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DREEM-ME: Distributed Regional Energy Efficient Multi-hop Routing Protocol based on Maximum Energy with Mobile Sink in WSNs

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ABSTRACT

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. We propose Distributed Regional Energy Efficient Multi-hop Routing Protocol based on Maximum Energy in WSNs (DREEM-ME), which uses a unique technique for clustering to cover these two problems efficiently. Clustering technique of LEACH does not assure a fix number of Cluster Heads (CHs) in each round. Therefore, its behavior is not so appreciable in case of network lifetime. DREEM-ME elects fix number of CHs in each round instead of probabilistic selection of CHs. We also implement the Packet Drop technique in our protocol which makes it more comprehensive and practical. Our simulations and results show that DREEM-ME competes all of its identical protocols.

1 INTRODUCTION TO EXISTING ROUTING PROTOCOLS

Wireless Sensor Networks (WSNs) have a large number of applications nowadays. For example, military applications, medical applications, civil applications, security, traffic management, environment monitoring, surveillance, etc. Randomly distributed wireless sensor nodes and one or more Base Stations (BSs) are embodied to form a WSN. Sensor nodes are deployed to sense physical or environmental parameters at different locations. These sensor nodes communicate efficiently with BS. BS is usually power rich and sensor nodes have limited power resources. Compared with the traditional wireless networks, WSNs have energy constraints, low-data-rate and data flow of high to one, and so on. Energy effectiveness and efficiency are the key performance factors in WSNs. Based on the analysis of energy management, the main factors of energy consumption are: sensing the data, data processing and radio communications where the radio communication is the major part of energy consumption. In WSNs, the realization of energy efficiency can be improved using different energy efficiency techniques [1], [30], [31],[33], [35] and [23]. However, on the basis of the limitations of the physical layer, our main focus is on the design and implementation of network layer protocol. Research shows that the clustering of nodes in WSNs is an effective program of energy conservation such as [39] and [16].

1.1. LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY

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.

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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.

1.1.1 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.

1.1.2 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.

$$T(n) = \begin{cases} \frac{p}{1-p(r \bmod \frac{1}{p})} & if \quad n \; \varepsilon \; G \\ 0 & otherwise \end{cases} \qquad (1)$$

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.

1.1.3 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.

1.1.4 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.

1.1.5 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.

1.1.6 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.

1.1.7 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.

1.2. 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[33]. 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. 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.

1.2.1. 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.

1.2.2. 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.

1.3. 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.

1.3.1 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.

1.3.2. 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_o is initial energy of normal node then $(1 + a)E_o$ becomes initial energy of advanced nodes. So, initial energy of heterogeneous system is given below in (2):

$$n(1 - m)E_o + nmE_o(1 + a) = nE_o(1 + a.m) \quad (2)$$

Energy of the whole system is increased by an amount (1+am), 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.

1.3.3 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.

1.3.4 SOLUTION FOR WELL DISTRIBUTED ENERGY CONSUMPTION DURING THE STABLE REGION:

SEP depends upon initial energy of the nodes. In SEP, each node has knowledge of the whole networks energy and decides whether to become a CH depending on its own remaining energy. A weight is assigned to p_{opt}, which is equal to initial energy of each node divided by initial energy of normal node. p_{nrm} is weighted probability for normal node and p_{adv} for advance nodes. For advanced and normal nodes, the weighted probabilities are given as: $p_{nrm} = p_{opt}/(1 + a.m)$ For advance nodes, probability will be: $p_{adv} = p_{opt}/(1 + a.m) * (1 + a)$. $T(S_{nrm})$ is threshold for normal node (3) and $T(S_{adv})$ is threshold for advance nodes (4) and given as:

$$T(S_{nrm}) = \frac{p_{nrm}}{1 - p_{nrm}\left(r * mod\left(\frac{1}{p_{nrm}}\right)\right)}, \quad if S_{nrm}\ G' \quad (3)$$

Where r is current round, G' is set of nodes that were not CHs in previous $1/P_{adv}$ rounds. $T(S_{nrm})$ is threshold of n(1-m) normal nodes. Now for advance nodes:

$$T(S_{adv}) = \frac{P_{adv}}{1 - P_{adv}\left(r * mod\left(\frac{1}{P_{adv}}\right)\right)}, \quad if S_{adv} \in G'' \quad (4)$$

Where G'' is set of nodes that were not CH in previous $1/P_{adv}$ rounds. So, the total number of CH per round in heterogeneous network is equal to: $n.(1 - m) * p_{nrm} + n.m * P_{adv} = n.P_{adv}$ As LEACH is sensitive to heterogeneity, it goes to unstable region quickly. SEP is aware of heterogeneity, so, it extends the stable region by assigning weighted probabilities to the nodes for CH election. SEP performance does not depend individually on values of m and a but on their product. The advance nodes have a.m times extra initial energy.

In SEP every sensor node elects itself independently as CH depending on its initial energy. The global knowledge of energy is not required at every round. Here two types of nodes can be seen. Normal nodes and advanced nodes. All nodes having same initial energy are normal nodes, whereas some of the nodes are assigned some extra energy so that these nodes can become CH again and again depending on the residual energy. Advanced nodes have more probability to become CH.

1.4 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.

1.4.1 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.

1.4.2 CH SELECTION CRITERIA:

N_i represents the number of rounds to be a CH for node s_i. In homogeneous network such as LEACH, each node becomes a CH only for a single time for $n_i = \frac{1}{p_{opt}}$ rounds. It is obvious that nodes can not have the same residual energy for the whole network. The average probability for CH during rounds n_i can be given as $p_i = \frac{1}{n_i}$. For nodes having equal energy during each round, average probability p_i can be replaced by p_{opt}. By doing this, we can be sure that there are $p_{opt} * N$ CHs for each round and that all nodes are completely energy depleted at the same time. For heterogeneous environment i.e. nodes having different energy[17], the nodes with higher energy have more average probability p_i than p_{opt}. The average energy $\bar{E}(r)$ of the network at round r can be calculated as shown in equation (6).

$$\bar{E}(r) = \left(\frac{1}{N}\right) * \sum_{i=1}^{N} E_i(r) \quad (6)$$

By taking average energy $\bar{E}(r)$, average probability can be calculated as:

$$p_i = p_{opt}\left[1 - \frac{\bar{E}(r) - E_i(r)}{\bar{E}(r)}\right] = \frac{p_{opt} * E_i(r)}{\bar{E}(r)} \quad (7)$$

So, the total CHs are ensured to be $N * p_{opt}$ per round. The threshold value for each node to become a CH during each round is given as:

$$T(s_i) = \frac{p_i}{1 - p_i\left(\frac{r mod 1}{p_i}\right)} \quad if s_i \in G \quad (8)$$

Where G is set of nodes to become CH during round r. S_i belongs to G only if it was not a CH during recent rounds. Node become CH by choosing a random number between 0 and 1. The node will become CH if the random number is less than threshold $T(s_i)$. The number of rounds is the inverse of average probability p_i and is calculated as:

$$n_i = \frac{1}{p_i} = \frac{\bar{E}(r)}{p_{opt} E_i(r)} = n_{opt} * \frac{\bar{E}(r)}{E_i(r)} \quad (9)$$

1.4.3 IN CASE OF HETEROGENEOUS NODES:

From equations of average probability p_i, p_{opt} was taken as reference value for p_i. The initial energy of the nodes are same for homogeneous environment, so, nodes generally use p_{opt} as reference of p_i. But the initial energy of nodes is different in case of heterogeneous environment, the reference value for each node will be different. For the case of two level heterogeneous environment, we have normal and advance nodes only, so, the reference value p_{opt} is replaced by weighted probabilities as:

$$p_{adv} = \frac{p_{opt}}{1 + am}, \quad p_{nrm} = \frac{p_{opt}(1 + a)}{1 + am}$$

And the average probability p_i is given as:

$$p_i = \begin{cases} \frac{p_{opt} * E_i(r)}{(1+am)\bar{E}(r)} & , if \ s_i \ is \ a \ normal \ node \\ \frac{p_{opt}(1+a)E_i(r)}{(1+am)\bar{E}(r)} & , if \ s_i \ is \ an \ advanced \ node \end{cases} \quad (10)$$

Substituting value of p_i directly to equation (8), we find a direct relation of threshold with initial and residual energy of each node. Now for heterogeneous network, the equation is written as:

$$p(s_i) = \frac{p_{opt} N(1 + a_i)}{\left(N + \sum_{i=1}^{N} a_i\right)} \quad (11)$$

And the equation of average probability p_i can be written for heterogeneous nodes as:

$$p_i = \frac{\left(p_{opt} N(1+a)E_i(r)\right)}{\left(N + \sum_{i=1}^{N} a_i\right)\bar{E}(r)} \quad (12)$$

So, from the above equations, the reference epoch is given as:

$$I_i = \frac{\left(N + \sum_{i=1}^{N} a_i\right)}{p_{opt} N(1 + a_i)} \quad (13)$$

This reference value is different for every node having different initial energy. As $n_i = \frac{1}{p_i}$, so, depending on residual energy$E_i(r)$, the n_i for each node varies around its reference value I_i . When $E_i(r > \bar{E}(r))$ we have $n_i < I_i$. So, from this it is clear that nodes with higher energy have more chances to become CHs than nodes with low energy. In this way, we get a well distributed energy network.

In real world applications of wireless sensor networks the wireless communication between nodes and sink does not behave ideally. Packet loss occurs when one or more packets of data traveling across a wireless link fail to reach their destination. This is because some packets are lost due to some factors like interference, attenuation, noise, etc. The wireless link can sometimes be in the bad state and as a result maybe some packets cannot be received at the destination. So, we have discussed and implemented the Random Uniformed Model[2] of packet loss in DREEM-ME to make it more close to reality and more practical.

Part of this work is accepted in 8th BWCCA Conference 2013(Broadband And Wireless Computing, Communication And Applications) in Compiegne, France. Remainder of this paper is organized as follows. Motivation is described in section 2. Section 3 presents the some related works in this field. A brief introduction of the radio model is depicted in section 4. Section 5 shows our proposed scheme. Section 6 shows all the results and comparison of DREEM-ME. Section 7 is showing the future work. Finally, Section 8 concludes our research.

2. MOTIVATION

Every node in the WSNs is crucial and has its own importance. Each node has a little amount of energy and that is not rechargeable, so, energy should be used efficiently for the sake of network lifetime. But Previous works on WSNs such as LEACH[1], LEACH-C[11], TEEN[15], SEP[16] and DEEC[17] have shown that the coverage holes may be created during lifetime of the network and that can not be accepted. And LEACH protocol have selected the CHs on the basis of probability, so, the number of CHs selected are not optimum, therefore, the energy usage is also not very good. We have used CHs selection which selects the node having maximum energy of that region. So, this technique also assures the optimum number of CHs in every round. In HEER [20], CH selection is based on the ratio of residual energy of node and average energy of network.

For efficient use of energy and improvement of coverage we have divided the total area into small sub-regions and these regions are treated separately for the nodes distribution and it helps improving the area coverage. In this way, the CHs will also be optimum in every round. Because research shows that 8 CHs are optimum in the network. And other problem of previous protocols is their stability period and network lifetime are not good enough. So, DREEM-ME is proposed as its lifetime and stable region are far better than previous protocols.

3. RELATED WORK

Research challenges faced today in WSNs managing with low power communication. Routing protocols in this regard play a key role in efficient energy utilization. In sending data from node to BS, selection of a specific route, which tends to minimize the energy consumption is necessary. Old fashioned routing techniques are not as energy efficient as present day clustering techniques. LEACH [1], LEACH-C [11] and M-LEACH [23] are few of the earlier techniques of cluster based routing protocols for WSNs.

The main objective of a routing protocol is to efficiently utilize the energy of the nodes. This is because these nodes are not rechargeable and in order to make them useful for a longer period of time, routing protocols have been proposed. Routing protocols improve the lifetime of a network and specifically the stability period of a network. Protocols [1], [6], [7], [8], [14], [15], [16], [28], [33]. [36] and [38] are proposed to achieve these goals. When the sink is static, the probability of coverage holes is greater [38]. After some rounds, there is a possibility that the energy of some part of the network becomes low and that results in a coverage hole. Coverage holes are the greatest enemies of a WSN because we cannot monitor the whole network area because some nodes are not functioning.

In [4], Nadeem *et al.* present a detailed framework consisting of modeling of routing overhead generated by three widely used proactive routing protocols; Destination-Sequenced Distance Vector (DSDV), Fish-eye State Routing (FSR) and Optimized Link State Routing (OLSR). The questions like, how these protocols differ from each other on the basis of implementing different routing strategies, how neighbor estimation errors affect broadcast of route requests, how reduction of broadcast overhead achieves bandwidth, how to cope with the problem of mobility and density, etc, are attempted to respond.

In [6], authors evaluate, analyze, and compare the impact of mobility on the behavior of three reactive protocols (AODV, DSR, DYMO) and three proactive protocols (DSDV, FSR, OLSR) in multi-hop wireless networks. We take into account throughput, end-to-end delay and normalized routing load as performance parameters. Based upon the extensive simulation results in NS-2, they rank all of six protocols according to the performance parameters.

In [7] Ding Yong *et al.* first makes a summary to power control and the existing routing metrics then finds the several key characteristics of wireless sensor networks communication link, show that the wireless links in real sensor networks can be extremely unreliable secondly the EEA (Expect Efficient Algorithm) is provided which based on power control. Finally, EEA in the paper is adapted to directed diffusion routing protocol, and evaluated the performance of EEA by comparing with existing routing protocols.

Authors in [10] compared six different protocols of different scenarios which are presenting their own schemes of energy minimizing, clustering and route selection in order to have more effective communication. This research is motivated to have an insight that which of the under consideration protocols suit well in which application and can be a guide-line for the design of a more robust and efficient protocol. MATLAB simulations are performed to analyze and compare the performance of LEACH, multi-level hierarchal LEACH and multihop LEACH.

Authors in [13] compare problems of cluster formation and cluster-head selection between different protocols for data aggregation and transmission. They focused on two aspects of the problem: (i) how to guess number of clusters required to proficiently consume available sources for a sensor network, and (ii) how to select number of cluster-heads to cover up sensor networks more proficiently. A sensor in WSNs can communicate directly only with other sensors that are within a radio range in a cluster. However, in order to enable communication between sensors not within communication range, they must form new clusters in distributed sensors.

EAST is an IEEE 802.15.4 standard compliant. In this scheme [19], open-looping feedback process is used for temperature-aware link quality estimation and compensation, whereas closed-loop feedback process helps to divide network into three logical regions to minimize overhead of control packets. Threshold on transmitter power loss ($RSSI_{loss}$) and current number of nodes ($n\ (t)$) in each region help to adapt transmit power level (P_{level}) according to link quality changes due to temperature variation. Evaluation of the proposed scheme is done by considering mobile sensor nodes and reference node both static and mobile.

HEER[20] was proposed for both homogeneous and heterogeneous environments. This protocol takes into account the initial and residual energies of the nodes for the selection of CHs. Data transmission in HEER, is dependent on two threshold values, i.e. Hard Threshold (HT) and Soft Threshold (ST). In this technique, the nodes sense their environment repeatedly and if a parameter from the attributes set reaches its HT value, the node switches on its transmitter and transmits data. The Current Value (CV), on which first transmission occurs, is stored in an internal variable in the node called Sensed Value (SV). Now the nodes will again transmit the data to their respective CH if:

$$CV - SV \geq ST \tag{14}$$

If the CV differs from SV by an amount equal to or greater than ST, only then the nodes will transmit their data. It results in reduced number of transmissions and hence, network lifetime is improved. In [21] authors take the case of high dynamic topology, reactive routing protocols which provide quick convergence by faster route discoveries and route maintenance. Frequent broadcasts reduce routing efficiency in terms of broadcast cost; Bk, and expected time cost; E[t]. These costs are optimized using different mechanisms. So, we select three reactive routing protocols; Ad-hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), and DYnamic Manet On-demad (DYMO). We model expanding Ring Search (ERS); an optimization mechanism in the selected protocols to reduce Bk and E[t]. A novel contribution of this work is enhancement of default ERS in the protocols to optimize Bk and E[t].

In [22], authors present an energy efficient routing protocol is the major concern in WSNs. In this survey paper, we present energy efficient hierarchical routing protocols, developed from conventional LEACH routing protocol. Main focus of their study is how these extended protocols work in order to increase the life time and how quality routing protocol are improved for WSNs.

This paper [26] presents mathematical framework and study of proactive routing Protocols. The performance analysis of three major proactive routing protocols: Destination-Sequenced Distance Vector (DSDV), Fish-eye State Routing (FSR) and Optimized Link State Routing (OLSR) are under consideration in this work. Taking these routing protocols into account, we enhance existing framework.

In [29] every protocol is not suitable for heterogeneous WSNs. Authors in [29] showed that Efficiency of protocol degrades while changing the heterogeneity parameters. In this paper, authors first test Distributed Energy-Efficient Clustering (DEEC), Developed DEEC (DDEEC), Enhanced DEEC (EDEEC) and Threshold DEEC (TDEEC) under several different scenarios containing high level heterogeneity to low level heterogeneity. We observe thoroughly regarding the performance based on stability period, network life time and throughput. EDEEC and TDEEC perform better in all heterogeneous scenarios containing variable heterogeneity in terms of life time, however TDEEC is best of all for the stability period of the network. However, the performance of DEEC and DDEEC is highly effect.

In [40] N. Javaid *et al.* proposed EDDEEC. It is a three level heterogeneous protocol which assigns different probabilities to each energy level node to become CH, so, that nodes with high energy become CHs more frequently as compared to the nodes with less energy. In EDDEEC, authors defined a residual energy level threshold. Under that threshold, all normal, advance and super nodes have same probability for CH selection. EDDEEC [40] is adaptive energy aware protocol which dynamically changes the probability of nodes for the selection of CHs. This is a balanced and efficient way to distribute equal amount of energy between sensor nodes. Setting a threshold can be very useful in efficient consumption of energy as in [31].

WBAN is an emerging domain in the field of wireless communication [24]. It comprises of many tiny sensors placed on or inside the body. These sensors measure patient's vital information and transfer it to medical personnel for diagnosis. WBAN has many applications, most important of which is in UHC. With UHC, patients are not required to visit doctor frequently. They can get diagnosis of their disease while sitting at home. In this paper, an analytical survey is done on different architectures of WBAN used in UHC. These architectures are suited for different applications. Wearable devices and standards used in WBAN are also discussed. Different standards are used depending on the type of application. Path loss in WBAN and its effects are also discussed in detail. Simulations for In-Body and On-Body communication are also performed. The results for On-Body communications show that path loss increases between transmitter and receiver with increase in distance and frequency. Similarly, phase distortion and attenuation also increases with frequency.

H-DEEC and MH-DEEC routing protocol are proposed as energy aware adaptive clustering protocols for heterogeneous WSNs. In H-DEEC, the network is divided into two parts on the basis of initial and residual energy. Normal nodes elect themselves as a CH and Beta nodes collect data from CHs and send it to BS using multi-hopping. Unlike SEP and DEEC, H-DEEC and MH-DEEC perform better in a heterogeneous wireless sensor field. Moreover, it also considers the problem of locating BS outside the network.

In [33], authors introduce adopted authentication approach for protecting our Ad-hoc wireless network by even- odd function. In this function mobile node will compute and generates random even or odd number during signaling process. If first node generates random odd number then next node will do computation and generates random even number by incrementing of decrementing digit numbers. There are number of attacks existing in wireless communication in different application of communication field. This scheme will secure the whole wireless network from the outsider attack.

In [31], Ad-LEACH is proposed for WSNs. This is an energy efficient routing protocol which is based on legacy static clustering approach. In this scheme, CH selection mechanism is inherited from DEEC whereas, protocol architecture is adopted from LEACH protocol. Simulation results validate the performance efficiency of Ad-LEACH in the case of two level heterogeneous networks as compared to LEACH and DEEC.

When the sink is static, the probability of coverage holes is greater. After some rounds, there is a possibility that the energy of some part of the network becomes low and that results in a coverage hole. Coverage holes are the greatest enemies of a WSN because we cannot monitor the whole network area because some nodes are not functioning due to depletion of their energy.

Authors in [39] used LP modeling for maximizing throughput in proactive protocols in wireless multi-hop networks. so that the maximum data will be gathered at the base station. This LP model also resulted in minimizing routing delay. This delay minimizing problem is very important to be solved because in time critical applications, this is a quite significant and is needed to be solved as is [34].

4. FIRST ORDER RADIO MODEL

Currently, there is a great deal of research in the area of low-energy radios. Different assumptions about the radio characteristics, including energy dissipation in the transmit and receive modes, will change the advantages of different protocols. In our work, we assume a simple model where the radio dissipates Eelec = 50 nJ/bit to run the transmitter or receiver circuitry and ε_{amp} = 100 pJ/bit/m2 for the transmit amplifier to achieve an acceptable Eb/No. These parameters are slightly better than the current state-of-the-art in radio design1. We also assume an r^2 energy loss due to channel transmission. Thus, to transmit a k-bit message a distance d using our radio model, the For these parameter values, receiving a message is not a low cost operation; the protocols should thus try to minimize not only the transmit distances but also the number of transmit and receive operations for each message. We make the assumption that the radio channel is symmetric such that the energy required to transmit a message from node A to node B is the same as the energy required to transmit a message from node B to node A for a given SNR. For our experiments, we also assume that all sensors are sensing the environment at a fixed rate and thus always have data to send to the end-user. DREEM-ME assumes a simple first order radio model in which the radio dissipates E_{elec} = 50 nJ/bit for powering the transmitter or receiver circuitry and ε_{amp} = 100 pJ/bit/m^2 for the transmitter amplifier to achieve an acceptable Eb/No as shown in fig. 1. Transmitter circuitry also consumes E_{DA} = 50 nJ/bit to aggregate the data received by the normal nodes. We also take in account the d^2 energy loss due to channel transmission. Thus, to transmit a k-bit message distance d the energy is given as:

$$d_o = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \quad (15)$$

if $d < d_o$

$$E_{Tx}(k, d) = E_{elec} * k + \varepsilon_{fs} * k * d^2 \quad (16)$$

if $d \geq d_o$

$$E_{Tx}(k, d) = E_{elec} * k + \varepsilon_{mp} * k * d^4 \quad (17)$$

Reception Energy:

$$E_{Rx}(k) = E_{elec} * k \quad (18)$$

Where E_{elec} is the energy dissipated per bit to run the transmitter or receiver circuit, ε_{fs} and ε_{mp} depend on the transmitter amplifier. A basic radio model is shown in fig. 1.

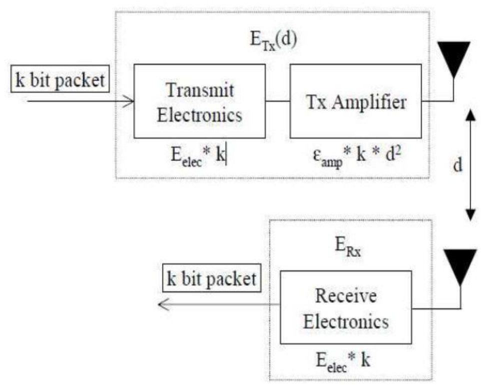

Fig 1. First order radio model

It can be seen that same energy is required to switch on the transmitter and receiver circuitry. This is because both use $E_{elec} \times k$ energy as shown in eq. (16), (17) and (18). So, it can be concluded that this radio model is symmetric such that the energy required to transmit a bit of data from node A to B is the same as the energy required to transmit a bit of data from node B to node A for a given SNR. We assume that all sensors are always sensing the environment and sending the data to their CH or BS. We also assume that nodes transmit fixed number of data to their CH and BS, i.e., k is same at all times.

5. PROPOSED SCHEME : DREEM-ME

Coverage and energy are both trade offs of each other. What we need to do is maximize the coverage. So, we have localized the whole network and divided the network into subregions that will help avoiding the coverage hole [8][9][11][12]. The following are the main parts of our proposed model:

5.1 NETWORK MODEL

In our Model, we have taken 100x100m area for the wireless sensor network and then divided it by three concentric circles with the center at origin. Innermost circle has 20m radius, middle circle is then having 35m radius and outer circle has 50m radius. These circles are again divided in sectors to make optimal regions for our network. Then the next step is to make sectors of the outer two circles by 90 degrees. So, 9 regions are formed, in this way, and then we deployed all 90 nodes in our area. We divided the nodes equally in our 9 regions, so, every region will be getting 10 nodes fixed in every round. The 10 nodes of every region will be deployed in their corresponding regions randomly[3]. Dividing the network into subregions will help reducing the distance between cluster members and CHs.

5.2 CLUSTERING ROUTING TECHNIQUES

The previous protocols have used the probabilistic techniques for CH selection [1][16][34]. Nodes then associate with each CH based upon received signal strength. But in DREEM-ME we have used CH selection which is entirely based upon the maximum energy. In a particular region, the node having the maximum energy out of all 10 nodes in that particular region will be chosen to be the CH of that region in that particular round. In this way, the burden of aggregating the data of 9 nodes and sending data to the next CH or the BS, will only be handled by the node with maximum energy.

Association is also important in energy utilization because if any node is forced to send its data to the CH of its own region while that CH is at a greater distance to that particular node than any other CH then that will not be efficient for energy of the network. So, in DREEM-ME we have applied a unique technique for association of nodes. all the nodes of outer regions (i.e. 6, 7, 8, 9) of our network which are not CHs will check the distances from CHs of six regions which are close to them. For example, each node of Region 6 will check the distance from CHs of its nearby regions which are Region 2, 3, 5, 6, 7, 9. And then finds the minimum of these six distances. In this way, every node of region 6 will send their data to the CH which is at minimum distance increasing the energy efficiency.

Routing is the backbone of the protocol because the consumption of energy depends upon routing [5][28]. We have placed the BS at the (0,0) simply. In DREEM-ME, 10 nodes of the Region 1 are using Direct communication to the BS because they are at small distance to the BS as compared to the nodes in other subregions. And all the other subregions are considered as static clusters of 10 nodes each.

We have also applied multi-hop technique only to the CHs. Because the CHs of the outermost circle are at a long distance to BS for direct transmission, so, to make it more efficient we have used multi-hop. Regions 2-9 choose their CHs by checking the maximum energy, those CHs then collect the data from each child node and aggregate the data. CH of Region 9 send its aggregated data to the CH of Region 5, CH of Region 8 send its aggregated data to the CH of Region 4, CH of Region 7 send its aggregated data to the CH of Region 3 and CH of Region 6 send its aggregated data to the CH of Region 2. CH of Region 2 receives the data packets of all its child nodes and also from CH of the Region 6 then aggregates all the data and sends to BS. Similarly, CH of Region 3 receives the data packets of all its child nodes and also from CH of the Region 7 then aggregates all the data and sends to BS. Similarly, CH of Region 4 receives the data packets of all its child nodes and also from CH of the Region 8 then aggregates all the data and sends to BS. Similarly, CH of Region 5 receives the data packets of all its child nodes and also from CH of the Region 9 then aggregates all the data and sends to BS. The logical divisioning of the network area is shown in fig. 2.

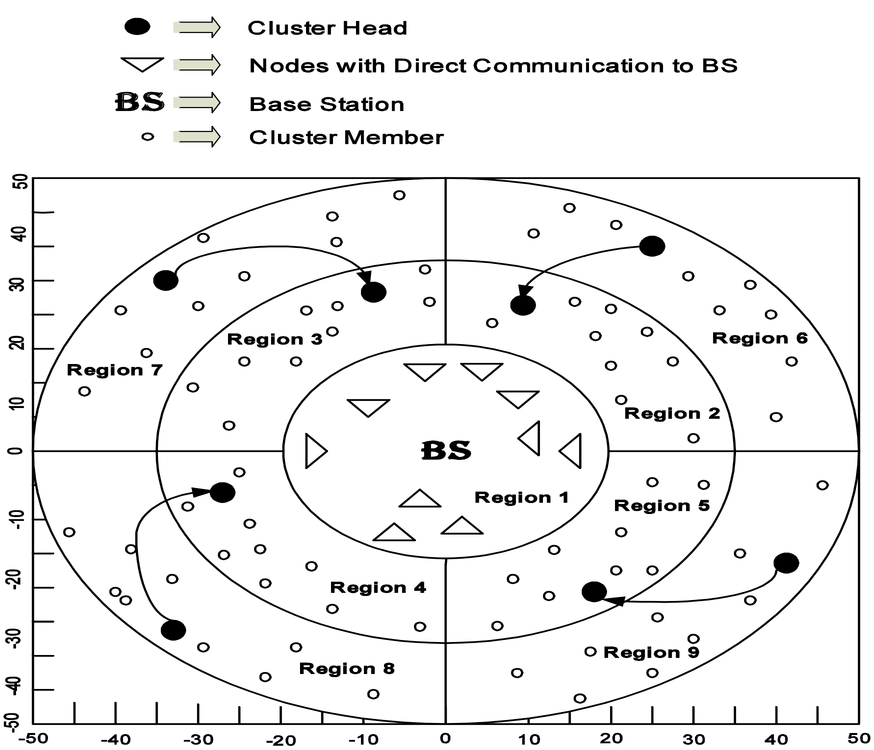

Figure 2: Division of Area

6. SIMULATIONS AND RESULTS

In this section, we will discuss the efficiency and performance of our purposed protocol. We take a 100m x 100m area for our network and total nodes are 90. We divided the area into three concentric circles having 20m, 35m and 50m radii and then made regions out of these three circles as shown in the fig. 2. We provided 10 nodes to each region of our network. Some basic simulation parameters are given in Table 1.

Table 2: Parameters used in Simulations

Parameter	Value
Network size	100m x 100m
Total Nodes	90
Initial energy of each node	0.5J
E_{TX}	50nJ
E_{RX}	50nJ
E_{DA}	5nJ
Maximum Radius of Circles	50
Packet size	4000 bits

6.1 SIMULATION PARAMETERS

Parameters of simulations are discussed below:

6.1.1 RANDOM UNIFORMED PACKET DROP

In DREEM-ME we have applied random uniformed model of packet loss in our protocol. This model specifies the dropped packets during the transmission. Normally researchers do not consider the fact that the wireless links are not ideal, therefore, they are not capable of sending 100 percent of the data successfully to the BS due to a lot of factors affecting the transmission. These factors may include interference, noise, attenuation and reflection etc. Aside from simulations the real world applications of WSNs, the wireless links between nodes and BS does not behave ideally. Packet loss occurs when one or more packets of data traveling across a wireless link fail to reach their destination. The wireless link can sometimes be in the bad state and as a result maybe some packets cannot be received at the destination. So, we implement the Random Uniformed Model[2] of packet loss in DREEM-ME to make it more close to reality and more practical. In DREEM-ME, the probability of packet loss is 0.3 and packet delivery in 0.7. So, we have simulated DREEM-ME, LEACH and LEACH-Circular 5 times and calculated the average of dropped packets in each round of their lifetime.

6.1.2 CONFIDENCE INTERVAL

In WSNs the deployment of the nodes is random and in every round of the simulation, nodes are placed on different locations in the network area so as a result the energy consumption of each node varies in every round. So, each time we simulate the results are different. These results fluctuate to-and-fro around a mean value. So, taking this thing into account we have simulated our protocol 5 times, averaged the value, calculated confidence interval of Dead nodes, Packets sent to BS per round and Packets received at BS and Dropped packets per round, then plotted all of them in figs. 3, 4, 5 and 6 respectively.

In statistics, a confidence interval is a type of interval estimate of data and is used to indicate the reliability of an estimate. Confidence interval is the interval in which we are pretty confident about our results simply. It is calculated from the observations that frequently includes the parameter of interest if the experiment is repeated. More specifically, the meaning of the term "Confidence Interval" is that, if confidence intervals are constructed across many separate data analysis of repeated experiments, the proportion of such intervals that contain the true value of the parameter will match the confidence interval; this is guaranteed by the reasoning underlying the construction of confidence interval. Whereas two-sided confidence limits form a confidence interval, their one-sided counterparts are referred to as lower or upper confidence bounds confidence interval. Confidence interval consist of a range of values that act as good estimates of the our values of interest. So, we have observed the range of variance of our desired results and then defined their upper and lower values and the mean also so that we can plot their confidence interval.

6.1.3 DEAD NODES

All Nodes remain alive until they have energy greater than zero. LEACH [1] uses its own probability function for clustering in the whole area and all nodes have the same probability to become a CH, therefore, all nodes die linearly after the first node dies. Whereas DREEM-ME is using Direct Communication to the BS in its 1st region and all other regions use clustering which is based upon maximum energy. It means the node which has maximum energy in its corresponding region will be selected as the CH, this technique ensures the energy efficiency of the system[19]. Nodes of outermost circle's regions will die first and after that nodes of middle circle regions will be dead and the Direct Communication nodes will die in last because they are much closer to the BS. Results shows that the stability region of DREEM-ME is 106% better than LEACH.

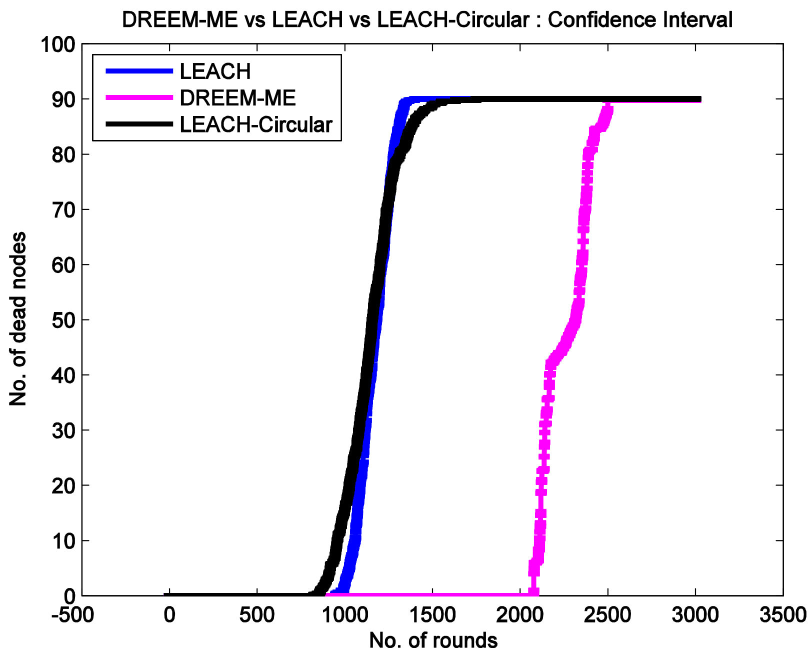

Figure 3: Dead Nodes

6.1.4 PACKETS SENT TO BS

The fig. 4 shows five times averaged values of the total number of packets sent to BS per round of the network lifetime of LEACH and DREEM-ME. According to our network strategy packets sent to the BS per round should ideally follow the explanation below: Packets sent to BS by 1st Region DT nodes = 10, Packets Sent to BS by 2nd Region CH Node = 1, Packets Sent to BS by 3rd Region CH Node = 1, Packets Sent to BS by 4th Region CH Node = 1, Packets Sent to BS by 5th Region CH Node = 1, Total Packets Sent to BS per round = 14. So, as long as all the nodes are alive the packets sent should be 14. When nodes of outer two circles start to die the number of packets gradually decrease till 2154th round and at that time only direct communication nodes are left. Now graph is stable until 2370th round and after that Region 1 nodes start to die the number of packets start to decrease. Whereas LEACH is using clustering in its network area of 100x100 and every node has the same probability to become a CH. LEACH does not assures how many CHs will be formed during any round and in every round the number of CHs are varying around 9 (p=0.1) when all nodes are alive, and packets start to decrease as soon as first node dies at 855th round. So the LEACH protocol forms approximately 9 CHs in its every round, so, the packets sent to BS should also be 9. So, as shown by the fig. 4 the Packets sent by LEACH in every round should be around 9 until first node dies.

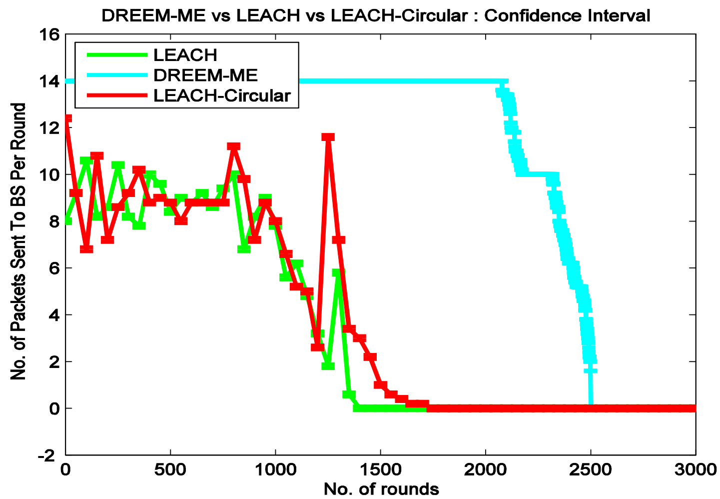

Figure 4: Packets Sent to BS

6.1.5 PACKETS RECEIVED BY BS

In DREEM-ME we have used Packet Drop concept which makes it more close to the reality situation. Because in reality the wireless links are not perfect or ideal, therefore, there is always a probability that some of packets will be dropped on their way. So, the graph below shows that packets received are not the same as the packets sent in the same round. As the nodes start to die the packets received also decrease. LEACH has variable CHs, so as a result, its received packets are also varying. DREEM-ME has 14 nodes that send their data packets to BS, therefore, this graph of DREEM-ME shows that maximum packets received are 14. We have used Uniform Random Model of Packet Drops that says there is a probability that a packet will be dropped during the transmission and cannot be received by the BS. We have also used confidence interval in the received packets by BS that shows the averaged range of possible values of the received packets because in every simulation the results are different, so, this makes it more general and authenticated result. There are also some peaks shown by the graph of LEACH, it is because LEACH does not assure the maximum number of CHs in the network, therefore, in some rounds packets received are more than expected because of the CHs variance.

In fig. 5 the number of received packets by the BS are shown. DREEM-ME sends 14 packets in each round but the probability of packet drop is 0.3, so, received packets by BS are fluctuating around 10 because almost 30 percent of packets are dropped during flight. Whereas LEACH sends 10 packets in each round and the packet drop probability is 0.3, so, the received packets are varying around 7 in the stability region. The anonymous peaks in the LEACH graph are because LEACH has a unique behavior of clustering and allows more than 9 CHs in some rounds hence the peaks come.

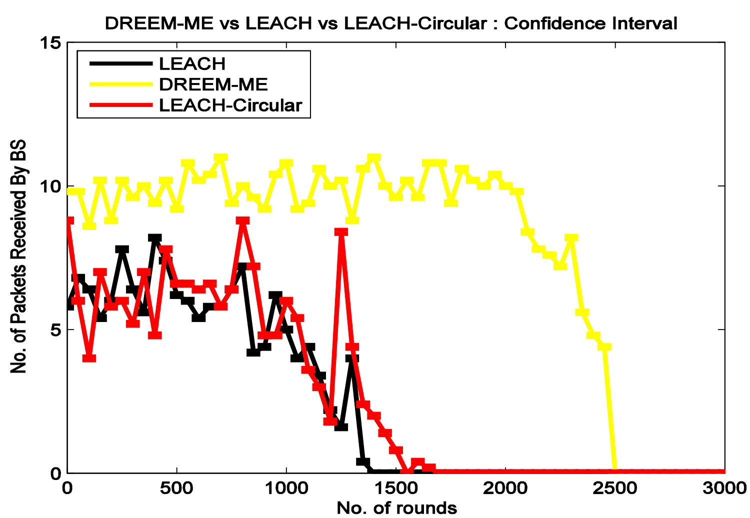

Figure 5: Packets Received By BS

6.1.6 PACKETS DROPPED

The number of packets dropped on the link in every round of LEACH, LEACH-Circular and DREEM-ME are shown in fig. 6. We have determined the dropped packets with the probability of dropping as 0.3 out of 1 but it could also be possible practically that the probability of packet loss is less than 0.3.

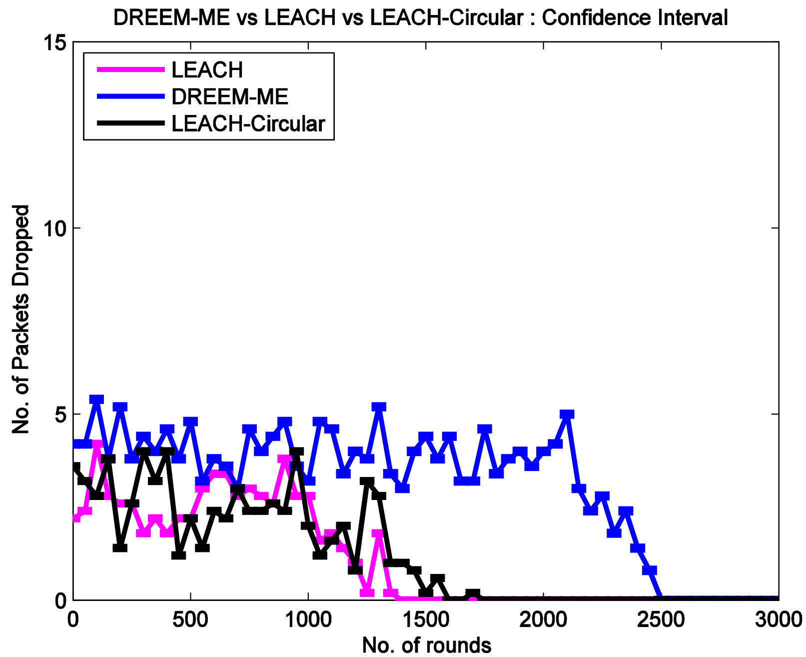

Figure 6: Packets Dropped

6.1.7 SCALABILITY ANALYSIS OF DREEM-ME

In this part, we discuss the scalability of our protocol in many ways. For example, this protocol is checked for different number of nodes and collected the results. As shown in fig. 7, the number of nodes are varied over a range and checked the number of nodes alive over the network lifetime. The network lifetime and stability period is the same almost in every case. So, the simulation results show that DREEM-ME does not fall behind in the case of 1000 nodes it works almost as it works for 100 nodes. The reason behind this behaviour is the energy efficient routing in the DREEM-ME protocol. As it can be seen that the instability period is very short that shows the energy efficient routing.

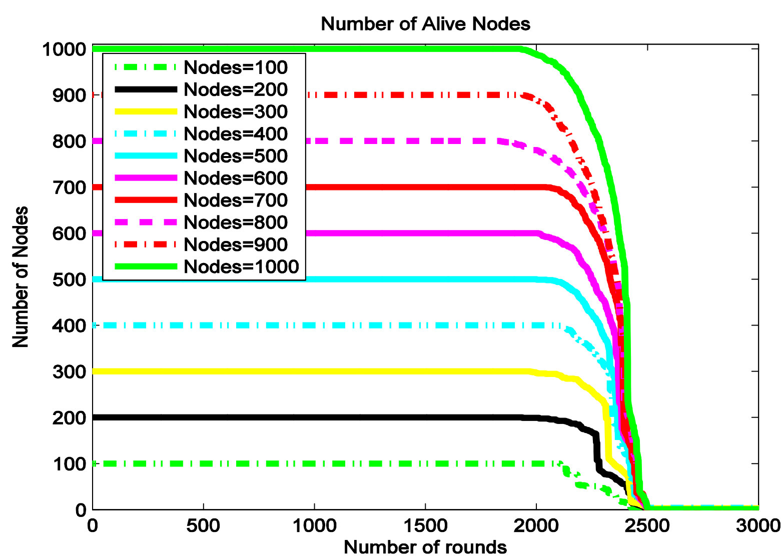

Figure 7: Alive Nodes

As shown by fig. 8, the number of packets sent to BS per round are not varying around some point like packets sent to BS in LEACH or LEACH-Circular. Number of packets sent to BS per round were 14 in the start of the network in the case of 100 nodes.

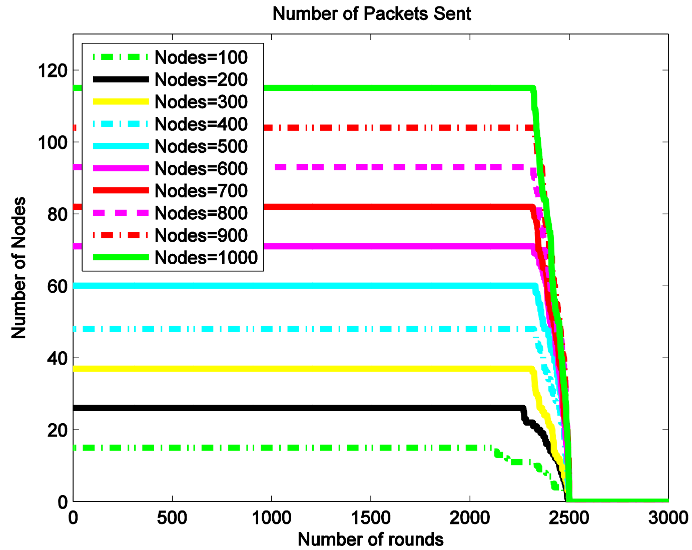

Figure 8: Packets Sent To BS

6.1.8 COMPARISON OF DIFFERENT PROTOCOLS

A comparison between DREEM-ME and other existing protocols is given in table 2, in which comparison of stability period, network lifetime, environment and their classifications are shown. This table shows that our proposed scheme outperforms them all.

Protocol	Stability period	Lifetime	Environment	Classification
TEEN	1221	1947	Homogeneous	Reactive
LEACH	910	1455	Homogeneous	Proactive
LEACH-Circular	1210	1930	Homogeneous	Proactive
DEEC	1395	2461	Heterogeneous	Proactive
DREEM-ME	2065	2475	Homogeneous	Proactive

Table 2: Comparison Between Existing Protocols And DREEM-ME

7. FUTURE WORK

We are working on some more clustering and routing techniques to make the network much better and more efficient than DREEM-ME. In future we would like to reduce deficiencies which are expected in this paper and implementation of DREEM-ME in other clustering protocols like Threshold sensitive energy efficient sensor network protocol [15], stable election protocol [16], distributed energy efficient clustering [17], etc. In future, we aim to introduce multiple QoS path parameters[27], energy efficient MAC protocols [18][37], sink mobility and heterogeneity[32] in our work. Application of Routing Link Matrices on the proposed scheme can be useful in achieving efficient consumption of energy in the network[25]. Mobility constraints also help to achieve better network lifetime [29].

8. CONCLUSION

In this paper we have proposed a new clustering technique for Wireless Sensor Networks. DREEM-ME uses static clustering and maximum energy based CH selection. We have used multi-hop route for the clusters at long distance to BS. Good thing about DREEM-ME is the network field is divided evenly into circles and sectors to reduce the distance between CHs and BS. In MATLAB simulations, we compared our results with LEACH and LEACH-Circular. In terms of achieving optimum number of CHs in each round and CH selection technique of our technique provided better results than its counterparts, in terms of network lifetime, stability period, area coverage and throughput.

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