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# Clustering Methodology for Improving Network Energy using LEACH Protocol in WSN

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***ABSTRACT:*** ***WSN- Wireless Sensor Networks is composed of tiny sensor nodes which are made up of sensors which sense change in temperature, light, humidity, radiation and more. These makes possible to monitor different types of environment for applications according to requirement. WSN is not able to operate sensors of network for long time period. In such type of networks amount of transmitted data between sensor nodes and base station is reduced with the help of data fusion. Different protocols are used for different purposes. Clustering in sensor network is an effective topology that encourages designing energy efficient protocols to develop sensor nodes with low cost. Elegant solution for this data collection problem is LEACH (Low-energy adaptive clustering hierarchical) protocol, in which self-organized small no. of clusters are formed. In this paper we proposed an algorithm that is considered as modified version of LEACH and with the help of MATLAB simulator we appraise the performance of improved protocol in case of network lifetime, no. of dead nodes and alive nodes in resemblance with existing protocol.***

***Keywords— Routing, LEACH, Energy efficiency, Energy level, Number of Cluster head NCH, Network lifetime, Cost Function.***

## 1. INTRODUCTION

WSN is considered as latest improvement in electronics area and wireless communication. WSN is consists of thousands limited battery operated nodes .Nodes are made up of radio for transmission and receiving, sensing, storage, data processing, mobilizer and global positioning system (GPS).These nodes are localized in large geographical area. These sensors are used to get different conditions of environment that are present surrounding them and then they transforms the data into electrical signals after that these signals are processed to get characteristics of remotely present area where sensors are present.. This is type of ADHOC network in which sensor

nodes first collects then processed and in last communicates data that they get from physical environment. They are distributed event based systems. There are several things that made them different from traditional communication networks such as they can easily adapt the environmental changes, they guarantee the optimization of entire network, provides interference between different users, also sensor networks save severe energy constraints, diffuse low-rate data.

Sensor networks have considered as a promising tool for analyzing the physical world, utilize self-organized nodes that can sense, process and communicate and are battery powered. In such networks, energy is a main as well critical resource, where exhibit have a limited characteristics. So that, this is necessary to optimize network architecture so resources consumed is minimized. Their boundaries form their design and protocols both stimulating and different.

## 2 LEACH PROTOCOL

LEACH is a hierarchical type protocol in this, every node transmit to cluster heads, and then cluster heads collects and process the data and transmit it to base station. Wireless sensor network is divided into several clusters in LEACH. Possibility of becoming cluster head node is equal for all nodes because it is selected randomly and energy consumed in network is averaged. Therefore, LEACH increases the life-cycle of network. In this, operation is divided into rounds, in every round there is different set of nodes are cluster heads (CH) .LEACH runs with N rounds and 1 node can become cluster head only once therefore each node have 1\n probability in every round .When round ends, those nodes which are not selected as cluster head joins the nearest cluster to transmit its data (laiali).LEACH uses single hop routing where nodes directly transmit to cluster head. LEACH performs its job in two different phases: - Cluster Setup State and Steady State. In first step i.e. setup state, it creates cluster by organizing themselves and in second phase, steady state, it transfers that data and it will take more time.in every round 5% of total nodes are comprising as cluster heads. Here desired percentage of cluster head is P, current round is r, and set of nodes that have not been cluster heads in last 1\p rounds is G.

Each node will be cluster head at some point within 1\p rounds with help of threshold. Node that become cluster head once can never become again in 1\p-1 rounds. Each node has probability of 1\p becoming cluster head in every round.

Those nodes which are not selected as cluster head joins the nearest cluster to transmit data. Cluster head is responsible to compress and combine and then transfer it to base station, therefore life spans of nodes extends. In this algorithm energy consumption allocated equally to all nodes and non-head nodes are turning off as much as possible. LEACH expects that all nodes are present in range of transmission of base station which is not the case of many deployments. Out of total nodes only 5% of those nodes play the role of heads in every round. For better management and schedule Time Division Multiple Access (TDMA) is delivered.

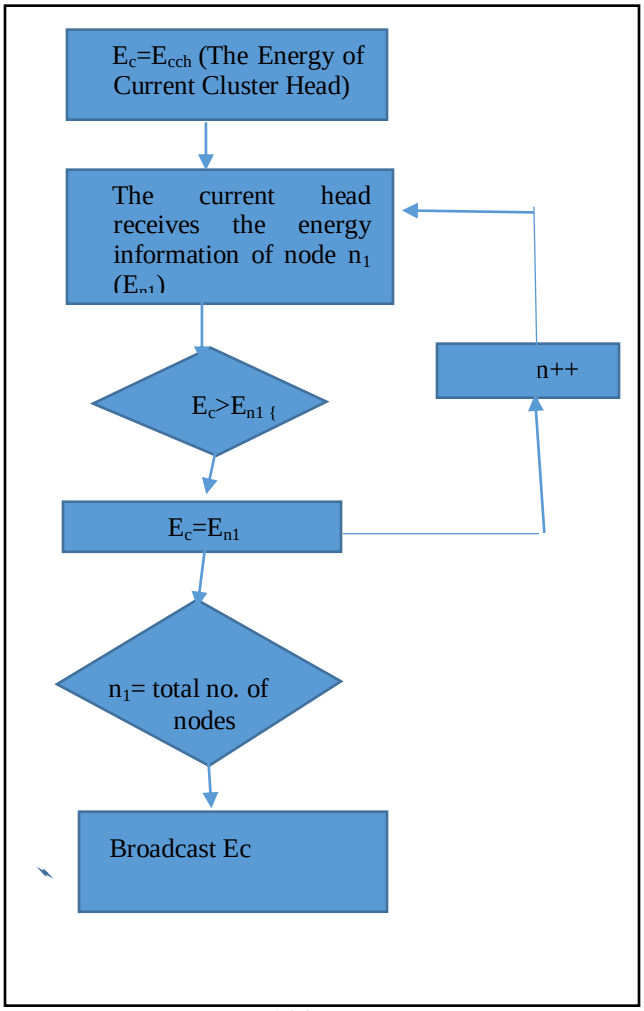
### 2.1 Problems With Traditional Leach

LEACH or all nodes to be selected as cluster head is may be considered as drawback. After several rounds probability is same for every node, there is no difference which node having less energy or which has more. If the selected cluster head node is having less energy then it will die earlier that's why lifetime or strength of network is affected. Network will no longer present.

Clusters are randomly divided in traditional LEACH protocol so it principals to rough distribution. Hence it is not compulsory that distribution of clusters is best. In such type of distribution some have more nodes where as some have fewer nodes. Cluster heads are also selected randomly therefore their positions are also not defined where they are present at center or at corner of cluster. How far are they from members? This will increase energy consumption and effect the overall performance of network.

## 2.2 Improved Leach Protocol




```
1     Ec = S(1).E;
2     for i=1:1:n
3     if ((S(i).E)<Ec)
4     Ec = S(i).E;
5     end
6     end
7     if(Ec==Eo)
8     Ec=0;
9     End
10    End
```

DEFINITION 1: ***Ec*** is the residual energy of cluster. DEFINITION 2: ***En1*** is the remaining energy of the node *n1* within the cluster.

***Ec*** can be expressed as: (2) ***Ec*** □ **min(*En1*)** Where

***Ec*** is the least value of the residual energy of every node in the cluster.

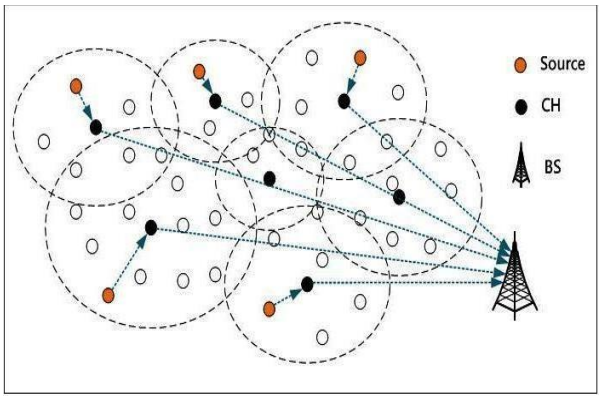



**Figure 1: Clustering based routing in WSN**

### 2.3 Working Principle

LEACH is hierarchical routing algorithm which is most popular for sensor networks. LEACH sensor nodes are combined in order to form clusters on the basis of received signal strength and then those cluster heads, act as routers to the sink. Transmission can be only done by cluster heads instead of all other nodes which will save energy. Protocol division can be done into rounds; every round is consists of two phases:

| **Set-up Phase** | **Steady Phase** |
|---|---|
| (1) Advertisement Phase | (1) Schedule Creation |
| (2) Cluster Set-up Phase | (2) Data Transmission |

**Setup Phase:**

Node may become CH or not each node decides $_{\varepsilon}$ independent of $_{\varepsilon}$ other nodes. This decision takes into account when the node served $^{\varepsilon}$as a CH for the $^{\varepsilon}$last time (the node that hasn't been a CH for long time is more possible to select itself than nodes that have been a CH recently).CH informs all neighborhood nodes that it becomes CH with advertisement packet in this advertisement phase. Non-CH nodes pick those advertisement packet which have the strongest signal strength. In the next cluster setup phase, those members who joins with CH tells the CH through transferring "join packet" in which their IDs using CSMA are present. After the cluster setup sub phase, the CH is known to number of members and their IDs which are present in their cluster. As per received messages basis CH creates a TDMA schedule and send it to all cluster members also pick a CSMA code randomly. After that next Steady-state phase starts.

**Steady-state phase:**

Data can be send to CH by nodes in their allocated TDMA slot during data transmission. A minimal amount of energy is used in this transmission that is chosen on bases of received strength of the CH advertisement. While TDMA slot is not allocated to non-CH node, its radio can be turned off so that minimizing energy is distributed in these nodes. When data from every node is collected by CH then it combines this data and transmit it to base station. LEACH combines the data that it gathers from different nodes of cluster to reduce the amount of data transmitted to base station.

Although LEACH performs in good manner but it also suffers with following drawbacks;

- CH can be selected randomly, energy consumption is more.
- It is not able to work in large area.
- CH can be located anywhere in cluster that is it may be present at edge of cluster.

### 2.4 Disadvantages

- In LEACH Protocol there is no knowledge of location of sensor nodes and how many cluster heads are present in network.
- Location of cluster head is not present it may be at corner of network and it directly transmits data to base station so lots of energy is consumed in this.
- Transmitting and collection of data is done by CH so it will die earlier than other nodes.

- Main drawback is considered as if CH dies than network become useless because gathered data is lost and no other node able to transmit data to base station.

## 3 PROPOSED WORK
## COST EFFECTIVE ENERGY-AWARE ROUTING IN WIRELESS SENSOR NETWORKS:

### 3.1 Leach-A* Routing Algorithm

Use of cost function is an important criteria for positioning in heuristic searching algorithm A*.Different cost function results to different effects. e.g

A cost function is as follows:-

$Fun\ (n) = g1\ (n) + h2\ (n)$ (1)

In formula (1),

- *fun*(*n*) is the cost function of the node *n*
- *g1* (*n*) real cost from source node to current node in state space
- $h_2$ (*n*) is the estimated cost of an ideal path from current node to target node. *h2* (*n*) is the essence of the heuristic searching algorithm A*, Optimal path can be find out through heuristic searching of *h2* (*n*).

### 3.2 Presuppositions

In the beginning, the wireless network is divided into clusters by the node location algorithm. First step is to form clusters and then doing time sequence distribution of TDMA. Then LEACH-A* algorithm is used to solve a multi-hop data transmission path which is done in relevance of position and energy consumption information of nodes. It leads to stability of network transmission stage.

In wireless sensor networks following hypotheses are assumed:

1) Base station (BS) is of infinite energy.
2) BS and sensor nodes are at fixed positions.
3) Initial energy is same for sensor nodes and all are homogeneous.
4) Data can transmitted to BS from all sensor nodes.
5) According to some node localization algorithms, position of all nodes is known, able to broadcast their own location.
6) Communication radio energy consumption model is adopted for consumption of energy for all sensor nodes.

Following structure can define a node :

```
Struct Node
{
C_id;   // ID no of the cluster-head node
Position_X;  // X direction coordinate
Position_Y;  // Y direction coordinate
Select; / / if the node enlarges a path
//data broadcast energy consumption
// from cluster-head node k to its neighbor
//data tr ansmε ission energy consumption
// from c luster-head node l to base station
DistanceToBasestation[l];
Energy; // Residual energy
};
```

### 3.3 Leach-A* Algorithm Derivation

Cost function for heuristic searching algorithm LEACH-A* is. $Fun\ (n) = g1\ (n) + h2\ (n)$. Here g1 (n) indicates that energy which is consumed throughout the data transferring from one cluster head node to its neighbor cluster head nodes, which can be observed as basic nodes. It is an important factor for LEACH-A* algorithm to solve cost function *h2* (*n*) to find the best way through basic nodes.

The definitions of parameters are as follows:

| | |
|---|---|
| *Source* | Source Node; |
| *Target* | Target Node; \| |
| *P* | Intermediate node in path from *Source* to Target |
| *Q* | A node next to *P* ; |
| *E*( P , Q) | Energy consumption from P to Q ; |
| | Iydrtse |
| *h** | |
| *F (P)* | Minimal energy consumption from *P* to Target ; |
| 0 | |
| $0f_s^*(P)$ | Minimal energy consumption cost function, which equals to $gs^*$ (P) + $h^*$(P); |
| *bi7* | |
| *fS* ( *P* ) | Current energy consumption cost function From *Source to P*, which equals to *gS* ( *P* ) + *h*( *P* ) |
| ; $f^S_\varepsilon$ ( *P* ) | Equals to $g^*_\varepsilon$( *P* ) + *g* s( P ) + *h*( P ) , and ε is a key node in the path; |
| *E*min | Minimal energy consumption in data fusion. |
| *E*max | Maximal energy consumption in data fusion. |

There continues a linear relation between cluster-head nodes.
In other words, if a cluster-head node has predecessor cluster-head node or successor cluster-head node, for example Q is successor cluster-head node of, then any cluster-head node relation (P,Q) can be expressed as the following formula:

$h(P) \le E(P,Q) + h(Q)$ *(2)*

*E (P, Q)* is energy consumed through current way from P to Q. For any one of cluster-head nodes ε, if ε is not the node in the linked list CLOS EDLIST, we can define that:

$f_\varepsilon(P) = g*(_\varepsilon Source) + f_s(P)$ *(3)* $f_s$ (P ) is current consumed energy of a path from ε to Target and through node Source and P. So, we can draw the following conclusions:

1) $g*$(M) is the cheapest energy cost for ε to *M.*
2) *g p* ( *P* ) is the energy incurred from *M* to P.
3) *h*( *P* ) is estimated energy from P to Target.

Assumed that $SS_1S_2.....Sk$ is the least energy consumption route as the optimal route from Source to Target, we can assume the following conclusion:

$f^s(S_\varepsilon 1) \le f^s(S_\varepsilon 2) \le ... \le f^s(S_{i\varepsilon}) \le f^s(S_{i+1\varepsilon}) \le ... \le f^s(S_{k\varepsilon}) \le f^s(Target_\varepsilon)$

*(4)* In a wireless sensor network, the energy consumption of every cluster-head node includes three parts. Energy consumption for data transmission can be calculated according to the node positioning algorithm and the first communication radio energy consumption model.

During data fusion, due to too massive data nodes died earlier while too little data consume much energy for data transmission. In this case, both minimal as well as maximal energy consumption data fusion model is there. Assume that $E'_{send}$ is that of data transmission, E'received is energy consumption of nodes in the process of data reception, $E'_{fusion}$ is that of data fusion. As M is an intermediate node in LEACH-A*algorithm, we have the following inference:

$$g(M) = \sum_{k=1}^{n} Ek \qquad (5)$$

As $E_{min}$ and $E_{max}$ is the minimal and maximal energy consumption of the cluster-head node, every cluster-head node can be expressed as the following formulas:

$E_{min} = \sum k = (1E'received + E'min\_fusion + E'_{send})$ *(6)*

$E_{max} = \sum k = (1E'received + E'max\_fusion + E'_{send})$ *(7)*

From the above derivation, the cost function can be calculated.

$f'_{min} = min\{\{ f(P)\}_{max}, \{ f(P)\}_{max}\}$ (8)

$f'_{max} = min\{\{f(P)\}_{min}, \{ f(P)\}_{min}\}$ (9)

According to solve minimal value to the maximal extent and maximal value to the minimal extent, it is sure that we can solve a minimal energy consumption route as the optimal route of LEACH-A*.

### 3.4 Leach-A* Algorithm Pseudocode

Pseudocode of A*-LEACH algorithm is as follows: Pseudocode of A*-LEACH algorithm is as follows:

```
Best_Leach_Search( )
{
Openlist=[Node_Start];
Closed=[ ];
While (Open!=NULL)
        {
//Get a node X1 from linked list Open,
//and delete from Open at first
If (X1==Goal_node)
{
Calculate PATHCOVER;
Return PATHCOVER;
}
 If (X1_Node->next==Y1_Node)

{
If (Y1_Node!= Open[]||Y1_Node!= Closed[])
{
//estimated cost of node Y1
Calculate Y1_Node_Evalue;
Open=[Y1_Node];
}

Else if (Y1_Node== Open[ ])
{
//Sort linked list Open again
If (Y1  Node  Evalue<Open[i]. Evalue)


    //update estimated cost of Open  Update Open[j]. Evalue
    } Else
     {
    //Put node Y1 to linked list Closed;
                    // Sort linked list Open according to  cost;
    If(Y1_Node_Evalue<Closed[i]. Evalue)
    Update Closed[j]. Eval;
    Delete Closed[j]= Y1_Node;
    Put Open[j]= Y1_Node;
    } //end if
    }//end for
    }//end while
    }//end function
```

## 4. PERFORMANCE OF LEACH PROTOCOL:

For evaluating LEACH performance, a 100 X 100 network configured with 101 nodes is considered, where initial energy assigned to each sensor node is 2.0 J, transmission energy amount is 50nJ\bit, transmit amplifier energy (E amp ) is 100 pJ/bit. Network lifetime, energy consumption, data combination at base station and living nodes are the criteria for performance evolution. For evaluating performance criteria we varying the number of cluster heads from 1 to 8. Quality of data is determined with measure of amount of data (data signal showed by combined signal) that received at base station. We tracked the rate of data transferred to the base station and energy required to get the data to the base station.

## 5. PERFORMANCE EVALUATION:

Evolution of performance of the protocol is done by implementing it on ns-2 simulator along with LEACH extension. LEACH and LEACH-CC are simulated by using many random 100 nodes network. Location of BS (50,175) in 100m*100m field. Initial energy 2J is required for standing each node .we aim in conducting the simulation is the comparison between performance of LEACH-CC and LEACH protocol based on comparison of longativity and energy dissipation of network. Our simulation show that LEACH-CC achieves:

- Approximately 1.12x lifetime of network when we compare it to LEACH around 80% nodes die for a 100m*100m network.
- Approximately 1.2x the total amount of data received at the base station over time compared to LEACH for a 100m*100m network.
- Balanced energy dissipation among the sensor nodes to have full use of the complete sensor network.
- Near optimal performance.

Here performance of LEACH-CC is better than LEACH. Because in LEACH-CC base station of it have the knowledge of location and energy of nodes that are present in given network, so it can produce better clusters which requires less energy for transmitting data. Otherwise, chain routing is established between clusters to reduce amount of communicated nodes with base station. Fig. 5 shows the total number of alive nodes that remain over the simulation time, while in LEACH-CC nodes remains for a long time, approximately 1.12x lifetime of network when we compare it to LEACH around 80% nodes die for a 100m*100m network. Fig. 6 represents the total amount of data received at the base station over time. We say that LEACH can deliver 1.2 times less effectively data than LEACH-CC for same nodes deaths. Therefore LEACH-CC uses available energy more efficiently .In LEACH scheme cluster head is selected randomly in each round. LEACH performs in two phases:-*steady phase* and *set-up phase*. Throughout the set-up phase, a sensor node elects a random number between 0 and 1. If this random number is not more than the threshold T (n), the sensor node is a cluster-head. Here T(n) is :

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

Here P is the preferred percentage of become a cluster head; current round is r; and the set of nodes that have not being selected as a cluster head is G in the last 1/P rounds. After the cluster-heads are elected, the cluster heads advertise to all sensor nodes in the network that they are the new cluster-heads.

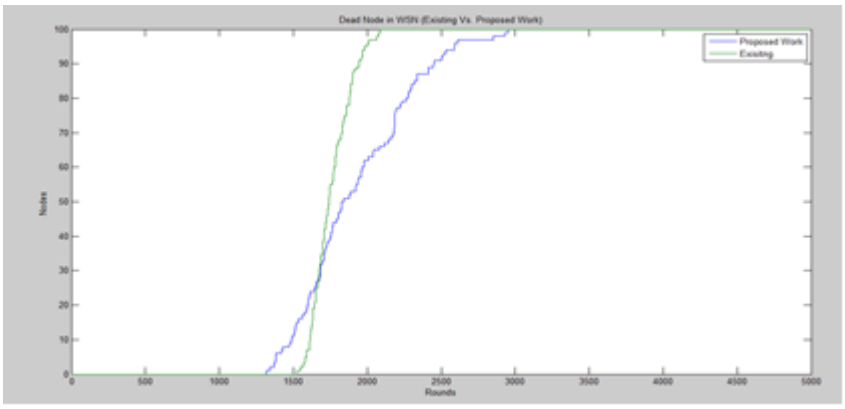



**Figure2: Dead Node in WSN (Existing vs proposed work)**

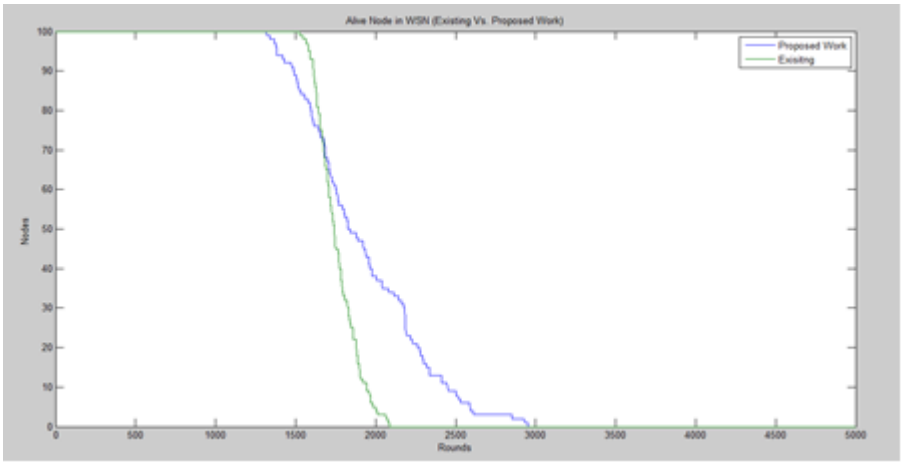



**Figure3: Alive Node in WSN (Existing vs Proposed Work)**

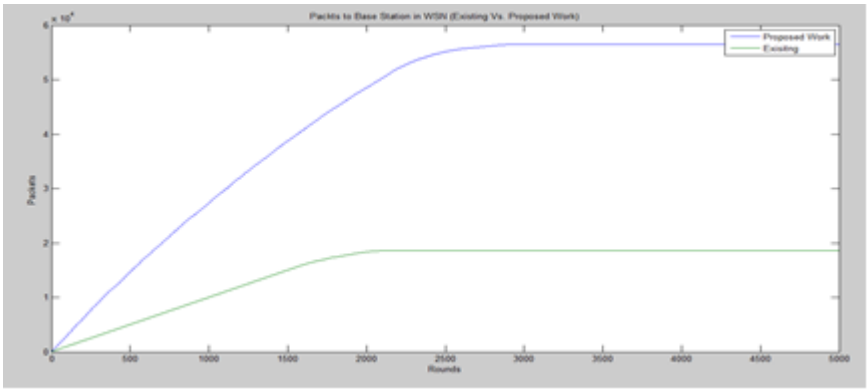



**Figure4:Packets to Base station (Existing vs Proposed Work)**

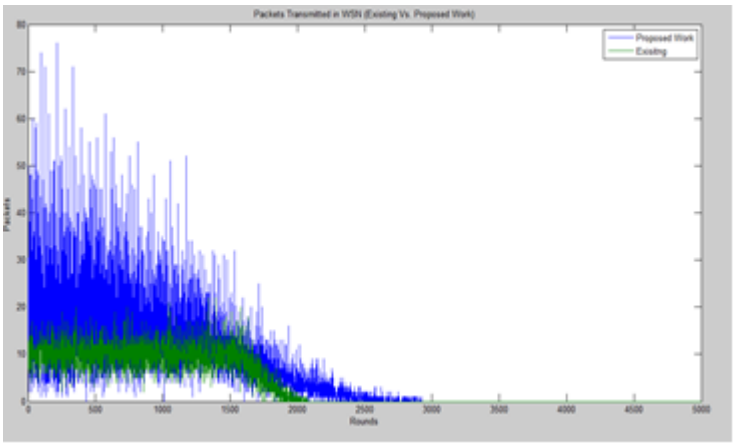



**Figure 5:Packets Transmitted in WSN(Existing vs Proposed Work)**

## 6. SUMMARY

In this paper, we represent a low energy-consumption chain-based routing protocol LEACH-CC. LEACH-CC exceeds LEACH with use of centralized clustering algorithm and by minimizing the distance of non-cluster heads to easy transmission of data. Only 1 cluster head is used to transmit the data to base station per round.

LEACH-CC allocates the energy load between nodes to increase the quality as well lifetime of network .Our imitations present that LEACH-CC executes better than LEACH by 1.12x the lifetime of network when 80% nodes die, and 1.2x the total amount of data received at the base station over time for a 100m*100m network. LEACH-CC presents an improvement in case of size of network increases as well.

$$T(n)=\begin{cases}\dfrac{P}{1-P*\left(r \bmod \frac{1}{P}\right)}*2P*\dfrac{E_{residual}}{E_{init}} & if \quad n\in G\\ 0 & otherwise\end{cases}$$

Here P is probability to become a cluster head, E residual is remaining energy of node and E init is initial energy of a node. If value of T (n) is larger than a number between 0 and 1 it becomes a cluster head.

After selecting cluster head, formation of cluster is done. Cost calculated by each node for joining a cluster, which incorporates the remaining energy and signal power strength of Cluster head. A node joins with cluster head which have largest cost value.

Cost (i) = CH (i) remaining energy + CH (i) signal strength

Here CH (i) remaining energy and CH (i) signal strength are remaining energy and signal strength of Cluster Head (i) Nodes calculate the cost value and join the cluster head with maximum cost value by sending the join message to cluster head.

## 7. CONCLUSION AND FUTURE WORK

In this paper, we introduced improved LEACH as a solution to limitations of traditional LEACH protocol. It can be able to solve the problem of probability of selecting node as cluster head is same. The problem of clusters head that are present at a corner of cluster and for communicating with members consumes more energy is solved. LEACH works on single hop routing but this paper defines multi path route algorithm based on energy hops. The simulation results shows: the improved LEACH consumes average energy of network and achieves the balance of network's flow and increase the life cycle of network. Since these constraints are precise and effective for sensor networks, new wireless ad- hoc networking techniques will have to be studied further.

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