energy constrained network.

III. ROUTING PROTOCOLS IN WSN

Routing in WSN differs from conventional routing .There is no infrastructure, wireless links are unreliable, sensor nodes may fail ,and routing protocols have to meet strict energy saving requirements. Many routing algorithms were developed for wireless networks. When sensor nodes are static, it is preferable to have table driven routing protocols rather than using reactive protocols. a significant amount of energy is used in route discovery and setup of reactive protocols. All major routing protocols classified into seven main categories shown below:

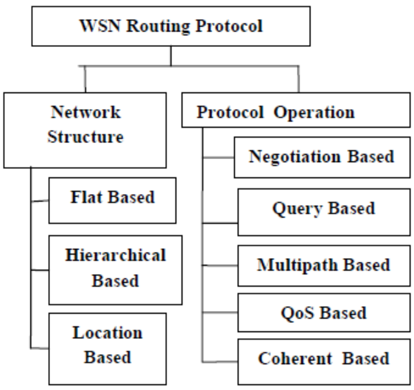


Figure 2. Categorization Of WSN Protocols

IV. REVIEW OF HIERARCHICAL CLUSTERING ALGORITHMS FOR WIRELESS SENSOR NETWORK

Clustering is an energy efficient communication protocol that can be used by the sensors to report their sensed data to the sink. Hierarchical routing is to efficiently maintain the energy consumption of network.This provides inherent optimization capabilities at the cluster heads. A network is composed of several clusters[3]. Each cluster is managed by a special node, called cluster head, which is responsible for coordinating the data transmission activities of all sensors in its cluster. In Wireless Sensor Networks, cluster heads are used for data aggregation and transmission in such a way that more energy is conserved. With the help of CH selection criterion in protocols (homogenous or heterogeneous) may enhance the stability region and lifetime of the network. Representative Protocols of hierarchical routing are as follows:

4.1. Low Energy Adaptive Clustering Hierarchy(LEACH) Protocol

LEACH is one of the earliest clustering routing protocols for WSNs to increase the lifespan of network. It is a self-organizing protocol that distributes energy load equally among all the sensors of the network. In LEACH, nodes make clusters and one node from that cluster acts as its CH. LEACH chooses high energy sensor node as CH and rotates this role among all nodes of the network so that the battery of a single node is not drained completely. LEACH also performs data fusion to compress the amount of data being sent from CH to BS. Thus LEACH reduces energy dissipation and increases network lifetime. For each round, sensors elect themselves as CH with certain probability. The status of these CHs is broadcasted within the network. Each sensor node selects its CH by choosing the one which requires minimum communication energy. After the formation of cluster, CH creates a schedule for the nodes to transmit data. In this way, nodes transmit data to the CH in their allocated time and are in sleep condition for the rest of the time. So, the energy dissipation of individual sensor node is minimized in this manner. When the CH receives all the data from nodes within its cluster, it aggregates that data and sends it to BS. In this way, energy dissipation of the whole network is reduced. A CH depletes more energy as compared to member nodes. To overcome this issue, LEACH has no fixed number of CH and a CH is self-elected at every round. For a node to become CH depends on energy of that node. So, node with higher remaining energy acts as CH for that round. LEACH behaves like a direct communication if it has 0% CHs or 100% CHs in the network.

4.1.1 Operation Of Leach: The operation of LEACH is broken into rounds. Each round consists of two phases, a set-up phase and a steady-state phase. In set-up phase, the clusters are organized and in steady-state phase data is transmitted to the BS. Generally steady-state phase is longer than set-up phase to minimize overhead.

4.1.2 Advertisement Phase: At the beginning, when clusters are formed, each node decides whether it should become a CH for the current round or not. This decision is taken by determining the suggested percentage of CH. A node n decides by taking a random number between 0 and 1. If the number is less than a certain threshold T(n), the node becomes CH for the current round. The threshold is determined in equation (1) below:

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

Where G is set of nodes that have not been selected as CHs in previous 1/p rounds, p is suggested percentage of CHs, r is current round. By using this threshold, each node has the chance of becoming a CH at some stage within 1/p rounds. During initial round zero (r=0), each node has the probability p of becoming a CH. Similarly, if a node becomes CH in round zero (r=0), it cannot be CH for the next 1/p rounds. The node that has elected itself as CH for a round, broadcasts an advertisement message to all nodes within the network. The non-CH nodes keep their receivers on during this time. This advertisement is received by non-CH during set-up phase. After receiving this message, each sensor node decides to join a certain cluster for the current round. This decision is taken on the basis of the strength of received signal. So, the non-CHs will join a CH whose received signal strength is larger. In this way, the energy required for communication between non-CH and CH is less. In certain cases where received signal strength is same for more than one CH, a random CH is selected from those CHs.

4.1.3 Cluster Set-Up Phase: When a node decides to join a cluster, it must inform the CH that it wants to be a member of that cluster. During this phase, the CHs have to keep their receivers on.

4.1.4 Schedule Creation: After receiving message from all nodes that would like to join that cluster, the CH creates a TDMA schedule based on number of nodes and tells the nodes when to transmit data.

4.1.5 Data Transmission: Data transmission begins after formation of clusters and allocation of TDMA schedule. Each node sends data to CH during allocated transmission time. The nodes are in sleep condition for the rest of the time to reduce energy dissipation. The receiver of the CH must be switched on to receive from all nodes. After receiving data from all nodes, the CH compresses it to a single signal and transmits it to the BS.

4.1.6 Advantages Of Leach: Here are some major advantages of LEACH protocol:
I. LEACH is completely distributed, requiring no control information from the BS and the nodes do not require knowledge of the global network in order for the LEACH to operate.
II. Each node becomes CH after 1/p rounds. So, the load is equally distributed among the nodes.
III. TDMA prevents unnecessary data collisions.
IV. Excessive energy dissipation is prevented by communicating only in the allocated time.

4.1.7 Disadvantages Of Leach:
I. It performs single hop communication which is not suitable for large networks because of excessive energy dissipation.
II. LEACH is not suitable for hetergeneous environments because CH selection is based on probability instead of initial or residual energy of the nodes.
III. The idea of dynamic clustering brings extra overhead.

4.2. TEEN (Threshold Sensitive Energy Efficient Sensor Network Protocol):
Routing protocols for wireless sensor networks can be classified into two classes, proactive and reactive protocols. LEACH protocol is considered as proactive protocol since it sends reports to the BS periodically. In reactive protocols, when an event of interest occurs, it is reported to the BS. Reactive protocols are generally used for time critical applications where quick response to changes in the sensed parameters is required. Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN) is a reactive protocol designed for time critical applications. In TEEN, nodes are arranged in a hierarchical clustering scheme in which certain nodes act as CH (first or second level). After a CH is selected, the user sets attributes for it. When the CH receives these attributes, it broadcasts the attributes (Hard Threshold (HT) and Soft Threshold (ST) values) to all member nodes of the cluster.
Hard Threshold: This is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report its cluster head.
Soft Threshold: This is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit.
The Sensor nodes sense the data and transmit only when the sensed data exceeds HT. HT is the minimum value above which values are noted. Sensed value (SV) is an internal variable which stores the transmitted sensed value.The sensor again senses data and when its value exceeds the ST, which is the minimum change in sensed value, it starts transmitting data. Also TEEN uses a homogeneous environment. In this way, TEEN conserves energy because it only transmits data when HT is achieved. ST further reduces the number of transmission, which otherwise would have occurred due to little or no change to level of sensed attributes. Since CH also performs extra computations, its energy consumption is more than other nodes. This problem is resolved by giving equal chance to every node to act as CH for a fixed cluster period. No transmission from nodes to CH occurs if the sensed value is below HT, so, the CH will not be aware of death of a sensor node. By giving smaller value to ST on cost of high energy due to frequent transmission, a clear scenario of the network can be obtained. Similar to LEACH, every node in the cluster is given a time slot for data transmission using TDMA schedule shows the 2 tier clustering topology in TEEN. But here two types of threshold are used. Its efficiency is improved on behalf of these thresholds. Soft threshold is used to on or off the sensing node while hard threshold is activated while sensing value is being changed. Here two level of CH are being used.

4.2.1. Advantages Of Teen: On the basis of two thresholds, data transmission can be easily controlled i.e. only the required data is transmitted. In this way, it reduces the transmission energy. Since, TEEN is complement for reacting to large changes in the sensed attributes, it is suitable for reactive and time critical applications.

4.2.2. Disadvantages Of Teen: It is not suitable for periodic reports applications because if the values of the attributes are below threshold, the user may not get any data at all. 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.

4.3. SEP(Stable Election Protocol):
In real life, sensor node is not able to keep energy uniformity. Therefore, the concept of heterogeneity is introduced. Stable Election Protocol (SEP) heterogeneous aware routing protocol which is proposed for the efficient consumption of energy. In SEP, each node has weighted probability to become CH which depends upon the initial energy of the node.

4.3.1 Heterogeneous Network: In such networks, nodes have different amount of initial energy. 'm' describes a fraction of total nodes 'n', which have 'a' times more energy other nodes. These greater energy nodes are called advance nodes and the remaining nodes having energy (1-m)*n are called normal nodes.

4.3.2. Optimal Clustering: In case of heterogeneous nodes, LEACH creates a large unstable region. This is because all remaining advanced nodes have nearly same amount of energy, so, the process to elect CH becomes unstable and no CH is elected and advanced nodes become idle. SEP improves the stable region using some fraction of advanced nodes 'm' and some additional energy factor 'a' to differentiate normal nodes from advance nodes. In SEP, the advanced nodes have more chances to become CH than normal nodes. In heterogeneous network with advanced and normal nodes, the a priori setting of p_{opt} is not affected but the total energy of the system varies. If E_0 is initial energy of normal node then (1 + a) E_0 becomes initial energy of advanced nodes. So, initial energy of heterogeneous system is given below in (2):

$$n(1-m)E_0 + nmE_0(1+a) = nE_0(1+a.m) \quad (2)$$

Energy of the whole system is increased by an amount (1+a.m), if:

- Normal node has the probability to become CH once in 1/(p_{opt} * 1 +a.m) rounds.
- Advance node has the probability to become CH (1+a.m) times in 1/p_{opt} * 1 +a .m times.
- $n*p_{opt}$ is average number of CH per round.

4.3.3. How To Maintain Well Distributed Energy Consumption During The Stable Region: Same threshold cannot be set for both normal and advance nodes. If it were so and normal nodes have probability of 1/p_{opt} (1 +a .m) per round and advance nodes have probability of 1+a.m times in every (1+a.m)/ p_{opt} per round, there will be no surety for the number of CH to become $n*p_{opt}$ per round. The reason is that this number can not be maintained per round with probability 1.

4.4 Distributed Energy Efficient Cluster Formation Protocol (DEEC) :
DEEC is designed for Multi-level heterogenous environment. The criteria for selecting CH in DEEC depends upon a probability which is based on ratio between residual energy of every node and average energy of the whole network. So, nodes with high initial and residual energy have more chances to become CH than nodes with low energy. Thus DEEC can prolong the stability period by heterogeneous aware clustering algorithm.

4.4.1 Deec Protocol: DEEC calculates an ideal value for the network lifetime. This value is used to calculate a reference energy that each node expends during a round. Thus each node needs not to have the global knowledge of the network. DEEC is a distributed clustering scheme for heterogeneous wireless sensor networks. In DEEC the cluster heads are elected by a probability based on the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster-heads for nodes are different according to their initial and residual energy. The nodes with high initial and residual energy will have more chances to be the cluster-heads than the nodes with low energy. DEEC introduces multilevel heterogeneity for maximizing K. The nodes having greater residual energy have more right to ecome a CH. Therefore, CH formation in DEEC is based on residual energy of entire network and residual energy of the node that wants to become aCH. Therefore, DEEC calculate optimum number of CHs for each round from the following two equations.

$$P(i) = \begin{cases} \frac{p_{opt}\, Ei(r)}{(1+a.m)\,E'(r)}, & if\ S(i)\, is\ normal\ node \\ \frac{p_{opt}\,(1+a)Ei(r)}{(1+a.m)\,E'(r)}, & if\ S(i)\, is\ advanced\ node \end{cases} \quad (3)$$

Where, E (r) is the average energy of the network at round r and is given by :

$$E'(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r) \quad (4)$$

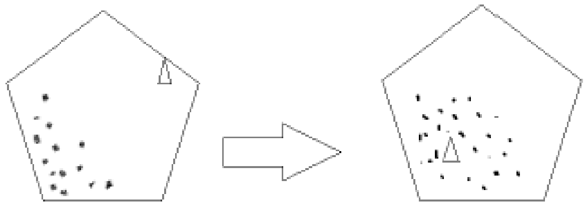
Ei(r) is the residual energy of the node at round r.

V. ENERGY-AWARE MULTI-HOP, MULTI-PATH HIERARCHY (EAMMH)

The aim of LEACH protocol is to minimize energy consumption or in other words, to maximize the network lifetime. To make this happen several ideas are proposed for CH selection but they were based on mainly the node's (to be selected as CH) energy level. The node having greater energy level will be selected as CH most of the times. But

here in the new proposed scheme not only the node's energy level is considered but also it's location or position both within the CH & from outside the cluster(neighbour clusters) are considered.
We know that there may a number of nodes in a cluster & there is always a CH. Suppose for example, if the CH lies at a distant position from the majority of nodes. So to communicate between CH & sensor nodes, since the distance between them is high, energy consumption for the communication is also high. That means, the higher the distance between CH & sensor nodes the greater the energy consumption. Here a new idea to select the CH is given below :

*1. Select the CH in the dense node zone. :*To illustrate this say for example, you are announcing something. If the persons, for whom your announcement is, are very far from you, you have to shout more to make them listen to it but if those persons are near to you, you won't have to shout that much. That means, if nodes are near to the CH, energy consumption is less.



2. Suppose a cluster is surrounded by 6 clusters. So 6 CH can communicate with the central CH. This central CH should be at an optimum distance from those CH. That means the distance between them should be balanced or on average.

Say, C0,C1,C2,C3,C4,C5,C6 are the CH of cluster 0(central cluster),cluster 1, cluster 2, cluster 3, cluster 4, cluster 5, cluster 6 respectively. There should not be a huge difference among distances between C0-C1,C0-C2,C0-C3,C0-C4,C0-C5,C0-C6.

Hence, energy consumption will be in control.

$$T(n) = \frac{p}{1-p\left(r \bmod \frac{1}{p}\right)} \left(\frac{S(i).E}{E_{max}}\right) \left(\frac{D_{avg}}{\sum D_{inter\ node}}\right) \quad \forall\, n \in G$$

$$T(n) = 0 \qquad \forall\ n \text{ not } \in G$$

Where S(i).E is the current energy of each node and Emax is the initial energy of each node. Davg is the average distance from all other nodes in the cluster. D inter_node is the distance between any two nodes in the cluster. Here with the original formula two factors are multiplied.

- Average distance from other nodes in same cluster/∑ inter-node distance.

This factor checks whether the node, to be selected as CH, belongs to a density popular area as well as the distance from the node to the other nodes within the cluster is on average.

- Current energy of the node/Initial energy of each node.

This factor suggests that each node computes the quotient of its own energy level and the aggregate energy remaining in the network. With this value each node decides if it becomes cluster-head for this round or not. High-energy nodes will more likely to become cluster-heads than low-energy nodes.

The operation of the EAMMH protocol is broken up into rounds where each round begins with a set –up phase, when the clusters are organized, followed by a steady- state phase, when data transfers to the base station occur. The below flow chart describes the overview of the protocol initially the user has to give the input which is in the form of number of nodes. Once the nodes are deployed, every node uses the neighbor discovery algorithm to discover its neighbor nodes. Using the cluster head selection algorithm cluster heads are selected among the nodes. These cluster heads broadcasts the advertisement message to all its neighboring nodes and thus clusters are formed with a fixed bound size. Each node in the cluster maintains routing table in which routing information of the nodes are updated. DRAND (distributed randomized time slot assignment algorithm) [11] method is used, it allows several nodes to share the same frequency channel by dividing the signal into different time slots. The cluster head aggregates the data from all the nodes in the cluster and this aggregated data is transmitted to the base station.

5.1 Setup Phase

Initially, after the node deployment the neighbor discovery takes place. This can be done using many methods like: k-of-n approach, ping, beacon messaging.After the neighbor discovery, when cluster are being created, each node decides whether or not to become a cluster-head for the current round. This decision method is similar to the one used in LEACH. The setup phase operates in the following sequence:

1. CH (Cluster Head) Selection
2. Cluster Formation

Data Transmission Phase

Once the clusters are created, the sensor nodes are allotted timeslots to send the data. Assuming nodes always have data to send, they transmit it at their allotted time interval. When a node receives data from one its neighbors, it aggregates it with its own data. While forwarding the aggregated data, it has to choose an optimal path from its routing table entries. It uses a heuristic function to make this decision and the heuristic function is given by,

$$h = K (Eavg/ h * t)$$

where K is a constant, Eavg is the average energy of the current path, hmin is minimum hop count in current path, t = traffic in the current path.

The path with highest heuristic value is chosen. If this path's Emin> threshold, it is chosen. Else the path with the next highest heuristic value is chosen, where

$$Emin = E /const$$

The constant may be any integer value like 10.

If no node in the routing table has Emin greater than threshold energy, it picks the node with highest minimum energy.The information about the paths and routing table entries at each node becomes stale after a little while. The Min heuristic values calculated based on the stale information often leads to wrong decisions. Hence the nodes are to be supplied with fresh information periodically. This will increase the accuracy and timeliness of the heuristic function. During the operation of each round, the necessary information is exchanged at regular intervals. The interval of periodic updates is chosen wisely such that the node does not base its decisions on the stale information and at the same time, the periodic update does not overload the network operation.

VI. SIMULATION AND ANALYSIS OF RESULTS

Both LEACH and EAMMH are simulated using MATLAB. The parameters taken into consideration while evaluating EAMMH 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 same.
- Nodes are static
- Nodes are assumed to have a limited transmission range after which a another equation
- for energy dissipation is used
- Homogeneous distribution of nodes.
- Nodes always have to send the data.

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

Table 1: Simulation Details

Simulation Area	200*200
Base Station Location	(150,100)
Channel Type	Wireless Channel
Energy Model	Battery
Transmission Amplifier Efs Emp	 10pJ/bit/m2 0.0013pJ/bit/m4
Data Aggregation Energy	5nJ/bit
Transmission Energy, E_{Tx} Receiving Energy, E_{RX}	 50nJ/bit 50nJ/bit
Packet size	4000bits
CH proportion	P=0.2
Number of nodes	200
Initial energy	1 J

6.1 Simulation of protocols at 0.05 probability

The below set of results represent the simulation of both LEACH and EAMMH 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

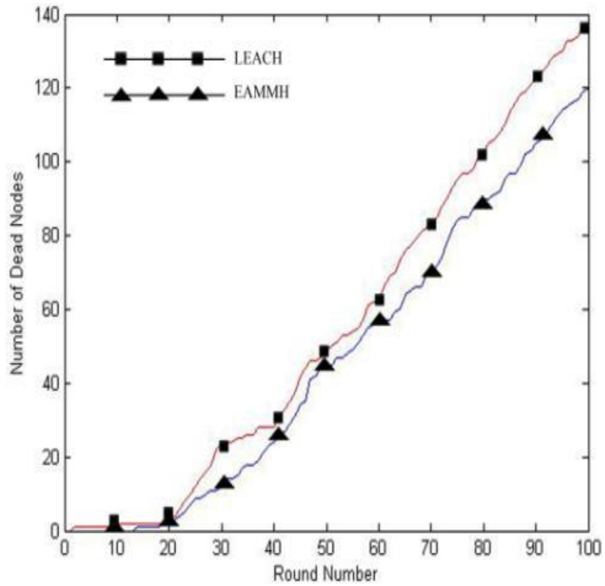


Figure 6.1 5: 200 nodes

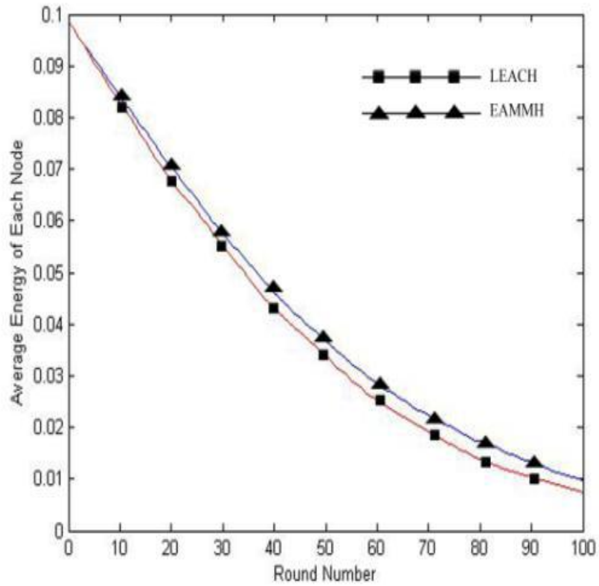


Figure 6.2 9: 200 nodes

Figure 6.1 represent the comparison of LEACH and EAMMH protocols for the number of dead nodes against the round number elapsed for 200 nodes respectively. From Figure we observe that, as the number of nodes increase, EAMMH results in lesser number of dead nodes after the completion of 100 rounds when compared to LEACH.Figure 6.2 represents the average energy of each node as the round progresses for LEACH and EAMMH protocols.The average energy of each node after 100 rounds EAMMH performs slightly better.

VII. COMPARISON OF ENERGY EFFICIENT CLUSTERING BASED HIERARCHICAL ROUTING PROTOCOL

7.1 Cluster Formation Process in Hierarchical Clustering Protocols

According to the hierarchical levels, The cluster formation process of LEACH, SEP and DEEC protocols is different from the TEEN and EAMMH. That is why, we characterize LEACH, SEP and DEEC as mono-level hierarchal protocols, whereas, TEEN and EAMMH is considered as mono, bi or multi-level hierarchical protocol i.e.,hierarchy level depends upon network size.

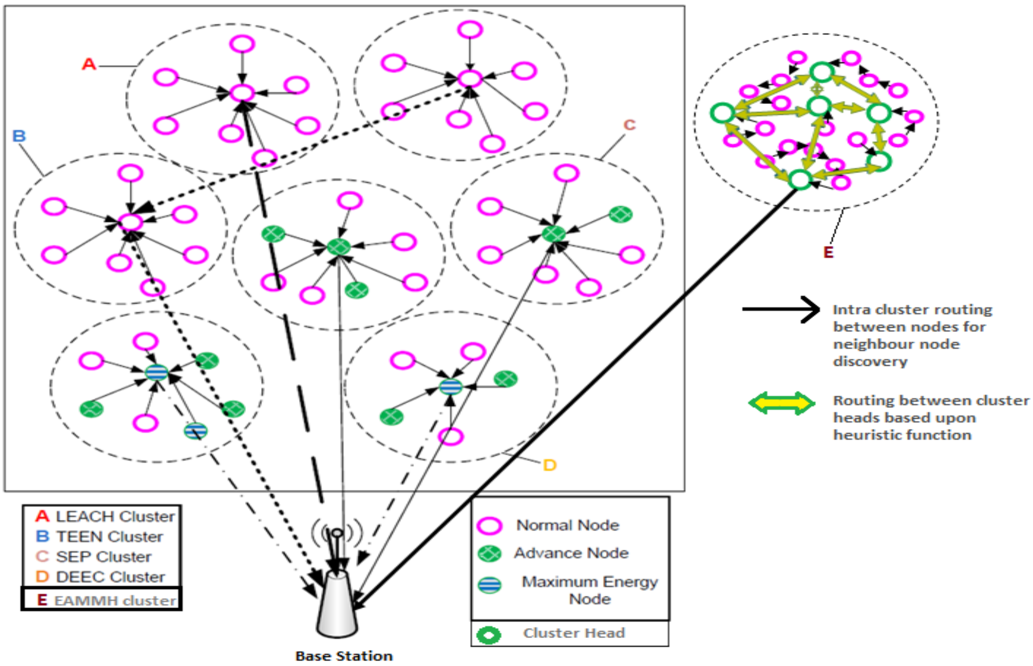


Figure 7.1 Comparison Of Cluster Formation Between LEACH,SEP,TEEN, DEEC And EAMMH

7.2 Simulation Results

In order to evaluate the performance of the selected protocols against maximizing objective function K, we perform analytical simulations in MATLAB. Simulation parameters are given in table. For N, 100 nodes are randomly scattered in network field of 100mm area. BS is placed at the center of the network field. In order to obtain more realistic results, we adjust the heterogeneity level for different routing protocols according to their proposed model. For energy dissipation characteristics, we adopted first order Radio Model. Before discussion of simulation results, it is necessary to define performance metrics. We will use following performance metrics in our results discussion.

Table. 7.1 Simulation Details

Parameter	Value
Network size	100×100 meters
Minimum initial energy	$E = 0.5Joule$
P_{opt}	0.1
Packet size	4000 bits
Transmit/ Receive Electronics	$E_{elc} = 50nJ/bit$
Data Accumulation	$E_{DA} = 5nJ/bit/report$
Transmitter Amplification $(d \leq d_0)$	$E_{fs} = 10pJ/bit/m^2$
Transmitter Amplification $(d \geq d_0)$	$E_{mp} = 0.0013pJ/bit/m^4$

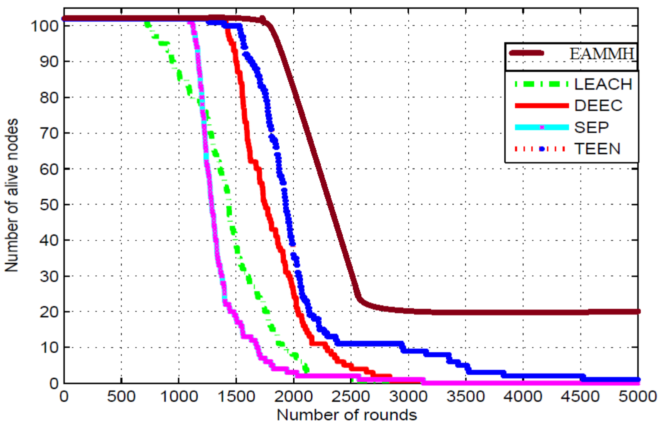
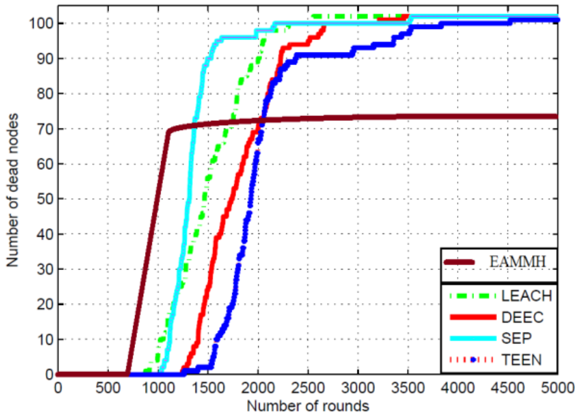


Figure 7.2 Number Of Alive Nodes Versus Number Of Rounds



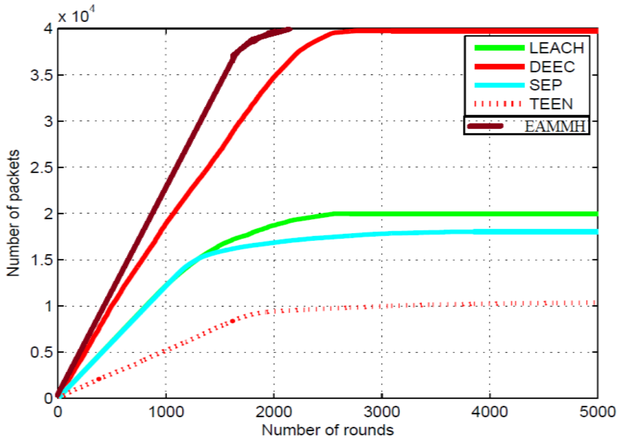


Figure 7.3 Number Of Dead Nodes Versus Number Of Rounds Figure 7.4 Number Of Packet Versus Number Of Rounds

Figure 7.2 shows stability period and network life time of the network for all routing protocols with respect to alive nodes in r number of rounds. We can observe that stable period of LEACH is very short. Stability period of LEACH is almost 23%, 55%, 50% , 80% less than SEP, DEEC,TEEN and EAMMH, respectively. Because, LEACH treats all nodes without energy discrimination therefore it looses full advantage of nodes that have more energy. While SEP treats all the nodes with initial energy discrimination, therefore, the stability period of SEP is more than LEACH. DEEC has almost 25%, 10% longer stable period than SEP and TEEN, as depicted in Fig. 7.3. This is because of heterogeneity-awareness of DEEC, which provides feasible solution TEEN has better stability, as compare to LEACH and SEP. Reason behind this performance of TEEN is less number of transmissions, done by TEEN. Network life time of TEEN is almost 48%, 85%, 98% greater than DEEC, SEP and LEACH, respectively.EAMMH outperforms all the protocols under this category as it has network lifetime 98%,85%,65%,48% greater than LEACH,SEP,DEEC and TEEN respectively.It is due to the reason it uses intracluster ,heterogeneity approach as well as more accurate cluster head selection approach. Dividing clusters into fixed number of subregions reduces energy load to more extent on nodes. Hence, the result is less number of dead nodes.
Fig. 7.4 shows the comparison of every protocol for number of packets that are sent to BS. Result shows that EAMMH has highest successful data rate, as compare to other routing protocols. It is because of shorter value of K in LEACH and SEP, as compare to EAMMH. However, TEEN has better network life time, as compare to DEEC,but EAMMH has the highest, however its execution provide low data delivery, as compare to DEEC. Reason behind this unusual result is limited transmissions of TEEN. DEEC, is time-based routing protocols and it has to transmit data continuously. While TEEN is threshold based and have limited information to share with BS. EAMMH is designed as Proactive type and for heterogeneoous environment,hence, increased stability and lifetime. Multihop and multipath approach reduces the total power consumption as well as the congestion in the network. Energy optimization and efficient route discovery are challenging issues in WSNs.

VIII. CONCLUSION

Wireless Sensor Networks are usually spread over large areas are recently finding applications in many fields. In this regard, there is a requirement of methods which can manage the WSN's in a better way. Wireless Sensor Networks are powered by the limited capacity of batteries. The main challenge in the design of protocols for Wireless Sensor Network is energy efficiency due to the limited amount of energy in the sensor nodes. The ultimate motive behind any routing protocol is to be as energy efficient as possible to keep the network running for a longer period of time. In this paper I have presented clustering as a means to overcome this difficulty of energy efficiency. Detailed description about the working of two protocols, namely LEACH and EAMMH are presented. I have also presented the details about the simulation and the results of it. From the brief analyses of the simulation I have come to a conclusion that LEACH can be preferred in cases of smaller networks where the total number of nodes is less than fifty where it performs slightly better than EAMMH and EAMMH can be chosen in larger networks and also when the heuristic probability of Cluster Head selection is more.

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