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ENERGY EFFICIENT IMPROVED LEACH PROTOCOL FOR WIRELESS SENSOR NETWORK

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***Abstract* - This research work deals to minimize energy spending of nodes and maximize lifetime of sensor network. As original LEACH (Low Energy Adaptive clustering Hierarchy) protocol selects cluster head (CH) on the basis of a random number generation and it does not see residual energy of nodes. In our dissertation, we proposed a modified cluster head selection algorithm and cluster formation algorithm. Proposed cluster formation algorithm executes in less number of iteration than existing K-Mean algorithm. The cluster formation is done on the basis of nearest neighbor distance algorithm which is an improvement over k-mean algorithm of forming clustering structure. Our simulation outcome show that our proposed protocol is improved in terms of dead node occurrence, percentage of the alive nodes, residual energy and throughput of the sensor network. Hence proposed cluster formation selection of cluster head have performed better than the original LEACH protocol.**

Keywords* –Network Lifetime, Clustering, Wireless Sensor Network, Residual Energy*

I. INTRODUCTION

Nodes of sensor networks have very limited battery power, memory capability and radio frequency [1]. It is very necessary to save energy of the Nodes. For energy consumption, we form a different clusters using different algorithm such as k-mean, k-Sep, and near neighbour distance algorithm [2]. After cluster formation we choose cluster head (CH) in every cluster on the basis of different parameter. There are two basic approaches may not well balanced between energy and load of the nodes for Smallest Energy Transmission and Straight Transmission of Wireless Sensor Network (WSN)[3]. In Straight Transmission sensor nodes send their information straight to the sink as a result; there exist a single hop contact between base station and cluster head. The clients die first who are far away from the sink. The smallest transmission energy used min cost path [4][8]. For figuring out these types of problem, LEACH is proposed which guarantees that the dynamically created clusters have effortlessly distribution energy load. At the Leach cluster head are selected on probabilistic basis, a random bit is generated between 0 and 1 [5][10]. Cluster formation is an operation in which each sensor node decides which CH they should link among various alternatives. In our proposed algorithm used extra more factors as like remaining energy, throughput and degree of node which take the decision for cluster head selection [6]. For instance if advertisement message received by a sensor node X from three special CHs P, Q and R. For choosing CHs the essential parameters are included distances, residual if P advertizes (.8j, 170), Q advertizes (.2, 110) and R (.5, 120) advertizes message. If we get a distance parameter, then Q is picked out as a cluster head, but it is a bad choice because of it has lower residual energy over all [8].

Rest of paper structured as section second focused on related work, in section III presents wireless sensor networks protocol named as LEACH. Section IV indicates planned cluster head election algorithm. Section V includes discussions based on simulation results and conclusions and future work are presents in section VI.

II. RELATED WORK

In 2007Sangho Yi , Junyoung Heo have proposed Power-efficient and adaptive clustering hierarchy protocol(PEACH) for WSN. Peach protocol works on both known location as well as unknown location based information. The following equations show the calculation of transmission and getting vitality expenditure for a k-bit package over separation. In the equations, $E_{Tx-Elec}$ and $E_{Rx-Elec}$ Are the power debauchery of sender and recipient circuitry, respectively. E_{Tx-amp} Is the energy profligacy of the transmit amplifier.

$$E_{Tx}(k, d) = E_{Tx-Elec}*k + E_{Tx-amp}*k*d^3$$

$$E_{Rx}(k) = E_{Rx-Elec}*k$$

In basic leach there are two phases, the cluster setup phase and data transmission phase. In LEACH [2] protocol the phase of bunch setup, the probabilistic approach used for election of group. We select extreme value for each bunch node. An arbitrary value is generated between 0 and 1 and we compare this arbitrary number to extreme value. If the value is less than extreme value then node is elected as a group head for current cycle otherwise it acts as a bunch member. In second phase of the protocol group head performs data aggregation and data fusion. Cluster head sends aggregated data to base station

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through multiple hops. LEACH-C is an improvement of LEACH algorithm [7][9]. In LEACH-C we use data centric routing algorithm. In data centric routing algorithm we find routing information when we are transmitting the message between sensor nodes after this we update the routing information. Typically data centric algorithm allows directed diffusion and SPIN. TL-LEACH is an improvement algorithm. In this algorithm there are two cluster head, Primary cluster head and auxiliary cluster head.

The location un-ware protocol is used whenever information of WSN is not available to every node. When GPS like hardware is present on network then location aware PEACH works. PEACH forms cluster without advertisement, joining and scheduling of message. In BANDYOPADHYAY presents the clustering algorithm based on randomization to systematize sensor nodes interested in clusters in a WSN. The most advantageous possibility is used to compute cluster head (CH). Recently LEO and LDACO is data centric algorithm. These algorithms have simple architecture but it suffers from problem of "Flooding". Flooding adds additional burden on sensor nodes to transmit information. TAO DU, 2013 proposed a new hierarchical routing algorithm with high Energy efficiency named EESSC, which is based on the improved HAC clustering approach. In EESSC, the sensor nodes' residual energy would be taken into account in clustering operation, and a special packet head is defined to help update nodes' energy information when transmitting message among the nodes. FAN YAN, 2014 proposed degree-energy-awareness principle in which data transmission is fast and every node in the network has to be updated each time so it is infeasible. In 2013 RASHMI RANJAN proposed Honey Bee Mating Based Clustering algorithm. It avoids the malicious node to be cluster head and generates the operating cost of cluster head selection mechanism in network management. In 2011 RAZIEH discuss about different energy efficient clustering protocols for heterogeneous wireless sensor networks and compares these protocols on various points like,

III. LEACH PROTOCOL

The nodes are arranged into various clusters and each cluster has its own cluster head. In that respect are various techniques of clustering such as adaptive clustering, hierarchical clustering and distributive clustering. Cluster heads are chosen along the base of different parameters such as minimum Euclidean distance, highest available energy among the sensor nodes and maximum node degree. In each cluster all cluster member nodes send out information to the cluster-head. There are two basic approaches for data transmission, which is experienced as direct transmission (DT) and minimum transmission energy (MTE). Both approaches have some disadvantage. Indirect transmission data is immediately transferred from cluster head to outside base station, which consumes more energy because of cluster head, can be far away from sink node. In minimum transmission energy method dead node occurs soon .hence this method increases transmission time and re-election of cluster head. In basic leach there are two phases, the cluster setup phase and data transmission phase. At the time of bunch setup phase in LEACH [2] the group heads are elected on the basis of probabilistic approach. We select a extreme value for each bunch node. An arbitrary value is generated between 0 and 1 and we compare this arbitrary number to extreme value. If the value is less than extreme value then node is elected as a group head for current cycle otherwise it acts as a bunch member. In second phase of the protocol group head performs data aggregation and data fusion. Cluster head sends aggregated data to base station through multiple hops. There are two basic approaches for cluster formation which is known as k-mean and near neighbor clustering. In k-mean algorithm we divide the n nodes into k cluster and we calculate Euclidean distance between nodes. We assume initial seeds point (centers of each cluster) and run the algorithm for several epochs. After each epoch we form the new clusters and centers of each cluster. Finally we calculate the centroid of each cluster. In nearest neighbor clustering we check all nodes closer to the cluster on the basis of Euclidean expanse. Initially we assume node 1 belongs to cluster 1. On the basis of this we evaluate distance of second node to first node. If this separation is greater than extreme value then it joins new cluster. This process executes in less time and takes less iteration as compared to the k-mean algorithm. The extreme value is computed as follows [6]:

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

Where p denotes bunch-head probability, existing cycle's value is r and group of hubs G which have not considered

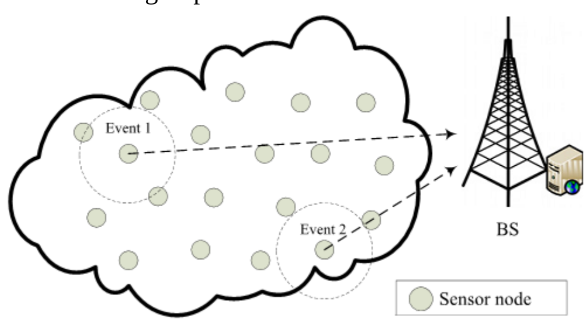

Figure no. 1: Wireless Sensor Network Model

group-heads in the end $1/P$ rounds. In each round group head delivers an announcement message (ADV) to its bunch member. Each non gathering head canter points takes choice about its selecting so as to gather head for this cycle the gathering head that need least correspondence, imperativeness, in light of the got signal quality of the declaration from every gathering head. It is decides that every node belong to which group, the group head know that node is joined by receiving message of link request (Join-REQ). The head node of the

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group sets up a The group head hub sets up a time division multiple access schedule and delivers this plan to all the member hubs within associated group.

IV. PROPOSED LEACH

We recommend a new scheme that focuses on reduction of energy expenditure using algorithm for selection of cluster head and cluster formation. The technique of cluster head selection is based on highest ratio of residual energy and distance from base station. Cluster formation technique is based on threshold distance and threshold value is determined by "the mean distance of all data-points to the center of their distribution". Let x be the center-of-mass of all data-points, the threshold is defined as the mean distance of all data-points to x. K-MEAN clustering is also known as partition based clustering in which we perform grouping of sensor nodes into different clusters. This algorithm is based on Euclidian distance. The location of the different sensor nodes and their clustering are shown below by graph.

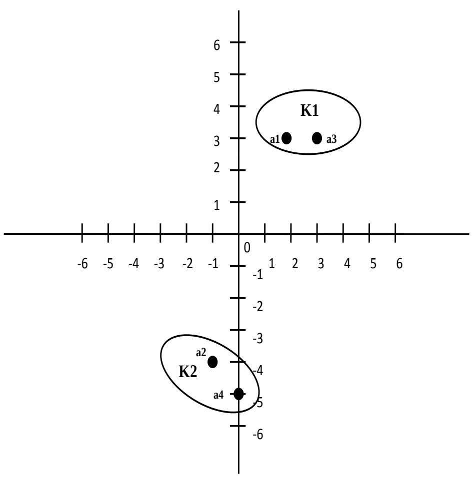

Fig. 3 Cluster Formation of Nodes

Modified Approach of Cluster Formation

In modified approach of cluster formation we calculate distances between the different sensor nodes and then we construct distance matrix. In modified approach we set threshold distance and its value is determined by "the mean distance of all data-points to the center of their distribution". Let x be the center-of-mass of all data-points, the threshold is set on the basis of every data points to x as their mean distance. Initially we assume first node belongs to first cluster. On the basis of this we evaluate distance of the second node from the first node. If this distance is larger than threshold distance value, then second node joins the new cluster. If distance is less than threshold distance then second node joins previous cluster. This process is continued for considering remaining nodes for cluster formation. We calculate distances of remaining nodes from nodes which are already in clusters and then we decide one by one to join existing cluster or member of new clusters by comparing minimum value from threshold (Th).

Algorithm of Threshold Distance Calculation

Step1: Read coordinates of the nodes (x_i, y_i)

For (i, j = 1 to n)

{

Step1a. Calculate distances between the nodes using Euclidean distance formula

$$d_{ij} = \sqrt{((x_i - x_j)^2 + (y_i - y_j)^2)}$$

}

Step2: Find Mean (M) of nodes (x_i, y_i)

For (i= 1to n)

{

$$M_x = \sum_1^n \frac{x_i}{n}$$

$$M_y = \sum_1^n \frac{y_i}{n}$$

$$M = (M_x, M_y)$$

Step 2a. Calculates distances of nodes (x_i, y_i) from $M(M_x, M_y)$

D_{Mi} = distance $((M_x, M_y)\ (x_i, y_i))$

Step 2b. Calculate mean of the D_{Mi}

$$M_D = \sum_{i=1}^{n} \frac{D_{Mi}}{n}$$

}

Step 3: Set M_D as threshold value (Th)

Threshold (Th) = M_D

Modified Cluster Formation Algorithm

1. Consider first node in cluster 1
2. For (i = 2 to n)
   {
   Calculate distances of remaining node (n_i) from $(n_1\ to\ n_{i-1})$
3. Find Min distance $(D_{min}) = \{d_1, d_2, d_3, \ldots \ldots . d_{i-1}\}$
4. Set S= D_{min}
5. If (D_{min} < Threshold distance (Th)
   {
   Node (n_i) joins that node (x_i, y_i) from which D_{min} is obtained then Node (n_i) joins the same cluster.

   }

Else

{

node (n_i) joins new cluster

}

}

Existing Approach of Cluster Head Election

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In existing approach, head selection is based on random number generation which lies between zero and one. We set the threshold value according to below equation .T (n)

$$= \begin{cases} \frac{P}{1-p\left(r \bmod \frac{1}{p}\right)} & \text{if } n\epsilon G \\ 0 & \text{otherwise} \end{cases}$$

Where p is the optimum cluster head probability, the total number of the nodes is n, r is the recent round and The group of nodes is G that have not chosen cluster head in most recent 1/p rounds. The cluster head is selected for most recent round if nodes random number is less than threshold value.

This algorithm is described by following example.

Let there are four sensor nodes that are located in different position, a1 (3, 3), a2 (-1, -4), a3 (2, 3), a4 (0, -5). Distance matrix is calculated with the help of Euclidean distance formula. Euclidean distance between the two nodes whose coordinates are (x1, y1) and (x2, y2) is calculated below by formula

$$D = \sqrt{(x1-x2)^2 + (y1-y2)^2}$$

TABLE I DISTANCE MATRIX OF SENSOR NODES

Node	a1	a2	a3	a4
a1	0	8.1	1	8.5
a2	8.1	0	7.6	1.41
a3	1	7.6	0	8.2
a4	8.5	1.41	8.2	0

In this approach we use threshold distance which is calculated below.

Center-of-mass of all data-points (x) = {(3+ (-1) + 2 +0) /4, (3+ (-4) + 3+ (-5) /4)}

= {1, -3}

Distance of a1 to x (d1) = 6.32
Distance of a2 to x (d2) = 2.23
Distance of a3 to x (d3) = 6.08
Distance of a4 to x (d4) = 2.23

Mean of these distances = {(d1+d2+d3+d4)/4} = 4.21 = Threshold distance value (Th)

Step1: a1 is placed in its cluster 1 hence K1 = {a1}

Step 2: d (a1, a2) = 8.1> threshold value (4.21) hence we put a2 in another cluster K2 = {a2}

Step 3: we calculate distance from a3 to a1 and a2, a3 is nearest to a1 by using distance matrix and d (a3, a1) = 1< threshold value (4.21) so we put a3 in cluster 1 hence K1 = {a1, a3}

Step4: we calculate distance from a4 to a1, a2, a3 but a4 is nearest to a2 by using distance matrix and d (a4, a2) = 1<4.21 so we take K2 = {a2, a4}

Hence centroid of K1 cluster = (2.5, 3) and centroid of K2 cluster is (-.5, -4.5).

Modified Approach of Cluster Head Selection

In modified approach of cluster head selection, we chose the cluster head on the basis of highest ratio of remaining energy

TABLE II RATIO OF RESIDUAL ENERGY AND DISTANCE

Node	Distance from base station (3, 5) (di)	Residual energy (E_i) in jule	Ratio ($\frac{Ei}{di}$)
a1 (2, 3)	2	.35	.175
a2 (-1, -4)	9.84	.25	.0254
a3 (3, 3)	2.23	.40	.179
a4 (0, -5)	10.44	.30	.0287

and space from base station. In existing approach we select the cluster head on the basis of random number generation. Existing approach of cluster head selection does not Considered residual energy. In modified cluster head selection algorithm we take both parameters distance from base station and residual energy of each node in each cluster.

Let there are four sensor nodes that are located in different position, a1 (3, 3), a2 (-1, -4), a3 (2, 3), a4 (0, -5). Cluster formation is shown below.

Initially all the sensor nodes have same amount of energy (.5 Jules) and we calculate distance of each sensor node from base station in each cluster. In above figure there are two cluster sets K1 and K2 and we have to select cluster head in K1 and K2. Below table (Ratio of residual energy and distance) is constructed with the help of residual energy equation and Euclidean distance formula.

The energy dissipation for transmitting an L bit message from the transmitter to the receiver at the distance d is defined as:

$$E_{Tx}(l,d) = \begin{cases} L.Eelec + L.\in fs.d^2 & if\ d < do \\ L.Eelec + L.\in mp.d^4 & if\ d \geq do \end{cases} \quad (1)$$

"Where E_{Tx} is the energy dissipated by the transmitter and Elect is the energy dissipated per bit to run the transceiver circuit. The parameters $\in fs$ and $\in mp$ depend on the transmitter amplifier used in the energy model. The amplifier parameter for the free space propagation model is $\in fs$. The amplifier parameter for the two-ray ground propagation model is $\in mp$. The crossover distance, d0, can be obtained from." $d_0=\sqrt{x/y}$ where x = ∈ fs and y = ∈ mp.

Euclidean distance formula is shown below

$$d=\sqrt{((x_i - x_j)^2+(y_i - y_j)^2)} \quad (2)$$

In cluster K1 we have selected a3 node as a cluster head because it has highest ratio of residual energy and distance from base station. In cluster K2 we have selected a4 node as a cluster head because it has highest ratio of residual energy and distance from base station.

Proposed Cluster Head Selection Algorithm

Selection cluster head (n)

Step1: For (i= 1 to n)

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{
Step2: For each node calculate remaining energy (E_i) and space from base station (d_i) and correspondingly calculate ratio (R_i) of remaining energy (E_i) and space from base station (d_i) as $R_i = \frac{E_i}{d_i}$
Sort the ratio in ascending order
}
Select the node as tentative cluster head and broadcast their ratio in the cluster nodes
Step3: All cluster nodes receive the ratio of current cluster head and compare with own ratio as
if (node ratio > received of cluster node's ratio)
{
Node becomes cluster head and broad cost their ratio to all cluster's nodes go to step 3
}
Else
Current node is a cluster head
}

V. SIMULATION RESULT AND DISCUSSION

We simulate our work using MAT lab software. The simulation for clustered based wireless sensor network area dimensions $100m \times 100m$. The parameters of the simulation are as shown in table 1. The numbers of sensors is n = 200 and these nodes both usual and sophisticated are equally spread over area. From figure no.4 it is clear that the number of the dead nodes occurs after more rounds in the proposed heterogeneous leach protocol than basic leach and in that respect are more dead nodes in basic leach which reduces data transmission rate and increases more traffic between the sensor nodes.

TABLE III SIMULATION PARAMETERS

Parameter	Value
Simulation Area(m)	100 x 100
No. of Nodes	200
Radio Propagation Model	Two ray Ground
Channel Type	Wireless Channel
Optimum Probability(P)	0.2
Initial Energy	0.9
Base Station Location	(50,50)
Data Packet Size	4000 bit
Data Aggregation Energy	5nj bit signal
Maximum No. of Rounds	100
Free Space Propagation(regular)	10 pj bit /m^2
Multipath Propagation(regular)	0.0013 pj bit / m^2
Percentage of Advance Nodes(m)	0.1

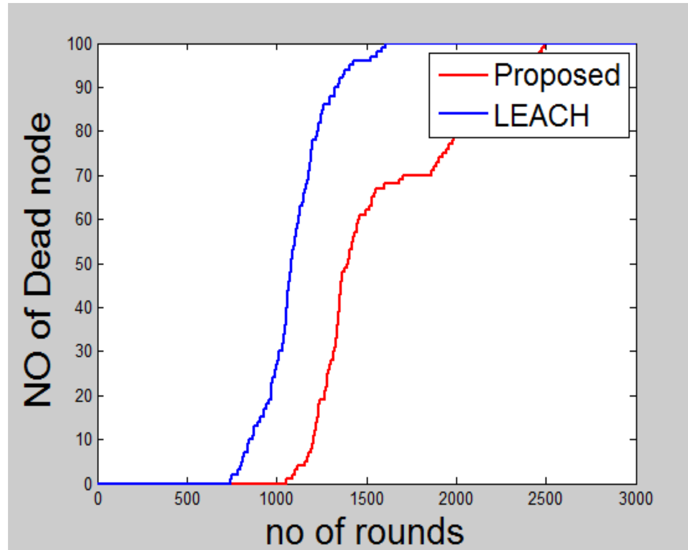

Fig. 4 No. of dead node occurrence in specific round

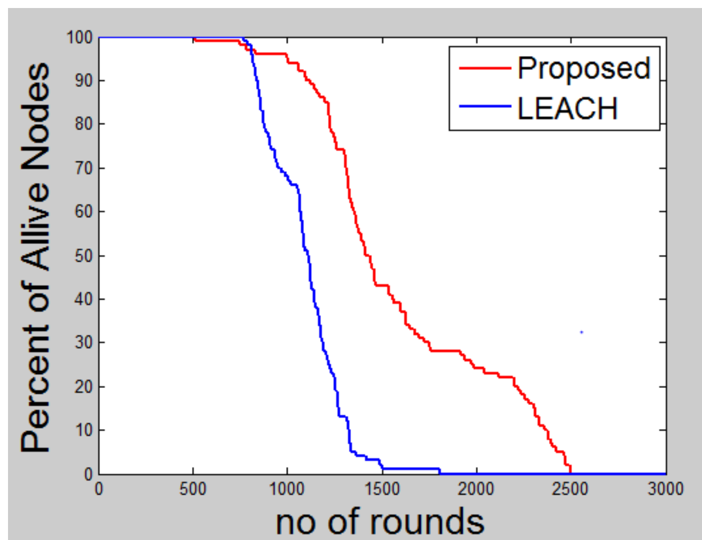

Fig. 5 Percentage of alive nodes in each round

Fig.ure 7 indicates throughput of the whole network. Throughput is showed as the fraction of the message length and broadcast time. In our proposed protocol there is less transmission time to send information from transmitter to receiver, hence it increases system performance and wastes less energy.

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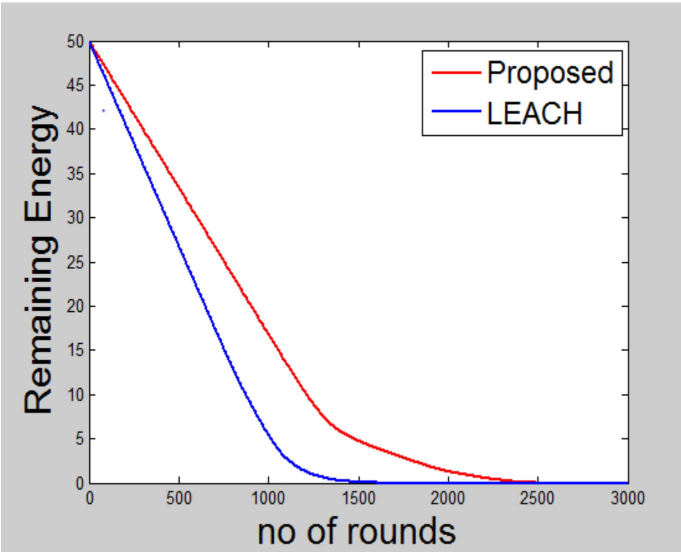

Fig.6 Percentage of the remaining energy in each round

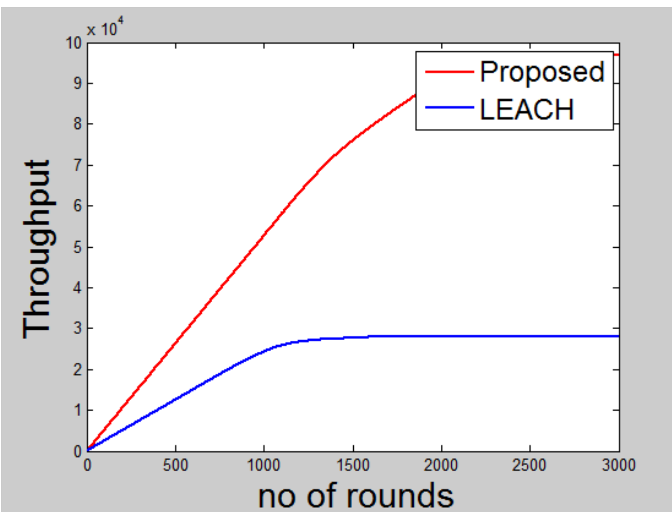

Fig. 7 Maximal throughput of the nodes in current round

VI. CONCLUSSION AND FUTURE WORK

In our dissertation work we have proposed a modified cluster head selection algorithm and modified cluster formation algorithm. In proposed LEACH protocol we have introduced a modified cluster formation algorithm based on Euclidean distance and threshold distance. In modified cluster formation algorithm we set threshold distance and threshold value is determined by "the mean distance of all data-points to the center of their distribution". Modified cluster formation algorithm executes in less number of rounds than the existing approach (K-MEAN) algorithm. In modified cluster head selection algorithm we were taking highest ratio of residual energy and distance from base station. In cluster head selection algorithm we find the ratio of residual energy and distance from base station for each sensor nodes in each cluster, we sort this ratio in ascending order and select that node as a cluster head which have highest ratio compared to other nodes in each cluster. The experimental results are clearly indicated that proposed LEACH is further accurate and balance on the basis of number of dead node occurrence, energy level, throughput and number of alive nodes.

In future work we will take heterogeneity of energy efficient clustering algorithm. We will take more parameters such as node degree and data aggregation for cluster head selection and more coverage of the sensing field.

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