An algorithm of the Shortest Path with Fuzzy Logic in Wireless Sensor Networks

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Abstract - *Development within the era of sensor such as micro electro mechanical structures (MEMS), wireless communications, embedded systems, and wireless sensor applications have contributed a huge transformation in wireless sensor networks (WSN). It improves overall performance of work both within the discipline of industries and day to day utility. Wireless sensor network has been extensively used in lots of areas in particular for surveillance and monitoring in agriculture and habitat tracking. The paper presents a method that can improves the lifespan of the wireless sensor network by using making use of the optimal path for the communication of the nodes. The outcome proves that the performance of the proposed work is better and much efficient to improve the lifespan of network.*

Key Words: WSN. Fuzzy logic, Clustering, LEACH, CHEF

1. INTRODUCTION

Wireless sensor network consist of distributed autonomous devices, called sensors which monitor physical conditions of environment for support of different types of applications. As Sensors have the ability to sense data, process and forward data to neighbour sensor node. For these purpose sensors use their resources energy, storage and computation capacity [1].

The major concern of sensor network is network performance and scalability. Network performance is achieved by increasing network lifetime/optimizing energy. Scalability is measured such that network performance should be constant with increasing network nodes. Hence wireless sensor network works as one in association as a network towards achieves a frequent goal of sensing a physical parameter over a huge geographic region with energy optimization [2].

In wireless sensor networks sensor nodes sense information, then forward to the base station. For efficient processing routing algorithms are accountable to choose an efficient path and forward data to the base station and increase network lifetime. Routing algorithms for sensor network must be QoS efficient. These QoS requirements include the end to end delay guarantee, bandwidth useful resource, energy consumption, loss packet ratio and the life of the network, etc. In wireless sensor networks field, there exist some algorithms to analyze the routing problem. But the most of all routing algorithms attempt to consider the energy consumption because the energy is a scarce resource to the wireless sensor node. Only some algorithms remember the QoS support at the same time. In this paper, we propose a new technique which find the optimal path for the communication.

For the aggregation of data through systematic organization of network, nodes can be subdivided into various small groups known as clusters. The phenomenon is called clustering. Every cluster has a supervisor known as cluster head (CH), and other member nodes. These CH are elected as: 1) The communication of members of a cluster with their CH can be done directly .2) The aggregated data can be forwarded to the sink station by a CH through other CHs.

Whenever any incident is detected by the nodes, they send the data to the base station or to the other nodes. Sometimes nearby nodes and base station receive the same information which causes inefficiency of the network. To prevents the network from this redundancy of data further creating the area of interest more energy optimized, fusion of sensor and data aggregation have been illustrated in the article[3].

This algorithm has following design goals: Increase energy optimization, and provide scalability to network [2]

2. LITERATURE SURVEY

In this part of the article parameter of sensors and different types of hierarchical protocols of routing [4] has been discussed in which election of cluster head is done efficiently.

Parameters of Sensor are:

a) Energy Efficiency: Energy is scarce resource of sensor network. So Energy consumption is one of the most challenging factor in designing the wireless sensor network. Energy consumption should be low for sensor network.

b) Scalability: As the number of nodes increases, wireless sensor network increases in size. With this increase in number of nodes the performance should not degrade.

c) Security: Effective security mechanism should be introduced for secure data transmission and avoidance of malicious attack in wireless sensor network.

d) End to end delivery: The sink must be able to receive any notification or data within short time period. So that any action can be taken by sink.

e) Packet Loss: Whole packets should be delivered at the destination without losing a single packet.

f) Small node size: Sensor node size should be small so that can easily deploy in harsh environment and reduce power consumption and cost.

g) Reliability: Network protocol designed for sensor network should provide error control and correction mechanism for reliable delivery of data packet. [5]

2.1 Application of Wireless Sensor Network:

a) Military applications

b) Environmental monitoring

c) Applications to agriculture

d) Human-centric applications

e) Applications to robotics [6]

2.2 Types of Routing protocols –

A. Flat Networks Routing Protocols :

Generally, flat networks routing protocols may be classified, in step with the routing approach, into three fundamental exceptional categories: Pro-Active protocols, Re-active protocols and hybrid protocols [7]. These types of protocols differ in lots of approaches and do not present the equal traits, even though they had been designed for the equal underlying network. Consistent with some other classification present within the literature, flat networks routing protocols may be categorized as Table-driven and Source-initiated (or call Demand-Driven) respectively (Pro-active and Re-active routing protocols.

B. Hierarchical Routing Protocols based on clustering -

LEACH-Low Energy Adaptive Clustering Hierarchy [8] is a disbursed clustering procedure for WSN that utilize random values to pick out cluster head. It has phases known as setup stage and steady stage. First of all, in the setup section, each node will choose itself as CH or now not, in the current round. Elements consisting of how oftentimes a node got elected as CH inside the last r rounds and the share of favored CHs will affect the selection. Every node selects either 0 or 1.If for a node, this value is much less than calculated quantity (threshold value) T(n), the node introduces itself as the cluster head and broadcast message to all other nodes.

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

Where, r denotes the round that has been completed, p denotes the probability of the nodes to become a CH, G denotes the set of nodes which never became the head in the previous 1/p rounds.

LEACH protocol assigns the load evenly on each cluster head, however, there are some issues which are required to be observed. These are:

- No guarantee that in each round the desired number of CHs is elected.
- A possible model is used to pick Cluster Head. So there is a chance of election of intently placed cluster heads that dissipate overall power in the network.
- In a view that a random number is generated and the threshold value is calculated in each round so greater CPU cycles are invested.
- If that node is elected that's positioned near to the network's boundary, more energy may want to expend via other nodes to pass the message to CH.

C. Location-Based Routing Protocols-

In this section, the basics of place-aided or location-based routing, through techniques proposed for WSNs, is presented. This kind of protocols recognizes the influence of physical distances and distribution of nodes to regions as significant to network performance. Location-based routing protocols are based on two important assumptions:

- It's far assumed that each node is conscious of its very own network neighbor's positions.
- The message source is supposed to be informed approximately the position of the destination.

This approach for the localized broadcasting of queries in geo-conscious sensor networks uses the existing query routing tree and does not involve the creation of any additional communique channels. The location-based totally routing approach may be very interesting because it operates without any routing tables. Furthermore, once the position of the destination is understood, all operations are strictly local, this is, each node is needed to keep a record only of its direct neighbor. The primary demerits of such algorithms are:

- Efficiency relies upon on balancing the geographic distribution as opposed to prevalence of traffic.
- Any necessity of performance with traffic load preventing the negligence of distance can also occur in overload.

D. Fuzzy Logic based Clustering Protocol-

1) CHEF: In CHEF [9] CH is picked based totally on parameters which are energy and the proximity distance. The Fuzzy based technique chooses the node to be the CH with great energy and regionally top-quality node. Simulation result shows that the chef is 22.7% greater green than leach. In [5], the writer has taken into consideration three fuzzy parameters including energy, concentration, and centrality.

These 3 parameters are the important factors to calculate the chance of node to be the CH that can enhance the network lifetime. The energy level is described as to be had energy at each node, awareness is the range of neighbor nodes and centrality is a value based on how significant the node to the cluster. However, the main shortcomings with this protocol are that all the nodes are not well-appointed with GPS receivers and that they won't be able to deliver region information in some locations.

2) F-MCHEL- In F-MCHEL [10] CH is elected by means of using fuzzy rules based on power and distance proximity. The node with the highest residual energy in the cluster heads is elected as a master cluster head (MCH) and sends the gathered information to the bottom station. F-MCHEL is an upgraded version of CHEF. Its network stability is more than leach and chef. F-MCHEL , static base station has been taken into consideration.

3) Adaptive MCFL- In this algorithm[11] multi-clustering is used which avoids selecting new cluster heads by trusting preceding cluster heads results in discount within the number of messages and saving electricity in some rounds. CH is elected via making use of the Fuzzy regulations based at the residual power, quantity of neighbors and distance to the cluster head of the previous round. This prevents lots of energy and makes the network energy efficient.

3. PROPOSED ALGORITHM

The main objective of clustering saving the energy of the system. Successive transmission of message between nodes and sink nodes consume energy. Also election on cluster head also results in loss of energy. Fuzzy logic is used to calculate the chance of the node to be selected as Cluster head. Here 3 level clustering is used [3].In the proposed method after selected the cluster head using fuzzy logic communication is done by finding the shortest path. Transmission of messages through the longer path dissipates more energy. Therefore shortest path is chosen using Dijkshtra's algorithm.

3.1 System Model-

Before dealing the proposed algorithm in detail, various network assumptions are examined. These are as follows:

- Homogenous network where every node is equally capable in terms of processing power and have the same energy level at the deployment time.
- All nodes are distributed randomly and evenly.
- The nodes are motionless after deployment in their AOI (Area of interest) and know their position and the position of other nodes and base station.
- Distributed manner is used for election in each round.
- All distance is calculated as Euclidean distance.
- Within the distance R the position nodes are considered as neighbor nodes of any particular node.
- Data is transmitted in multi-hop method i.e, from normal node to Cluster Head and from Cluster Head to sink (Base station).

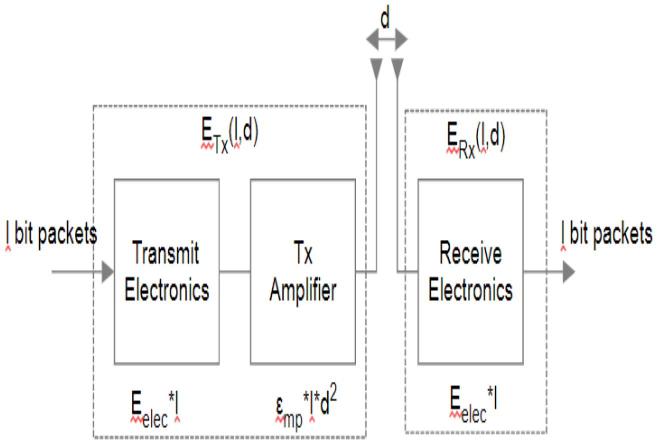

Fig. 1. Radio model. [12]

Fig. 1) shows the model taken from [12]. The consumption of energy from transmitter to receiver for 'l' bits and the distance 'd' for transmitting and receiving is calculated as following relation-."

$$E_{Tx}(l,d) = \begin{cases} l * E_{elec} + l * \varepsilon_{fs} * d^2 & if\ d \le d_o \\ l * E_{elec} + l * \varepsilon_{mp} * d^4 & if\ d > d_o \end{cases} \quad (2)$$

Here d_o is obtained as-

$$d_o = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \quad (3)$$

Where,

E_{elec} =Energy dissipated per bit of sender and Receiving device. Factors are like digital coding, modulation, filtering and spreading of signals.

ε_{fs} And ε_{mp} are the features of transmitter circuit whereas ε_{fs} is for free space (with d2 loss) and ε_{mp} is for multipath propagation (with d4 loss)

If the distance of the communicating nodes is lower than do, then the multipath attenuation model is used for calculating the energy consumption of the nodes therefore farther distance causes more consumption of the energy. For the data transmission phase use of multi-hop transmission among the cluster heads and node minimizes the further energy consumption.

3.2 Clustering in proposed algorithm-

3.2.1 First clustering-

- Identifying neighbors and their number for each node
- Fuzzy inference using parameters such as "residual energy", and "number of neighbors" for each node
- Comparing fuzzy output of each node with the fuzzy output of its neighbors
- Selecting the node with the highest fuzzy output as the cluster head within every neighboring radius
- Sending data from each node to cluster head and from each cluster head to base station (Fig. 2)

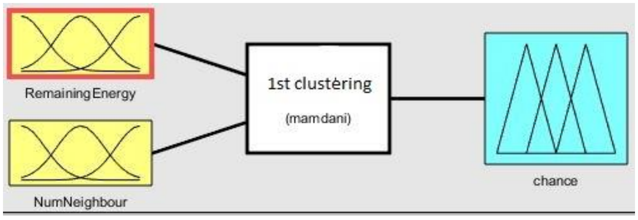

Fig. 2a) Fuzzy rules

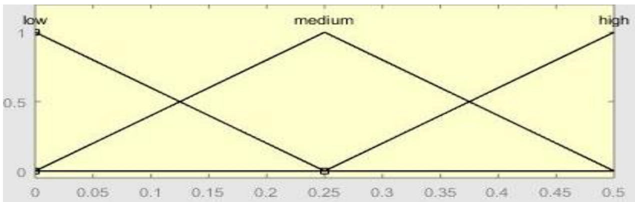

Fig. 2b) Membership function for the input (Remaining energy)

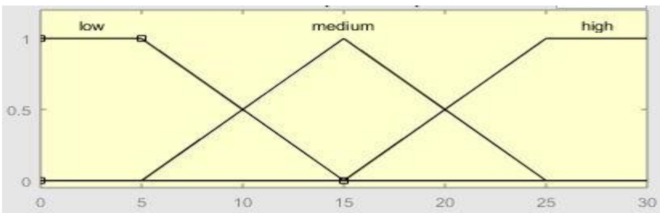

Fig. 2c) Membership function for the input (Number of nodes)

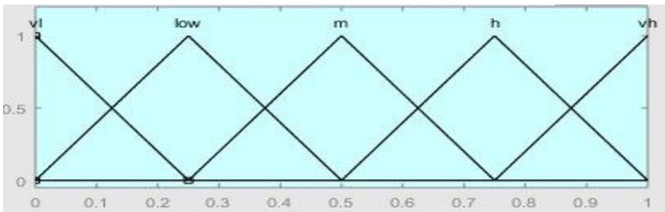

Fig. 2d) Output (Chance)

Fig.2 Fuzzy interference for 1st clustering

3.2.2. Second clustering-

- Re-selecting the cluster heads of the previous round as the cluster heads of the current round

3.2.3. Third clustering-

- Identifying neighbors for each node
- Fuzzy inference using parameters such as "residual energy", and "and distance to the cluster head of the previous round" for each node
- Comparing fuzzy output of each node with the fuzzy output of its neighbors.
- Selecting the node with the highest fuzzy output as the cluster head within every neighboring radius
- Sending data from each node to cluster head and from each cluster head to base station (Fig. 3)

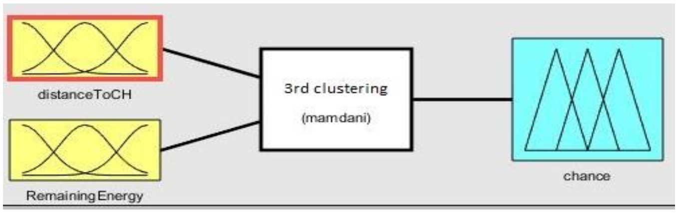

Fig. 3a) Fuzzy rules

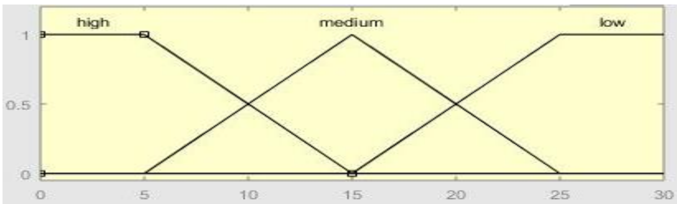

Fig. 3b) Input Membership function (Distance to CH)

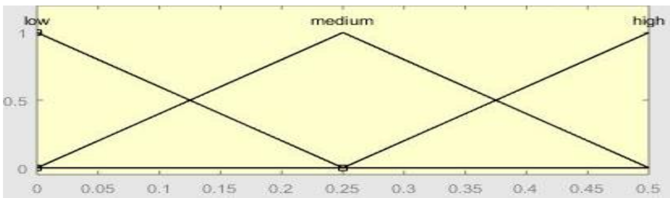

Fig. 3c) Input Membership function (Remaining energy)

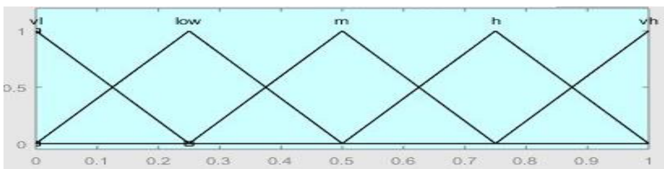

Fig. 3d) Output (Chance)

Fig.3 Fuzzy interference for 3nd clustering

3.3 Algorithm for Shortest Path Tree-

The mechanism of the communication among nodes is the SPT. Initially the distance between nodes and sink is calculated. The participating nodes then evaluate the distance between clusters head and themselves, and after every clustering modifying the set of cluster heads distance. Then for exchanging the data they search for the path with minimum distance from the nodes to head node and to sink node with Dijkstra's algorithm. First, selecting the shortest distance, then select the second shortest distance after calculating the minimum with Dijkstra's algorithm then sends data to sink along the optimal path as shown in Fig. 4

This is the parent algorithm for a number of other shortest path algorithms. Numerous shortest path algorithms have been discovered till date- some of which are applicable for routing in WSN while some are not.

The Dijkstra's Algorithm is stated as follows:

1. Enter the input graph, number of vertices n, source vertex vs and destination vertex vd as parameters in a function, say dijk(a[][], n, vs, vd).

2. Repeat Step3 for i=1, 2,.....,……………………… n. Reset array element set[i] to 0

3. Repeat loop for i=1, 2,......................................, n. Check if a[vs,i]=0 [In case no direct edge between vs and vi]. Then: leng[i]=Infinity [Infinity value is taken to be 999] and path[i]=0 [Invalid path]. Else: leng[i]=a[vs,i]and path[i]=vs [vs is immediate predecessor of vi]. [End of loop.]

4. Set the value set[vs] to 1 and reset the value leng[vs] to 0.

5. Repeat loop while(vd is not included in the set[]). Set j=search_min(leng,set,n) [This function will return a vertex with minimum label such that it is not included in set[]] and value of set[j]=1.

6. Repeat loop for i=1, 2,..................................,n. Check if vi is there or not in set [], then check if vi and vj are connected by an edge. If yes, then check if leng[j]+a[i,j]<leng[i] [Replacement occurs if existing label is not minimum]. If yes, then leng[i]=leng[j]+a[i,j] and path[i]=j [End of loop.] [End of Step5 loop.].

7. Set weight=leng[vd].

8. Print the shortest path-weight and then the shortest path by backtracking.

9. Exit.

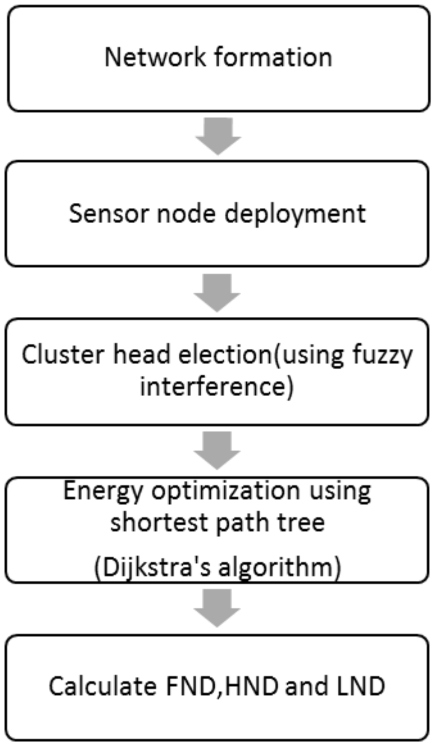

Fig. 4 Flow chart of proposed algorithm

4. SIMULATION AND ANALYSIS

The proposed algorithm is compared with the previous one [11] . Evaluation of the Wireless sensor network can be done using various evaluation parameters for the system such as Energy, Number of nodes died in each round as FND, HND and LND. When the first nodes dissipates its energy the performance starts degrading. Hence it is required to mark the death of very first node in the network. For the same cause time of HND (Half Nodes die) is marked and so as of LND (Last Node Dies).

In the scene methods are evaluated according to parameters in Table 1.

Table -1: Simulation Parameters

Parameters	Scene 1
Area of interest(AOI)	100x100 m
Sink node	(50,50)
Total nodes	100
Energy (initial)	0.5 J
Packet size of data	500 byte
Control packet size	25 byte
ε_{mp}	0.0013 pJ/bit/m4
Eelec	50nJ/bit
ε_{fs}	10 pJ/bit/m2

The network space (area of interest) is shown in Fig 5 .

In the scene different methods are evaluated according to simulation parameter. Here base station is located at the center which can be shown in Fig.5.

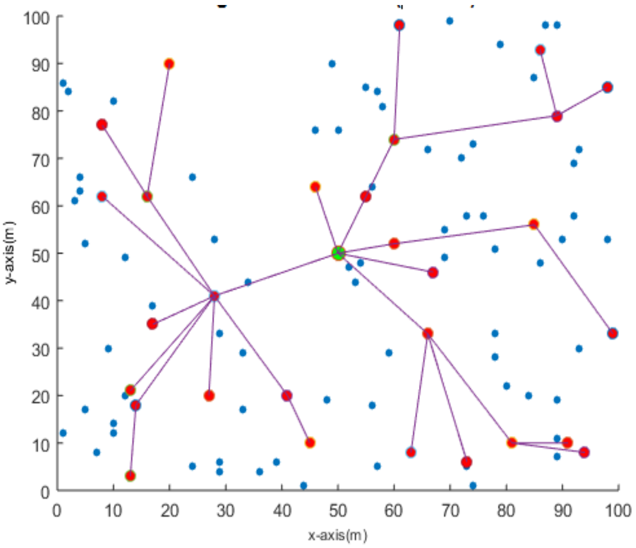

Fig. 5 Area of interest

The proposed method proves better in first parameter that is energy conservation which can be shown in Fig. 6.

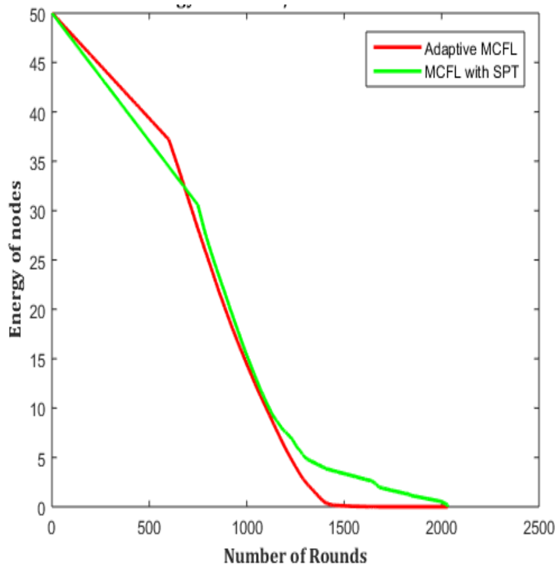

Fig. 6 Remaining energy of the deployed nodes

Second analyzed parameter is Number of dead nodes in each round and Rounds at which the nodes starts dissipating energy can be represented with Fig.7

The proposed method enjoys the overall high energy. The reason is the reduction in number of sent and received messages and energy of each node.

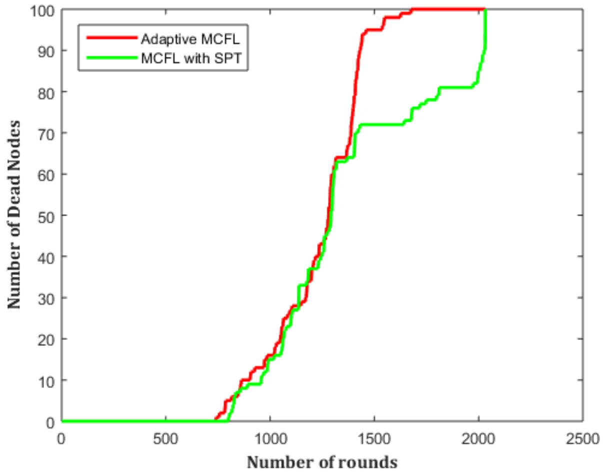

Fig. 7. Number of nodes dead in each round

Performing selection in each round results in increase in number of messages. Any increase in number of packets will augment network traffic and increase the collision property.

Fig.8 shows the comparison of first node dead, half node dead and last node dead. It shows that proposed method outperform the previous methods.

Table-2 Number of FND, HND and LND

AOI	FND	HND	LND
FORMER	741	1281	1676
PROPOSED	800	1292	2032

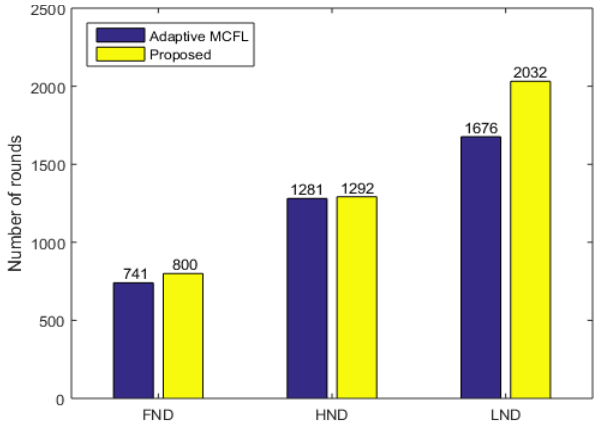

Fig. 8 Comparison of FND, HND and LND

Though using fuzzy logic with 3 level clustering increased the network efficiency, but using shortest path tree for communication between CH improved the lifespan to great extent. Hence, proposed method results in prolonged lifetime of the network. Table 2 presents the results rounds when the very first node dissipates its energy, half of the deployed node dies and finally the last died node.

5. CONCLUSIONS

The energy efficiency is a completely vital issue for the networks especially for WSNs which might be characterized with the aid of restricted battery skills. The complexity and reliance of corporate operations on WSNs require the use of strength efficient routing strategies and protocols, that allows you to guarantee the network connectivity and routing of information with the less required energy. Routing is an important manner and needs to be taken into careful consideration a good approach to make certain the continuity of connections and the power consumption of the nodes. Consequently, the utility of the right routing protocol will boost the life span of the network and on same time, it will make certain the network connectivity and efficient delivery of data.

By selecting the shortest path for the cluster heads and delivering the message to a mobile base station. In future this can be useful for numerous sectors such as health care department, in agriculture, disaster areas, in military etc. Simulation result shows that algorithm presented here is better in performance than previous one for the various parameters considered and thus resulting in stabilized and life longed network.

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