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LIFETIME MAXIMIZING DYNAMIC ENERGY EFFICIENT ROUTING PROTOCOL WITH MIMO FOR ENERGY EFFICIENT INFORMATION TRANSMISSION IN THE SENSOR NETWORKS

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Abstract

Wireless sensor network is one of the important technologies which are used in the various applications like hospital, military and so on. These applications using the various characteristics such as energy harvesting, resilience, scalability while transmitting the information in the network. Even though the WSN having the efficient characteristics, it has some of the issues like network load routing, power consumption, node failure etc. Thus the paper introduces the MIMO concept with network coverage and energy efficient sensing model to avoid the above issues. Initially the network sensitive region is analyzed using the Shadow fading sensing model. From the recognized region, the clusters are formed according to the concept of multi scale fuzzy clustering process. Then the information is transmitted with the help of the Lifetime Maximizing Dynamic Energy Efficient Routing Protocol which reduces the power consumption process at the entire node life time. The efficiency of the system is analyzed with the help of the experimental results and discussions.

Keywords:

Wireless sensor network, MIMO, shadow fading sensing model, multi scale fuzzy clustering process, Lifetime Maximizing Dynamic Energy Efficient Routing Protocol

1. Introduction

Wireless Sensor Network [1] consist a large scale sensor node deployed randomly or statistically distribution is predefined over a geographical region of interest. Sensor node resources are power, memory, processor, computation and communication. Since important criteria of WSN is node deployment strategy and efficient power consumption technique therefore going to shadow fading sensing model which is deploying the node randomly and movable. The coverage of sensing model is not uniform at all direction and move a number of nodes across sensing fields. This model aim to maximum nodes are detected when an event occur. Coverage and connectivity treated as a quality of service in that sensing model [2]. In large scale network is usually partition into a small subgroup is known as cluster for reducing the power consumption. Determines the clustering is according to energy location ID and other information. Usually clustering has two methods which are classified into centralized clustering and distributed clustering.Centralized clustering requires all the nodes send the data packet along base station directly [3]. Distributed clustering is performed by randomly [4].

Basically the clusters have cluster head and the cluster members which collect the data from member and forward to base station [5]. Some energy could be preserved long distance data transmission to the base station therefore going to organize unequal clustering and multi hob routing for save the residual energy [6]. Fuzzy logic is an energy aware algorithm of wireless sensor network for energy consumption. Therefore proposed a multi scale fuzzy clustering process which is partitioned a set of nodes into a group based on membership function. Another important concentrated area is routing protocol over the clusters for data transmission. It is necessary to consider the amount of remaining energy and increases the network lifetime [7]. In general the concepts of energy efficient and residual energy have been applied to fore the data move through high energy node and protect the low energy nodes [9].After forming the cluster then the data is transmitted trough inter cluster and intra cluster with the help of Lifetime Maximizing Dynamic Energy Efficient Routing Protocol. Establishment of algorithm with optimum energy efficient routing path have both end to end energy efficiency and residual energy of entire node has be taken.In this paper presents initially, the network coverage is determined by applying the shadow fading sensing model and the applying multi scale fuzzy clustering process is help to form a clustering the nodes. After forming the cluster, the information has been transmitted with the help of the Lifetime Maximizing Dynamic Energy Efficient Routing Protocol which reduces the network traffic also improves the energy efficiency and network lifetime. Finally the efficiency of the system is analyzed with the help of experimental results.

The remaining part of the paper is organized as follows. Related work is discussed in section 2. Sensing model, routing protocol and the proposed multi scale fuzzy clustering is given in section 3. Section 4 presents a Result and discussion and the conclusions are presented in section 5.

2. Related Work

Mariam Al Nuaimi [10] proposed energy efficient routing algorithm using threshold values. In this algorithm select the cluster head based on ranking method which high energy level node among the clusters. Additionally the base station calculate number of rounds have been to select cluster head this is a great effort for network life time and reduces the amount of wasted energy. However hybrid redundant nodes duty cycle is turn covering the monitored surface which helps to improving the performance of network. Simulation is done by MATLAB. An energy threshold is improved the network lifetime almost 15% by replace the cluster head and hybrid redundant nodes duty-cycle has improved the network lifetime is 8%.FirojAhamad [11] provides an approach is fuzzy logic based cluster head selection to extend the network lifetime. In this consider the two important issues in WSN are node distance and residual energy of nodes. Multi hub communication is using the data transmission among the network.

Harsha [12] provides LEACH- ERE to forming a clusters and select cluster head for collect the data and forward to base station. Therefore the WSN environment could increase the lifetime of network and energy efficiency. This approach has been eliminates the hand off of data transmission and increasing the through put.SarkisMoussa [13] introduce allocation

based routing protocol to point out the location of each nodes therefore when nodes arepreprepared with a small low power GPS receiver which is available by communicating satellite using GPS. Main aim of the protocol is reducing the energy consumption. When the data transmission a through long distance and the energy consumption is maximize. Here the algorithm is minimizing the distance between the two nodes and dividing the many clusters therefore achieving the minimum energy consumption. The simulation result is compared with LEACH protocol.

Ben Salah [14] proposed an algorithm LEACH for homogenous network for enhance the network lifetime, less energy consumption and more stability of network. Cluster head selection considering the remaining energy of sensor nodes in the network. In future work the algorithm has to improve and simulate heterogeneous environment. Muhammad ZainulAbidin [15] proposed energy efficient routing protocol for two-tiered WSN. The cluster head selection process based on residual energy of sensor node at periodically. Moreover, greedy algorithm is used to create a routing with the help of genetic algorithm. Relay reselection mechanism balance the energy consumption of entire sensor nodes.

3. Methodology

3.1 Shadow fading sensing model

The sensing ability of a node is all the directions not uniform. This is similar to shadowing in radio wave transmission. The sensing radius of a node is not uniform in all directions and no longer since signal come from different direction is related to different transmission paths in shadowed environment. Let *x* is defined as distance between an arbitrary sensor node and an event of significance. Here assume *P*s is equal to the event for the power emit. Assuming shadowing path loss model, the node received power is due to the event as follows.

$$P(x)[dBm] = P_s[dBm] - PL(s)[dB] \qquad (1)$$

Where path loss is

$$PL(x) = \overline{PL}(x_0) + 10nlog_{10}\left(\frac{x}{x_0}\right) + x_\sigma (2)$$

The path loss exponent is known as parameter *n* anda zero mean Gaussian distributed random variable (in dB) withstandard variation σ (in dB) is known as X_σ [16].

Let *P*s be the sensitivity of the sensor node, then $P(x) \geq P$sis describes the transmission will be successful. Thus theprobability of shadow fading environment isdetecting the event as follow

$$P_{det}(x) = Prob\{P(x) \geq P_{s,th}\} = Q\left(\frac{P_{s,th} - (P_s - \overline{PL}(x))}{\sigma}\right) (3)$$

Where $\overline{PL}(x) = \overline{PL}(x_0) + 10nlog_{10}\left(\frac{x}{x_0}\right)$ (4)

Let $r_s$be the sensing range of non-shadowed environment for which (5) does hold well.

$$P(r_s) = P_{s,th} = P_s - \overline{PL}(x) - 10nlog_{10}\left(\frac{r_s}{x}\right) \quad (5)$$

Plugging (5) into (3) yields

$$P_{det}(x) = Q\left(\frac{10nlog_{10}(x/r_s)}{\sigma}\right) \quad (6)$$

Where

$$Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^\infty e^{-y^2/2}dy \quad (7)$$

The probability of shadow fading sensing for network coverage is an event will be detected.

$$P_{det} = \frac{2\pi}{A}\int_0^\infty P_{det}(x)xdx$$

$$= \frac{2\pi}{A}\int_0^\infty Q\left(\frac{10nlog_{10}(x/r_s)}{\sigma}\right)xdx \quad (8)$$

The network coverage is dependent on sensing model. IT is appearance is very simple due to Boolean sensing model. It is quite complex probabilistic sensing model. It reveals from [17] that when the shadowing parameter increases then the network coverage of shadowing sensing model gets reduces.

3.2 multi scale fuzzy clustering

Multi Scale Fuzzy Clustering (MSFC) approach using to forms a clusters after node deployment in the coverage of shadow fading sensing model for reducing the energy consumption of network and increasing the lifetime.Select tentative cluster head randomly C is treated as tentative cluster head which predefined threshold between 0 and 1. The process of clustering algorithm is performed as follows. Figure 1 show the member ship function of joules.

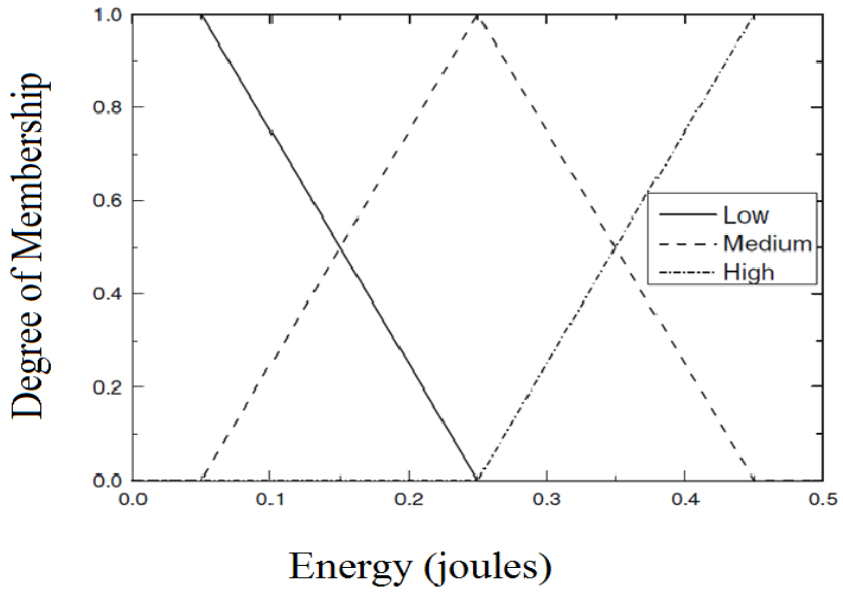

Figure 1 Membership function

Number of nodes $N = \{x_1, x_2, x_3, \dots, x_n\} \in R^L$ partitioning the nodes into small number of groups is known as$C$. Each nodeare $x_j = x_{j1}, x_{j2}, \dots, x_{jL}$. The proposed Multi Scale Fuzzy Clustering (MSFC) is minimizing the objective function as following.

$$J_{MSFC} = \sum_{j=1}^{N}\sum_{i=1}^{C}\sum_{k=1}^{L}(\mu_{ij}^{m})\left(\|x_{jk} - v_{ik}\|^2 + \frac{\alpha}{N_R}\sum_{r\in N_j}\|x_{rk} - v_{ik}\|^2\right) \quad (9)$$

Equation (8) can be derived by objective function with respect to the membership functions $\mu_{ij}$and centridsv_{ik}.

$$\mu_{ij} = \frac{\left(\sum_{k=1}^{L}\left(\|x_{jk} - v_{ik}\|^2 + \sum_{r\in N_j}\|x_{rk} - v_{ik}\|^2\right)\right)^{-\frac{1}{m-1}}}{\sum_{\omega=1}^{C}\left(\sum_{k=1}^{L}\left(\|x_{jk} - v_{wk}\|^2 + \frac{\alpha}{N_R}\sum_{r\in N_j}\|x_{rk} - v_{wk}\|^2\right)\right)^{-\frac{1}{m-1}}} \quad (10)$$

Equation (8) with respect to v_{ik} is iterative function as follows.

$$v_{ij} = \frac{\sum_{j=1}^{N}\mu_{ij}^{m}\left(x_{jk} + \frac{\alpha}{N_R}\sum_{r\in N_j} y_{rk}\right)}{(1+\alpha)\mu_{ij}^{m}} \quad (11)$$

The Multi Scale Fuzzy Clustering (MSFC) algorithm can be summarized as follow in figure 2.

Let n=1, initialize $v_i^{(n-1)} = (v_{i1}, v_{i2}, \dots, v_{iL}), 1 \le i \le C$
Set $J_{MSFC}^{n-1} = \xi$, Where ξ is random
Compute $\mu_{ij}^{(n)}$ based on (10)
Calculate v_{ik}^{n} according to (11)
Obtained $J_{MSFC}^{(n-1)}$ with (9)
If $\left|J_{MSFC}^{(n)} - J_{MSFC}^{(n-1)}\right| < \xi$,
Stop
Else n ← n-1,
Go to step 2
End if

Figure 2Multi Scale Fuzzy Clustering (MSFC) Algorithm

3.3 Lifetime Maximizing Dynamic Energy Efficient Routing Protocol

The energy parameter related with communication of sender and receiver which referred as transmitter and receiver electronics E_{elc} energy is referred in terms of amplifier E_{amp} and d is referred as distance between sender and receiver. Fined the energy consumption equation as follows

$$E_{tx} = k\,E_{elc} + k\,E_{amp}d^2 \quad (1)$$ And

$$E_{rx} = k\,E_{elc} \quad (2)$$

WhereE_{tx}, E_{rx} is the amount of energy of send and receive k bits. Additionally $w \in W$ is referred as energy consumption of each node for transmitting data.

$$k\,E_{elc}\sum_{w \in W} I(W) \quad (3)$$

$$I(W) = \begin{cases} 1, & w \in W \\ 0, & otherwise \end{cases}$$

Total energy consumption equation as given below

$$E_{total} = k\,E_{elc} + k\,E_{amp}d^2 + k\,E_{elc}\left(1 + \sum_{w \in W} I(W)\right) \quad (4)$$

The number of nodes $n.level\ (n)$ as defined as distance of n from the base station therefore nodes delivered the data from high energy level to low energy level finally, the data reach to the base station. This level is determined by strength of receiver. In this protocol maintains the routing tree for transmitting the data from sender to the base station via the intermediate

nodes. Node cost is defined as C_{nm} and transmission from node n to m using $RE_n, RE_m, E_{tx}, E_{rx}$.

$$C_{nm} = min\{RE_n - E_{tx}, RE_m - E_{rx}\} \quad (5)$$

Figure 3 is Computations of energy efficiency for each node as follows.

Algorithm

For each node n on $level\ (n)$**do**

For Every node $m \in N_n$ either on $level\ (n)$**do**

$$E_{total} = k\,E_{elc} + k\,E_{amp}d^2 + k\,E_{elc}\left(1 + \sum_{w \in W} I(W)\right)$$

End for

End for

Figure 3 energy efficient routing protocol

4. Result and Discussion

The simulation of the multi scale fuzzy clustering is performed and graphical evaluation is generated using MATLAB[18]. In simulation, the sensor nodes are deployed randomly under the coverage area of network which is 500 × 500 square meters. The proposed clustering algorithm forms the clusters in the network for reducing the energy consumption.

4.1 Coverage fraction of Shadow fading sensing model

The sensing range r to the deployment range A is assumed to be 500 m^2respectively. 30 simulation runs for reported all the results which are average. As figure 4shown, under the random deployment, the deviation between the coverage fractions derived from the simulation. N number of deployed the sensor nodes randomlyselect N locations and let them distributed not uniformly and independently in*C.*There exist more than 50 nodes in deployment area C, the coverage fraction derived from simulation equals 150$m^2$and when 80 nodes deployed in C area, the coverage fraction derived from simulation equal 200m^2. The following figure4 shows coverage fraction of Shadow fading Sensing Model (SSM) which is compared with two existing model Boolean Sensing Model (BSM) andElfes Sensing Model (ESM).

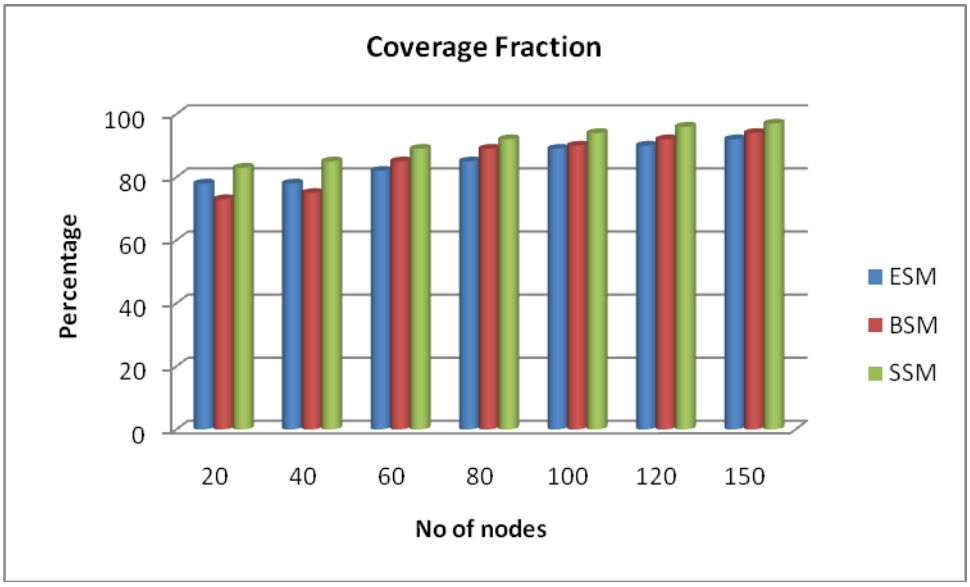

Figure 4 Coverage fraction of SSM

From the analysis of figure 4 is network coverage of shadow fading sensing model gets reduced and the shadowing parameter has increases that why achieve better coverage fraction compared with existing BSM and SSM model.

4.2 Accuracy of multi scale fuzzy clustering

In the evaluation of result compare with Accuracy, Sensitivity, FPrate, Precision, Recall F-Measure, and Specificity. The number of instances in different classes is then used to calculate the following metrics: True Positive Rate (TPR) or Recall: It is calculated by TP/ (TP+FN). It shows how much fraction of the elements classified as positive is true. Higher TPR means better classification.False Negative Rate (FNR) or Miss Rate: It is calculated by FN/ (TP+FN). It shows how much fraction of the elements classified as negative is false. Higher FNR means worse classificationPositive Prediction Value (PPV) or Precision: It is calculated by TP/ (TP+FP). It shows how much fraction of the elements truly positive is classified as positive. Higher PPV means better classification. Accuracy (ACC): It is calculated by TP + TN/ (TP+TN+FP+FN). It shows how much fraction of the total elements classified correctly. Higher ACC means better classification. Figure 5 shows the comparative analysis of MSFC.

Table 1 Performance analysis

Metrics	MSFC	FCM	FKM	WFCM
Accuracy	0.9	0.7	0.8	0.7
precision	0.9	0.6	0.7	0.8
Recall	0.8	0.5	0.66	0.57

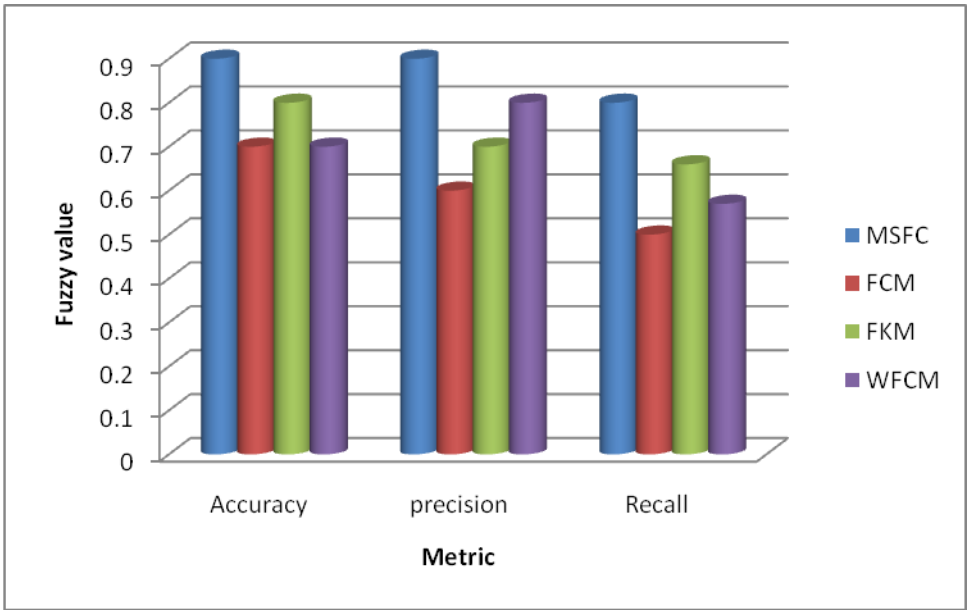

Figure 5 Performance analysis

From the simulation result obtained the fuzzy objective, which is maximizing the clustered nodes. The accuracy of the Multi Scale Fuzzy Clustering (MSFC) algorithm is higher than the other three existing algorithm like fuzzy c-means clustering, fuzzy k-means clustering and weighted fuzzy c-means clustering.

4.3 Lifetime Maximizing Dynamic Energy Efficient Routing Protocol

Lifetime Maximizing Dynamic Energy Efficient Routing (LMDER) Protocolcluster head sent the collected data from base station to member by multi-hop manner in heterogeneous, which saves the energy consumption since the cluster head and participant in WSN. In LEACH and EMHR protocols is energy burden due to the long-haul communication links between header and the cluster members. however the energy dissipation is directly relative to the exponent of transmission distance. The energy consumption of the LMDER protocol is less than that of LEACH, EMHR and MEE. Less energy consumption means longer lifetime of network. Table 1 shows the energy consumption. Energy measurement is based on joules.

Table 2 Residual Energy

No of nodes	LEACH	EMHR	MEE	LMDER
100	40.16	32.75	36.15	52.80
200	92.42	89.96	82.16	105.82
300	135.20	102.26	123.26	155.84
400	182.93	145.56	164.74	205.67
500	248.45	225.34	205.12	231.56

Figure 6 shows Energy consumption analysis of LMDER compared with three existing Low-energy adaptive clustering hierarchy (LEACH) protocol, Energy-Efficient Multi-hop

Hierarchical Routing (EMHR) protocol, Multipath based Energy Efficient (MEE) routing protocol.

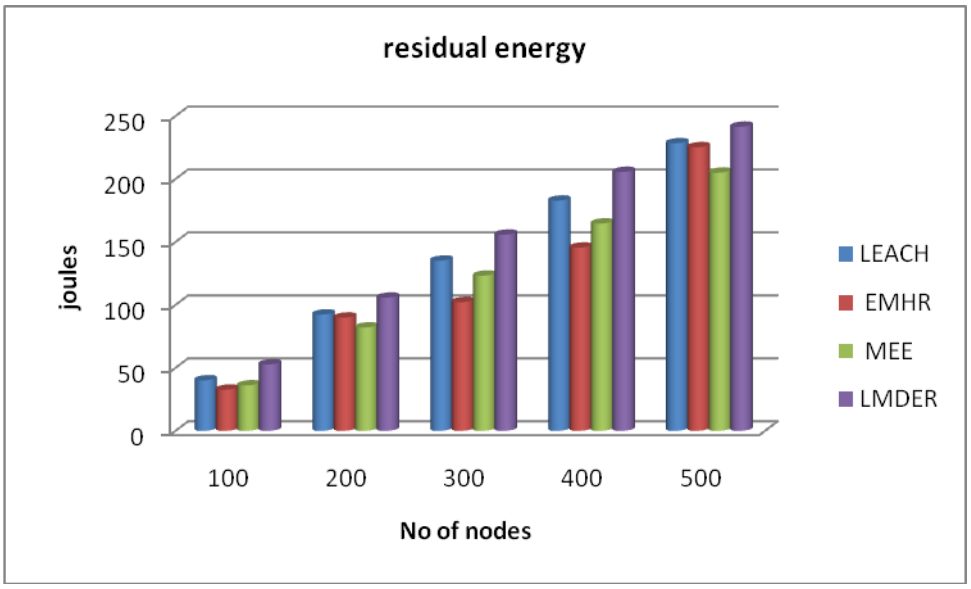

Figure 6 Residual energy of LMDER compared with three existing protocol

From the analysis report of figure 6Lifetime Maximizing Dynamic Energy Efficient Routing (LMDER) protocol is less power consumption compared with other three existing protocols.

5. Conclusion

Shadow fading sensing model is deploying the node randomly and movable. This model aim to maximum nodes is detected when an event occurs and Coverage, connectivity treated as a quality of service in that sensing model. In large scale network is usually partition into a small subgroup is known as clustering. Fuzzy logic is an energy aware algorithm of wireless sensor network for energy consumption. Therefore proposed a multi scale fuzzy clustering process which is partitioned a set of nodes into a group based on membership or objective function. After forming the cluster then the data is transmitted trough inter cluster and intra cluster with the help of Lifetime Maximizing Dynamic Energy Efficient Routing Protocol. Establishment of algorithm with optimum energy efficient routing path have both end to end energy efficiency and residual energy of entire node has be taken. The accuracy, recall precision of the Multi Scale Fuzzy Clustering (MSFC) algorithm is higher than the other three existing algorithm. The LMDER protocol achieves the less energy consumption which means save more energy however reach the long lifetime of the network.

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