Multi-Geographical Threshold based Routing Protocol to Enhance Network Lifetime for Wireless Sensor Networks

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ABSTRACT

A Wireless Sensor Network (WSN) is an aggregation of sensor nodes which are remotely deployed in large numbers and operate the environmental condition and have limited energy resource. In most of the hierarchical routing protocols, the cluster head (CH) selection is on the basis of random probability equation. There is a scope to reduce the energy dissipation by improving CH selection procedure. The proposed scheme, coined as Multi Geographical Threshold based Routing Protocol, makes use of evolutionary algorithm for improving CH selection in legacy LEACH routing protocol in sensor networks. The concept of relay node is introduced which acts as an intermediary between CH and base station (BS) to ease the communication between the CH and BS. The simulation results obtained supports that our proposed algorithm is efficient in terms of network lifetime.

KEYWORDS :- *WSN, Cluster, Routing, Gateway, Hard Threshold (HT), Soft Threshold (ST), Sensed Value (SV), Current Value (CV)*

1. INTRODUCTION to WSNs

Wireless Sensor Networks (WSNs) consist of mobile or stationary sensor nodes which are spatially distributed for sensing and processing the data. Sensor nodes sense the event according to the intended application. WSN is used for monitoring physical and environmental conditions such as temperature, sound, pressure etc. Some of its applications include area monitoring, air pollution monitoring, disaster management, security surveillance, healthcare monitoring, industrial monitoring, forest fire monitoring, landslide monitoring etc. [1]. Due to mobility in sensor nodes, the topology of network changes dynamically [2,3].

The Architecture of WSN is shown in Fig 1.Some of the limitations from which WSNs suffer are limited battery source, lower data rates, slower computing speeds, smaller memory and limited communication range. Sensor nodes are battery powered and have to operate in an unattended environment for a longer period of time so it becomes cumbersome to change or recharge their batteries. Due to resource constrained nature of WSNs, routing has become a challenging task. These limitations should be given due weightage while designing the routing protocols for WSNs as they directly impact functioning of whole network [4]. The focus of routing protocols in WSN should be more in finding out the routes that may result in prolonged lifetime of the network apart from considering other parameters such as shortest distance, minimum delay or maximum bandwidth.

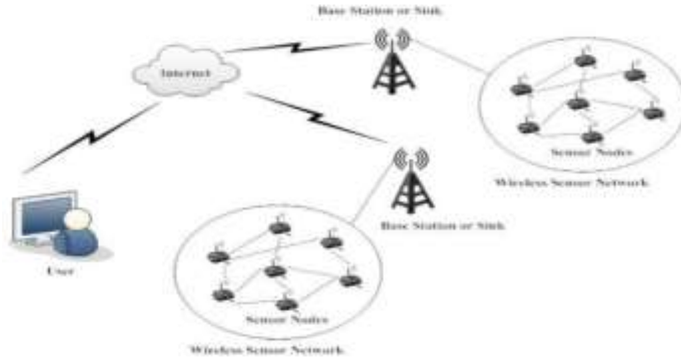

Fig1.1 Wireless sensor network architecture.

Design issue for such protocols is formation of clusters and selection of CHs to reduce the energy consumption. LEACH, one of the popular hierarchical routing protocols [5,6], though uses cluster based routing to maximize energy consumption distributes energy consumption non-uniformly as CH selection doesn't consider residual energy and distance of nodes selected as CH. The major challenge in the design of routing protocols for WSNs are minimizing energy dissipation and maximizing network lifetime[7-10].

Aslam et al. [11-16] Clustering techniques have emerged as a popular choice for achieving energy efficiency and scalable performance in large scale sensor networks. Cluster formation is a process whereby sensor nodes decide which cluster head they should associate with among multiple choices. Typically this cluster head selection decision involves a metric based on parameters including residual energy and distance to the cluster head.

Naregal et al. has proposed LEACH-E and LEACH-EX protocol [2] which is an improvement over LEACH. In LEACH-E, the residual energy of nodes is also considered during the second round of the selection of the cluster head thereby making the network more energy-efficient than LEACH. In LEACH-EX, formula for calculation of threshold in LEACH-E has been simplified by taking the ratio of current energy and initial energy, instead of taking the square root of this ratio which results into reduced computational complexity and increased overall probability of n\ode to be selected as CH.

Karimi et al. proposed GP-LEACH [17] which optimizes CH selection in WSNs using GA by partitioning the network and considering residual energy and nodes' position information for optimization. It ensures CH selection from each partition for better network stability. The simulation results show that GP-LEACH is more efficient than P-LEACH [17,18].

Peiravi et al. proposed M2NGA [19], a multi-objective two-nested genetic algorithm based clustering algorithm to optimize network lifetime and delay. The top level GA considers energy consumption for sending one bit to CH and delay in terms of hop count as fitness function to optimize network lifetime. The lower level GA is used within the cluster to optimize communication from sensor nodes to CH. Their approach works only for the homogeneous and static WSNs. It also requires BS to have complete knowledge of geographic location of all other nodes in the network which increases communication overhead.

Salim et al. proposed an Intra-balanced routing protocol (IBLEACH) [20] for balancing the energy consumption in WSNs which is an improvement to LEACH in terms of the minimization of energy consumption and the lifetime of the network. In this protocol, a new phase i.e. pre-steady phase is introduced between the setup phase and steady phase of round. There is random election of CH and dynamic formation of the clusters similar to the LEACH protocol in setup phase. In the pre-steady phase, the cluster's workload is calculated in one frame, and the cluster member (CM) is selected from the cluster nodes for handling the process of data aggregation in the round through all the frames. If any such type of node doesn't exist, then CM is elected for handling the aggregation process for each frame in the round and the frames that do not have aggregators, their aggregation process is handled by the CH itself. The sensor nodes by the end of this phase are divided into two categories i.e. CH and CM in each frame. The third phase i.e. the steady state phase is divided into frames [21]. All the nodes transfer their data in each frame to the aggregator in their time slots. Once the aggregator receives all the data from the nodes, it gathers the whole data and forwards it to base station.

Kumar et al. [23-26] proposed a protocol EEHC (Energy Efficient heterogeneous clustered scheme for WSN) that aims at increasing the stability and network lifetime in presence of heterogeneous nodes. Nodes in the network are divided into three categories: normal nodes, advanced nodes and super nodes which are referred to as heterogeneous nodes. In this, it is assumed that energy of advanced nodes is more than energy of normal nodes and energy of super nodes is more than energy of normal nodes. In this protocol, the lifetime and performance of network is improved by using weighted probability of election of CH.

2. MOTIVATION

Clustering provides network scalability, resource sharing and efficient use of constrained resources that gives network topology stability and energy saving attributes in WSNs.
Multi-Hop TEEN based Routing Protocol is considered as the most popular routing protocol using cluster based routing so as to minimize the energy consumption and maximizing the network life time. But LEACH doesn't take into account of the distance and the residual energy of the nodes to be selected as CH node. Thus, there are chances that energy consumption in the network is not distributed in uniform manner. So the new proposed approach is designed in a way that considers these factors during the selection of cluster head and network performance can be improved.

3. RELATED WORK

Despite the multitudinous applications of WSNs, these networks have various limitations, e.g., limited energy supply, and limited bandwidth available to each sensing node for communication etc. It has been noticed that one of the main design goals of WSNs has been to carry out data communication while trying to sustain the nodes for a longer period and also to prevent the connectivity abjection by employing aggressive energy management techniques. Routing protocols design in WSNs hence faces many challenging factors.

Data-Centric Protocols
Location-based Protocol
Hierarchical Routing Protocol

Data Centric Protocols

These were the first set of protocols defined which helps in reducing redundancy. In data-centric routing, the sink or the base station sends queries to certain region nodes in a network and awaits the data from the sensor nodes in the selected regions where event occurred. Hence, if this protocol is used then data is requested through queries. Many data-centric protocols have been proposed so far such as SPIN, Directed Diffusion, Rumor Routing, COUGAR, Acquire and EAD but only some have been described below.

- **Energy Aware Routing**

This data-centric protocol was proposed to provide a set of optimal paths rather than just one optimal path. This set of paths is chosen by means of probability whose value depends upon the energy consumption of each path. This protocol consists of three phases

a. Setup Phase
b. Data Communication Phase
c. Route Maintenance Phase

Location-based Protocols

In this kind of routing, sensor nodes are addressed by means of their locations. By using the location information the distance between neighboring nodes can be estimated, thus helping in estimating the amount of energy consumption by the sensor nodes. In these protocols, the location information is utilized in routing data instead of the addressing scheme for sensor networks like IP-addresses. Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors. Alternatively, the position of nodes may be available directly by communicating with a satellite using GPS, if nodes are consists with a small low power GPS receiver. To reduce energy consumption, some location based schemes demand that nodes should go to sleep if there is no activity. Energy savings can be increased by having as many sleeping nodes in the network as possible. Some of the location-based protocols are MECN, SMECN, GAF.

Hierarchical Protocols

A single-tier network is not scalable for a larger set of sensors as it caused the gateway to overload. As a result, the concept of hierarchical routing was introduced. It allowed energy-efficient routing in the networks. The hierarchical architecture basically meant to form a two-layer network where the one layer consisted of the cluster head and the other layer consisted of the similar sensor nodes but they were considered to have lower energy as compared to that of the cluster head. The second layer basically involved routing. The higher energy nodes are used to process and send the information. The creation of clusters and assigning special tasks to cluster heads greatly contributes to the overall system's scalability, lifetime, and energy efficiency. There are many hierarchical protocols LEACH, PEGASIS, HEED, TEEN and APTEEN.

- **Low Energy Adaptive Clustering Hierarchy**

LEACH protocol is one of the most popular hierarchical routing algorithms for sensor networks. The abstract idea is to form clusters of the sensor nodes based on the received strength of the signal and use local cluster heads as routers to the BS. This will leads to enhancement of energy since the transmissions done through such cluster heads rather than all sensor nodes. For number of cluster heads there is estimation of 10 percent of the total number of nodes in the networks. For each activity in the CHs such as data fusion and aggregation are performed locally into the cluster. Cluster heads are not fixed rather it changes randomly over time in order to balance the energy dissipation of nodes. For deciding which node is cluster head depends upon network nodes, choosing a random value that exists between 0 and 1? Node becomes a cluster head for the current round if the value is less than the following threshold:

$$T(n) = \begin{cases} \dfrac{p}{1-p*(r \bmod \frac{1}{p})} & \forall\, n \in G \\ 0 & \text{if } n \notin G \end{cases}$$

Where, p is the desired percentage of cluster heads (e.g. 0.1), r is the current round and G is the set of nodes that have not been cluster heads in the last 1/p rounds.

- **Power-Efficient Gathering in Sensor Information Systems (PEGASIS)**

PEGASIS is the extension of LEACH protocol, which forms chains of sensor nodes so that each nodes transmits and receives from neighboring nodes and only one node from the chain is responsible to transmit data to the sink. The data moves from one node to other node, aggregation performed and transmitted to sink. The formation is done in greedy way.

Unlike LEACH, PEGASIS not form clusters and uses only one node from the chain to transmit to sink instead of using many nodes. A sensor transmits data to neighbors in data fusion phase. In PEGASIS, the construction phase supposes that all nodes have global information about the network, especially positions of sensors, and use a greedy approach. When a node dies due to low power, the chain is constructed using same greedy method by bypassing the failed sensor. For every round, a randomly selected node from the chain will transmit aggregated data to sink, thus helps in reduction of per round energy consumption compare to LEACH.

- **Threshold Sensitive Energy Efficient Network (TEEN)**

TEEN [3] is also one of the hierarchical protocols. All the nodes report their sensed data to their sensor. The CH sends the aggregated information to higher level of CH until the information reaches to the sink. Thus, the architecture of TEEN is based upon the hierarchical grouping where closer nodes form clusters and this process goes on second level until the sink is reached. It uses data-centric technique with hierarchical policy. TEEN is suitable for time critical sensing applications. Also message transmission takes more power than data sensing, so that energy consumption in TEEN protocol is less than the hierarchical protocol in proactive networks. However it is not suitable applications where periodic reports needed because user may not get any data at all if thresholds are not reached.

- **Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN)**

APTEEN is an advancement of TEEN protocol to overcome its shortcomings and aims for capturing both periodic as well as time critical data. Thus, it is a hybrid protocol that allows nodes to send their sensed data periodically and react to any sudden change in the value sensed value. The architecture of APTEEN is same as TEEN protocol, which uses the concept of hierarchical energy efficient communication nodes and the sink. APTEEN supports mainly three types of query:

- One-time query
- Historical query and
- Persistent query

These queries are used for monitoring an event for a period of time. APTEEN guarantees low energy dissipation and a large number of sensors alive.

In the proposed work, the cluster formation and CHs communication procedure of LEACH protocol has been modified in order to improve network lifetime.

4. PROPOSED WORK

TEEN Protocol

In this section, we proposed the detail of our TEEN Protocol. TEEN protocol uses the initial and residual energy level of the node to select the CH, to avoid that each node need to know the global knowledge of the networks.

Cluster-head selection algorithm based residual energy

Let n_i denote the number of rounds to be CH the node S_i and we refer to it as the rotating epoch in homogeneous networks, to guarantee that there are average $P_{opt}N$ CH every round, LEACH let each node S_i (i=1,2,….N) become a CH once every $n_i = 1/P_{opt}$ rounds. in our TEEN protocol we choose different n_i based on the residual energy $E_i(r)$ of node S_i at round r.

$$T(S_i) \begin{cases} \frac{p}{1-p\,(r \bmod \frac{1}{p})} & \forall\ S_i \in G \\ 0 & \text{otherwise} \end{cases}$$

Where G is the set of node that are eligible to be CH at round r we have $S_i \in G$ in each round r, note the epoch n_i is the inverse of P_i

$$n_i = 1/p_i = E(r)/\{P_{opt}\ E_i(r)\}$$

For cluster head selection in each round ‘r’, average probability P_{iE} is calculated which is the ratio of residual energy of S_i node and $E_i(r)$ average energy of the network. $\bar{E}(r)$ Average energy of network is

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

The optimal probability of a sensor node to become a cluster head P_{opt} can be calculated on the basis of optimum number of clusters k_{opt} as follow:

$$P_{opt} = \frac{k_{opt}}{N}$$

Average probability for CH selection can be calculated by using $\bar{E}(r)$ and $E_i(r)$ for Homogeneous Network

$$P_{iE} = P_{opt} = P_{opt}\frac{E_i\ (r)}{\bar{E}(r)}$$

Coping with hetrogeneous modes

We can see that P_{opt} in the reference vlue of of the average probability p_i which determine the rotating epoch n_i and threshold $T(s_i)$ of node s_i.

Let $p_i = 1/n_i$, which can be also regarded as average probability to be a cluster-head during n_i rounds. When node have the same amount of energy of each epoch, choosing the average probability p_i to be p_{opt} can ensure that $p_{opt}N$ cluster-head every round and all node.

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

To compute $\bar{E}(r)$ each node should have the knowledge of the total energy of all node in the network.

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

This model can be easily extended to multi-level network. We use the weighted probability

$$p(si) = \frac{P_{opt} N(1 + ai)}{(N + \sum_{i=1}^{N} ai)}$$

to replace p_{opt} and obtain the p_i heterogeneous node

Estimate average energy of networks

The average energy $\bar{E}(r)$ is needed to compute the average probability p_i. it difficult to realize such scheme So average energy of r^{th} round in the network is to be calculated as follows [17]:

$$\bar{E}(r) = \frac{1}{N} E_{total} \left(1 - \frac{r}{R}\right)$$

Where "r" is the current round and "R" denotes total round of the whole network. "n" is the number of nodes in the network. "R" can be formulated as:

$$R = \frac{E_{total}}{E_{round}}$$

E_{round} is the energy dissipated in a network during single round as given and calculated as:

$$E_{round} = L\left[2NE_{elec} + NE_{DA} + N\varepsilon_{fs} d_{toCH}^2 + k\varepsilon_{mp} d_{toBS}^4\right]$$

Where E_{elec} is energy used per bit for running circuit of transmitter and receiver. Free space (fs) model is used if distance is in less than threshold otherwise multi path (mp) model is used.

k = number of clusters,
E_{DA}= Data aggregation cost in CH
d_{toBS} = Average distance Between CH and BS
d_{toCH} = Average distance between cluster members and CH

Assuming all nodes are uniformly distributed over network so, d_{toBS} and d_{toCH} can be calculated as following [8,13]

$$d_{toCH} = \frac{M}{\sqrt{2\pi k}}, \; d_{toBS} = 0.765 \frac{M}{2}$$

By finding the derivative of E_{round} with respect to zero, we get the k_{opt} optimum number of clusters as,

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}} \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \frac{M}{d_{toBS}^2}$$

Where, M is design of heterogeneous model area M×M in square meter
At start of each round in MHTRP-LEACH, cluster head transmits the following values:

Hard Threshold- predefined threshold value of attributes beyond which node will send data to cluster head [10].
Soft Threshold- minimum possible value of attributes which spark the node to switch on its transmitter and broadcast the data [10].

5. PROPOSED ALGORITHM

Step 1: for i=1 to n

```
s(i).xd=rand(1,1)*xm
XR(i)=s(i).xd
s(i).yd=rand(1,1)*ym
```

```
YR(i)=s(i).yd
s(i).G=0
end
```

Step 2: Creating nodes for multi-hop and multi- path

```
mm = floor(min1+(max1-min1).*rand(1,n11))
```

Step 3: After creating a sensor networks we have calculated energy used by the sensor networks

```
for I = 1 to n
 if (d > do)
  s(i).E=s(i).E-((ETX+EDA)*(4000)+Emp*4000*(d^4));
 else
 s(i).E=s(i).E - ((ETX+EDA)*(4000)+Efs*4000*(d^2));
```

Step 4: Selection of Cluster Head for a cluster

```
if((s(i).E==1&&(temp_rand<=(padv/(1-padv*mod(r,round(1/padv)))))))
```

Step 5: For detection of dead nodes

```
for i=1 to n
if (s2(i).E<0)
n_dead=n_dead+1;
else if(s2(i).E==1)
n_dead_adv=n_dead_adv+1;
else
  n_dead_nor=n_dead_nor+1;
end
```

6. SIMULATION EXPERIMENT

6.1 Simulation Environment

The proposed algorithm has been designed in MATLAB. MATLAB is A Multi-Paradigm Numerical Computing Environment And Proprietary Programming Language developed By Math works. MATLAB Allows Matrix Manipulations, Plotting Of Functions And Data, Implementation Of Algorithms, Creation Of User Interfaces, And Interfacing With Programs Written In Other Languages, Including C, C++, C#, Java, Fortran And Python.

Although MATLAB Is Intended Primarily For Numerical Computing, An Optional Toolbox Uses The Mupad Symbolic Engine, Allowing Access To Symbolic Computing Abilities. An Additional Package, Simulink, Adds Graphical Multi-Domain Simulation And Model-Based Design For Dynamic And Embedded Systems.

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming environment. Furthermore, MATLAB is a modern programming language environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. These factors make MATLAB an excellent tool for teaching and research. MATLAB has many advantages compared to conventional computer languages (e.g., C, FORTRAN) for solving technical problems. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. The software package has been commercially available since 1984 and is now considered as a standard tool at most universities and industries worldwide. It has powerful built-in routines that enable a very wide variety of computations. It also has easy to use graphics commands that make the visualization of results immediately available. Specific applications are collected in packages referred to as toolbox. There are toolboxes for signal processing, symbolic computation, control theory, simulation, optimization, and several other fields of applied science and engineering.

In this random distribution of 100 nodes is done in area of 100 X 100 m^2. Implementation consists of selection of cluster heads on the basis of Multi-Geographical Threshold based Routing Protocol for optimization technique and then formation of clusters is done. A relay node is deployed at the center of the network. Cluster heads calculate the distance from the Base station and distance from the relay node and the aggregated data is sent to the either which has the shortest distance from it. So by the use of concept of relay nodes the energy consumption of the cluster heads is decreased and hence the network lifetime increases with this scheme. The proposed scheme thus is efficient in both cluster head selection and the routing of data from cluster head to the base station.

Evaluation is done based upon following metrics:

- Network Lifetime
- Packets Delivered to Base Station

Simulator parameters are given in following table

Network parameters	**Values**
Network Size	100X100m^2
Number of nodes	100
Packet Size	4000 bits
Routing Protocol	LEACH,E-LEACH, EX-LEACH, GADA LEACH, MHTRP-LEACH
Initial energy of node	0.5 J/node
Energy to run transmitter and receiver	50 nJ/bit
Data aggregation energy	50 nJ/bit
Amplification Energy (Efs)	10 pJ/bit/m^2
Amplification Energy (Emp)	0.0013 pJ/bit/m^2
Primary population	100
Crossover rate	0.4
Mutation rate	0.006
Selection method	roulette wheel selection

Table 6.1: Simulation Parameter

7. RESULTS & DISCUSSIONS

7.2.1 Network Structure of MHTRP-LEACH

In MHTRP the BS is situated outside the network and relay node is introduced inside at the center of the network. The purpose of using relay node is to decrease the energy degradation of cluster head while sending the aggregated data to BS. CH sends data to BS through relay node when its distance from relay node is lesser than its distance from the BS. The energy of relay node is higher than cluster heads and lesser than BS and they are assumed to be rechargeable. By the use of relay nodes the lesser energy of cluster heads is used and so the results obtained are better. Network Structure of MHTRP-LEACH is shown below in fig 6.1. The blue node at center is relay node and the node represented with (x) is the BS. Nodes numbered from 1 to 100 are the sensor nodes.

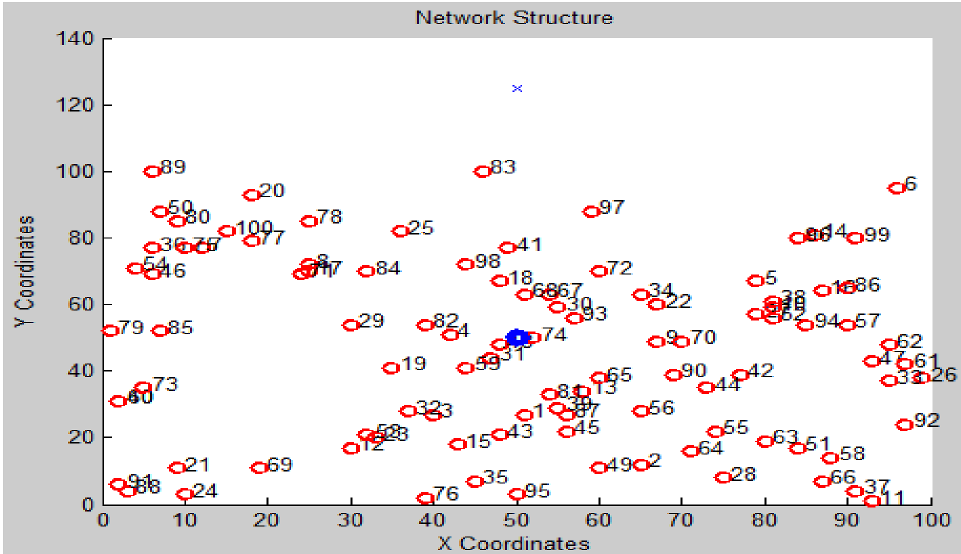

Figure 7.1 Network Structure of MHTRP-LEACH

7.2.2 Comparison of Network Lifetime with varying initial energy

7.2.2.1. When Initial Energy = 0.3J

In fig. 7.2 in case of LEACH, LEACH-E, LEACH-EX, GADA- LEACH and MHTRP-LEACH the first node dies at different round. The first node died at round 533, 540, 570, 700 and 1100 in LEACH, LEACH-E, LEACH-EX GADA-LEACH and MHTRP-LEACH respectively. Lifetime refers to the time when first node dies. So lifetime of network is highest in case of MHTRP-LEACH followed by LEACH-EX, LEACH-E, LEACH and GADA-LEACH.

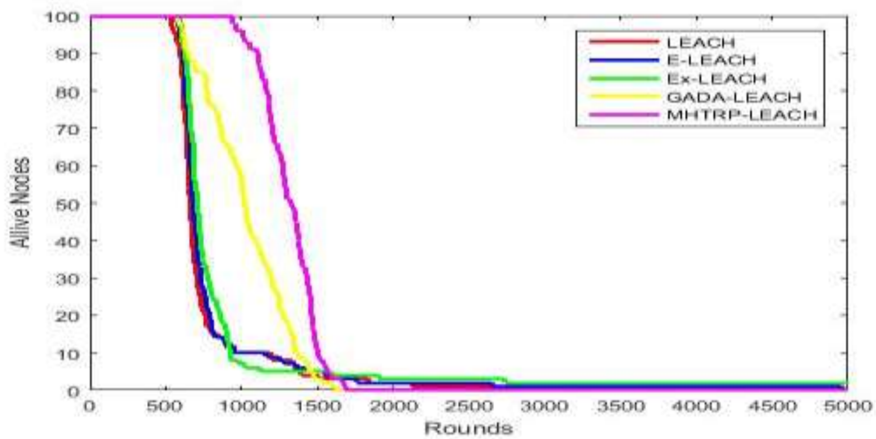

Figure 7.2 Plot of comparison of network lifetime LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH at Eo = 0.3J/node

7.2.2.2. When Initial Energy=0.4J

In fig. 7.3 in case of LEACH, LEACH-E, LEACH-EX, GADA- LEACH and MHTRP-LEACH the first node dies at different round. The first node died at round 744, 764, 799, 1050 and 1470 in LEACH, LEACH-E, LEACH-EX GADA-LEACH and MHTRP-LEACH respectively. Lifetime refers to the time when first node dies. So lifetime of network is highest in case of MHTRP-LEACH followed by LEACH-EX, LEACH-E, LEACH and GADA-LEACH.

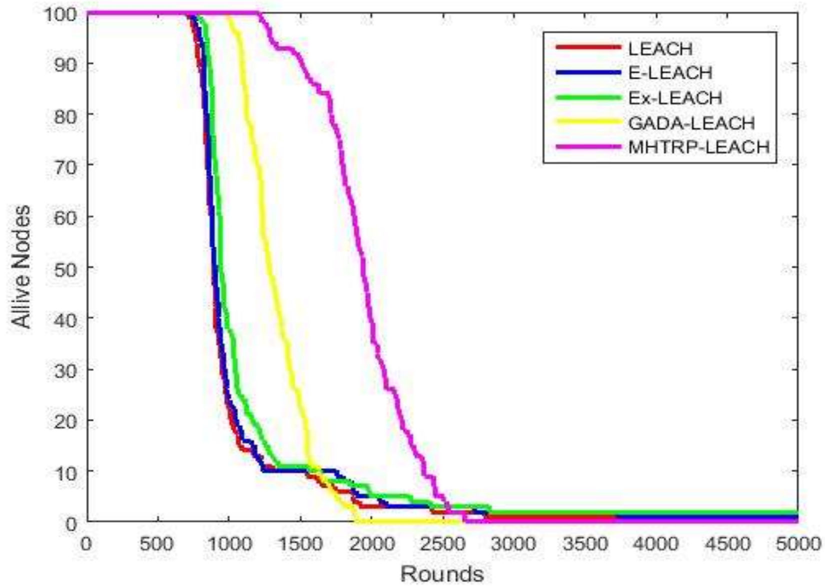

Figure 7.3 Plot of comparison of network lifetime LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH at Eo=0.4J

7.2.2.3 When initial energy=0.5J

In fig. 7.4 in case of LEACH, LEACH-E, LEACH-EX, GADA- LEACH and MHTRP-LEACH the first node dies at different round. The first node died at round 921, 970, 997, 1413 and 1810 in LEACH, LEACH-E, LEACH-EX GADA-LEACH and MHTRP-LEACH respectively. Lifetime refers to the time when first node dies. So lifetime of network is highest in case of MHTRP-LEACH followed by LEACH-EX, LEACH-E, LEACH and GADA-LEACH.

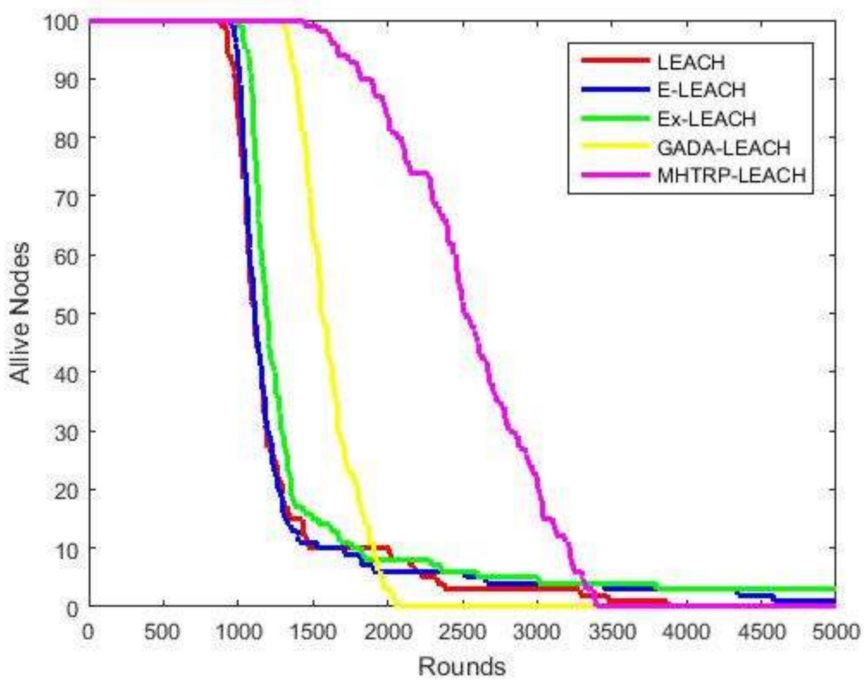

Figure 7.4 Plot of comparison of network lifetime LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH at Eo =0.5J/node

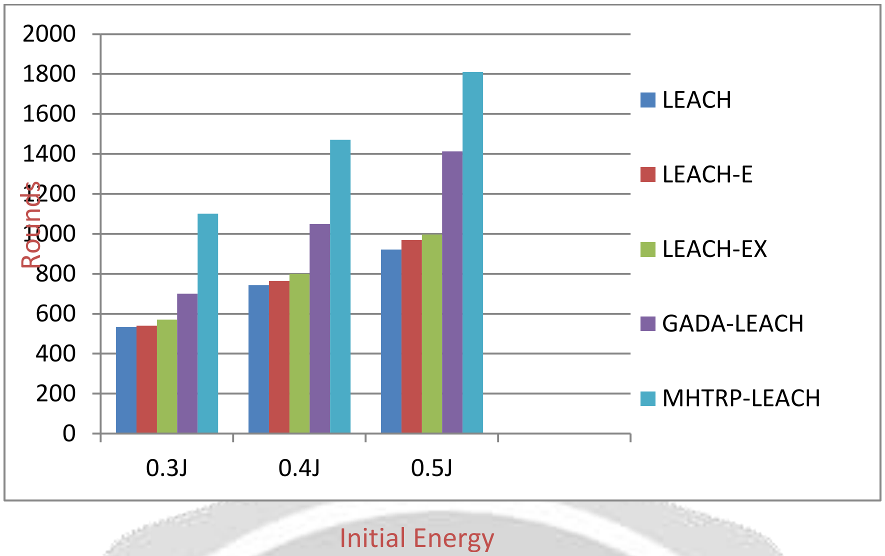

Figure7.5 Network Lifetime of LEACH, LEACH-E, LEACH-EX GADA-LEACH and MHTRP-LEACH when varying Eo

So lifetime of network is highest in case of MHTRP-LEACH followed by LEACH-EX, LEACH-E, LEACH and GADA-LEACH.

7.2.3. Comparison of Network Lifetime with varying packet size

7.2.3.1. When packet size=2000

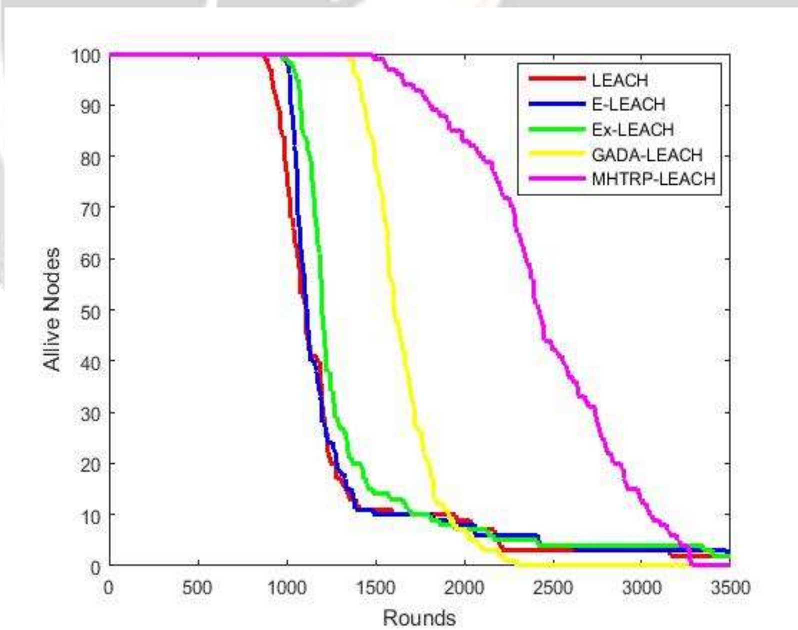

Figure 7.6 Plot of comparison of network lifetime LEACH, LEACH-E, LEACH-EX GADA LEACH and MHTRP-LEACH when packet size=2000

In fig. 7.6, in case of LEACH, LEACH-E, LEACH-EX, GADA- LEACH and MHTRP-LEACH the first node dies at different round. The first node died at round 925, 1085, 1165, 1566 and 1800 in LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH respectively.

7.2.3.2. When packet size=3000

In fig. 7.7, in case of LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH the first node dies at different round. The first node died at round 895, 980, 1110, 1353 and 1599 in LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH respectively. So lifetime of network is highest in case of MHTRP-LEACH followed by of LEACH-EX, LEACH-E, LEACH and GADA-LEACH.

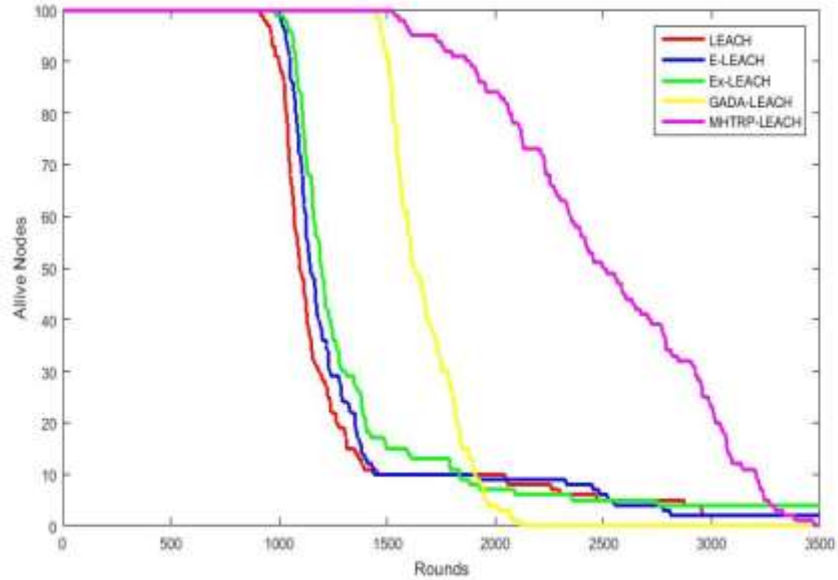

Figure 7.7 Plot of comparison of network lifetime LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH when packet size=3000

7.2.3.3. When packet size=4000

In fig. 7.8, in case of LEACH, LEACH-E, LEACH-EX, GADA- LEACH and MHTRP-LEACH the first node dies at different round. The first node died at round 810, 913, 1095, 1200 and 1390 in LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH respectively. So lifetime of network is highest in case of MHTRP- LEACH followed by LEACH-EX, LEACH-E, LEACH, GADA-LEACH.

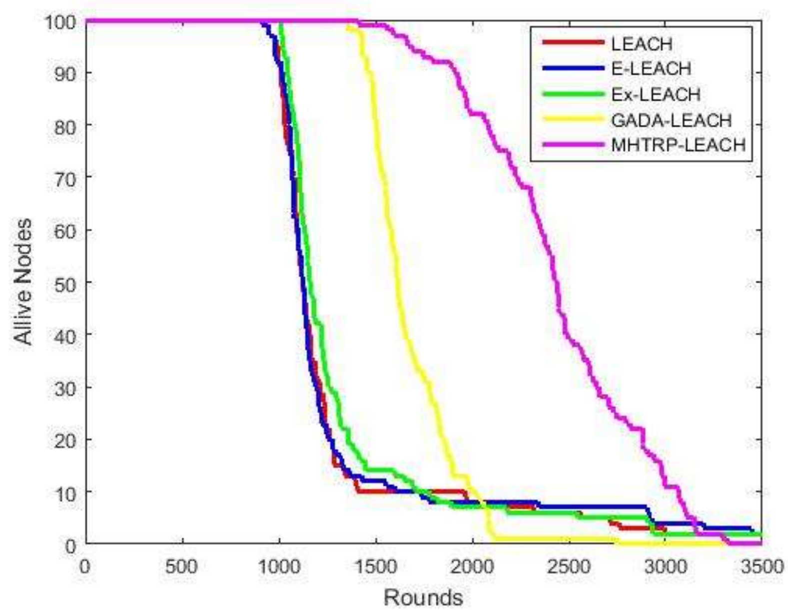

Figure 7.8 Plot of comparison of network lifetime LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-

LEACH when packet size=4000

So from above observations it can be concluded in fig. 7.9 that size of packet to be transmitted has effect on the network lifetime in WSN. Higher the size of the packet higher is the consumption of the energy.

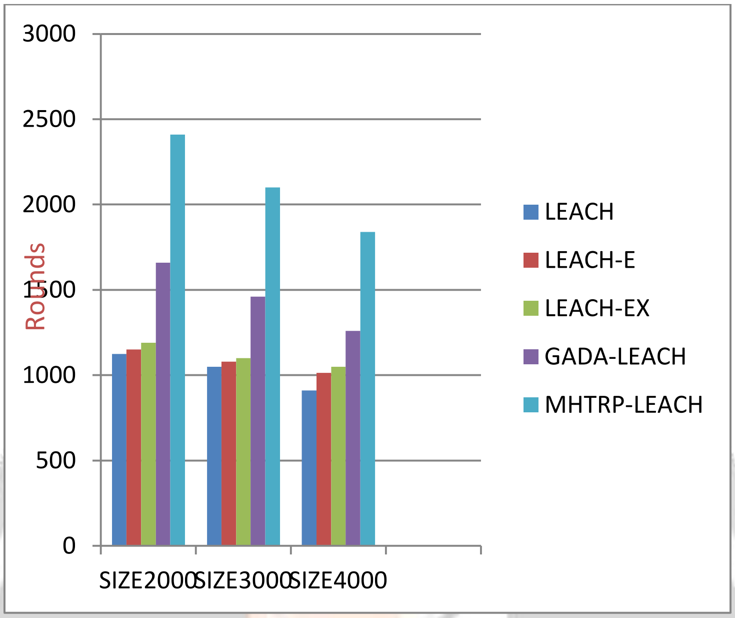

Figure 7.9 Network Lifetime LEACH, LEACH-E, LEACH-EX, GADA-LEACH and GADA-LEACH when varying packet size

7.2.4. Comparison of Packets Delivered to Base Station

Fig 7.10 shows the number of packets sent to the base station in LEACH, LEACH-E, LEACH-EX, GADA-LEACH and MHTRP-LEACH. MHTRP-LEACH runs for more number of rounds than other protocols so the number of packets sent to BS is more followed by GADA-LEACH, LEACH-EX, LEACH-E and LEACH.

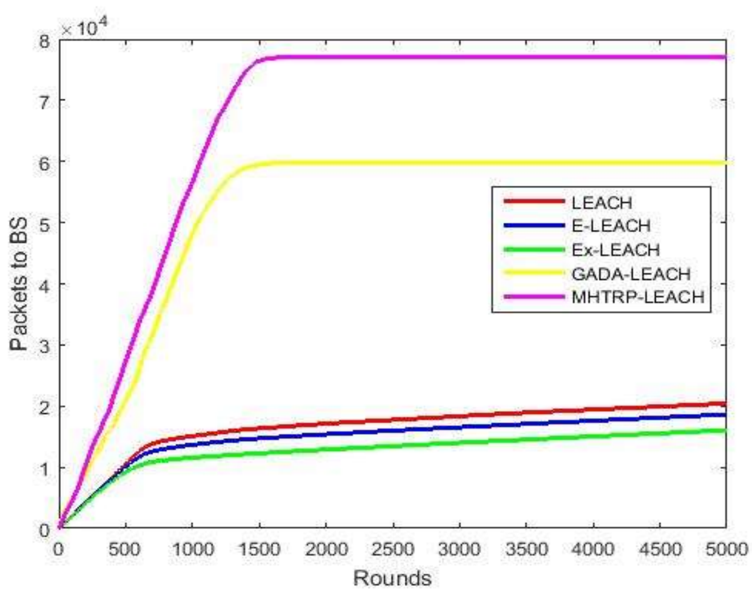

Figure 7.10 Packets Delivered to Base Station in MHTRP-LEACH, GADA-LEACH, EX-LEACH, E-LEACH and LEACH

Packets to BS will be sent till round MHTRP-LEACH send to the more number of data in comparison to GADA-LEACH, EX-LEACH, E-LEACH and LEACH, Which shows that due to having more network stability it runs for more number of rounds and more number of packets is sent to BS in MHTRP-LEACH and shows significant improvement.

8. CONCLUSION & FUTURE SCOPE

8.1 Conclusion

In paper an optimized scheme with Multi hop TEEN based Routing Protocol is proposed. Network lifetime of proposed scheme MHTRP-LEACH is compared with LEACH, LEACH-E, LEACH-EX and GADA-LEACH by varying the initial energy and size of the packet. MHTRP-LEACH proves to perform better by providing improved results in comparison. The first node died at 1504th round in MHTRP-LEACH whereas first node died at 1371th, 1008th, 994th and 875th round in GADA-LEACH, LEACH-EX, LEACH-E and LEACH respectively.

Due to improved CH selection and introduction of relay node in the network the data sent to the BS is more as there is increase in network stability. It can be concluded that the introduced approach is better and efficient than the conventional approaches as it include more number of parameters in fitness function for selecting the cluster head and also introduction of intermediate node i.e. relay node reduces the distance between the cluster head and sink and to ease the communication between them.

8.2 Future Scope

In this scheme, it is proposed to introduce a relay node as an intermediate node between cluster head and sink that helped to increase energy efficiency which in turn improved the network lifetime. Cluster head selection procedure is improved by using MHTRP. Further the improvements can be made in the scheme by using sleep and awake concept. In this concept all the nodes do not remain active throughout. The energy of the nodes will be calculated and the node having highest energy will be awake and the rest of the nodes will be considered sleeping i.e. there will be no movement in them. This concept of sleep and awake nodes will also enhance the energy of the system and will increase network lifetime. Further enhancements can be done by using other swarm intelligence optimization techniques for getting more optimized results. Still number of improvements can be made in the proposed scheme and better results can be obtained.

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