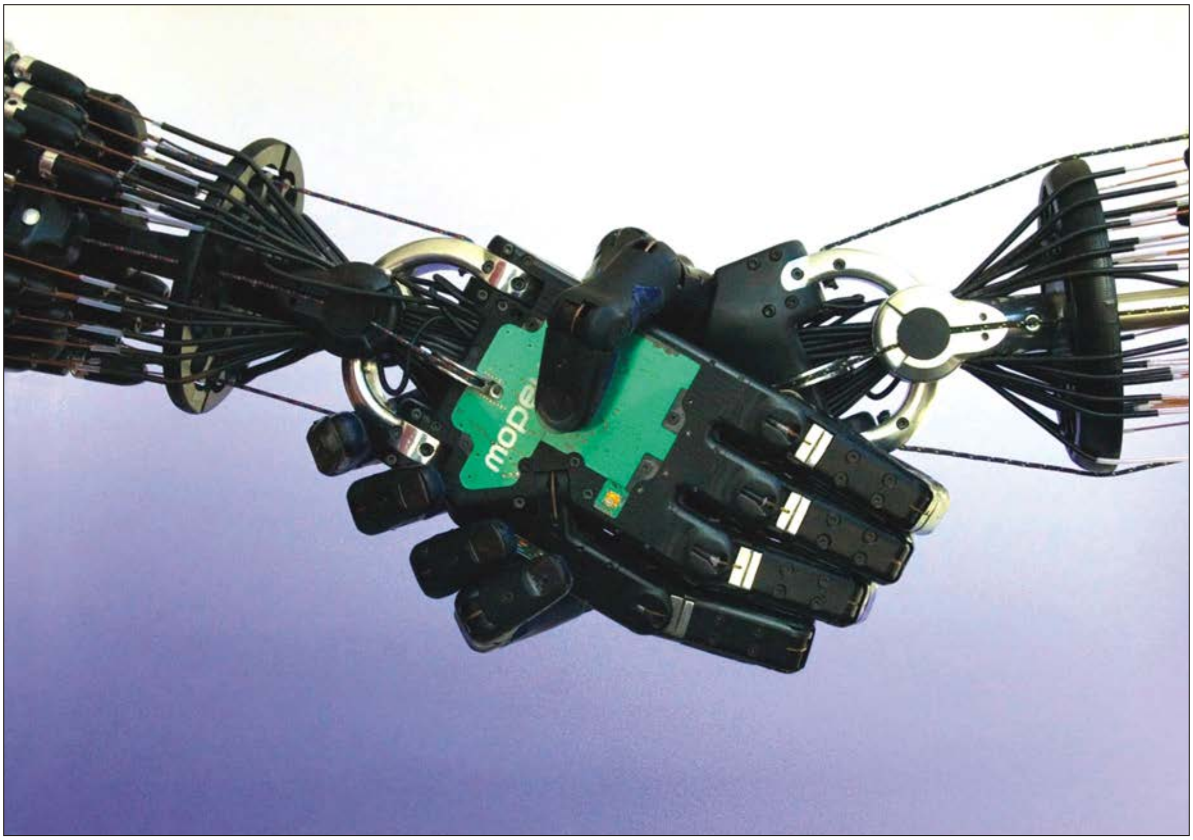

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Research Article
Soft Computing Based Cluster-Head Selection in Mobile Ad-Hoc Network

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Abstract

Background and Objective: Mobile ad-hoc network (MANET) is a specific type of network that can be quickly deployed without any existing framework. Cluster formation and cluster head selection in MANET is an important issue in such networks. Clustering is one of the vital issues used in increasing the network life time by gathering the information from specific group of nodes and forwarding it to other neighbouring cluster heads. This paper propose a soft computing based approach for the selection of the cluster head in MANET. A cluster head selection model based on fuzzy logic has been devised. Cluster head selection is done on the basis of three parameters viz., residual energy, centrality and hop-count. **Materials and Methods:** The proposed approach has been implemented in MATLAB followed by execution of cluster-head selection based on fuzzy logic using 3 criteria viz; residual energy, hop count and centrality. **Results:** The benefits of this approach include reduced overhead, improved performance of cluster node selection and increased network lifetime. **Conclusion:** Through simulation, it has been observed that this approach outperforms over existing approaches. The model has also been analytically validated. The new important aspects can be integrating mobility and trust to the existing model as fourth parameter for cluster-head selection that helps in improving the network performance.

Key words: Mobile ad-hoc network, fuzzy logic, cluster head, residual energy, centrality, hop-count

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

MANET is a subset of wireless ad-hoc network (WANET) that more often has a routable system administration condition above the link layer ad-hoc network[1]. It is auto design system of mobile nodes and the whole transmission connections are situated through wireless medium who joined by wireless links. In MANET, each device behaves like a host as well as a router or server and are capable to reconfigure themselves. It is imagine to create a network dynamically on-the-fly without depends on any wired infrastructure. That is why, they are also called "infrastructure less network". In MANET, it is a gathering of autonomous MN that can impart by means of radio waves[2]. Each gadget in a MANET is allowed to move freely toward any path. It might often interface with different gadgets.

MANET is one of the superior choice for correspondence in different sorts of fields like military, condition, tracking following and so on because of its cost viability. If we want to forward a packet so that they can communicate must have one radio range in order to transfer a packet from one cluster node to another cluster node. If they are unable to communicate with each other means they are out of coverage area. Clustering is a system which collect total node in to gathering[3].

These groups are implied by the network and they are known as clusters. Clustering builds a backbone network of nodes, providing scalability for huge network and stability for movable network. It serves to support of MANET by dividing the system into clusters. In this way the network becomes more controllable. A cluster is mainly a subset of nodes of the network that satisfies a few property. The reason for a clustering method is to deliver and keep up an associated clusters. MANET shown in Fig. 1.

The objective of the clustering are to constrain the total transmission control over the node in the chose way and diminish throughput of nodes for increment the system lifetime.

Clustering: Clustering is the principle method for outlining energy-efficient, powerful and large scalable distributed sensor network[4]. It is a technique for dividing the network into different group of nodes and manage the forwarding of the data between the interactive nodes. Each group is known as cluster shown in Fig. 2.

Cluster structures: Basically 3 kinds of nodes present in a cluster.

Cluster Head (CH): CH is serve as a leader node for its cluster. It is responsible for forward the data packets to other cluster head or base station (BS). With the help of CH any node can easily communicate with each other. In network CH is a key factor for communication of nodes. It is a consistency of the cluster.

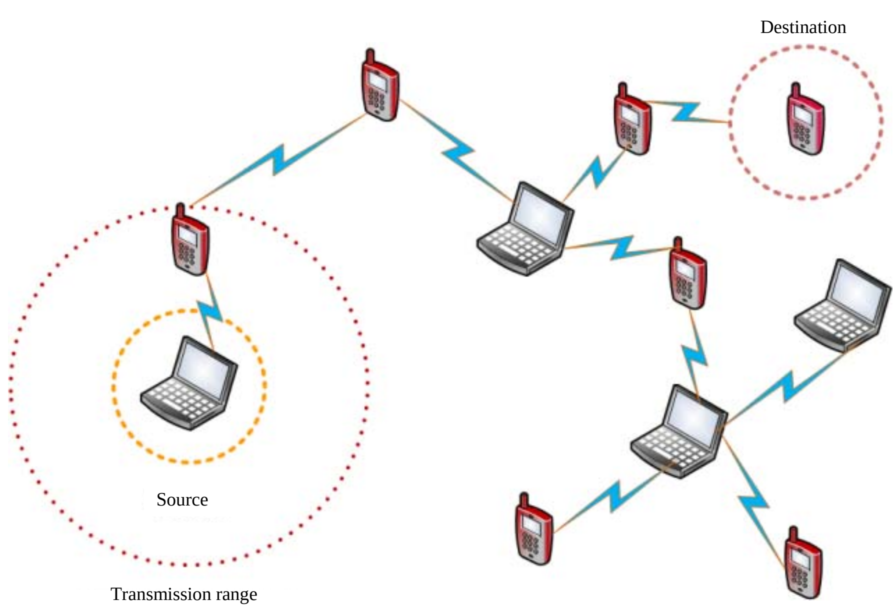

Fig. 1: MANET Architecture

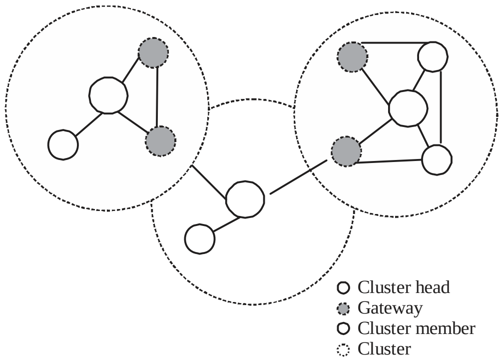

Fig. 2: Clustering in MANET

Cluster gateway (CG): Cluster gateway is a non-cluster head node. It is placed on border so it is also called border node[5]. The objective of CG is to connect one cluster with another cluster and forward the information.

Cluster member (CM): Cluster member is also a part of cluster. It is also called ordinary node. The aim of this node is to transmit information to their CH.

Communication of nodes in cluster as following:

- Firstly cluster head receives data from its cluster members
- Then it compresses the data
- After this, it finally transmits data to other cluster or base station

Motivation of clustering: Clustering is used to division of an ad-hoc network into some smaller groups. Every cluster is included of a number of ordinary nodes, gateway nodes and cluster head node[6]. If any node wants to transmit the data outside of its own individual partition, it can go through a CH, or the cluster head deputy its authority to a gateway of where it belongs to initiate the transmission.

In this study, fuzzy inference system for reduce overhead as well as time of node in MANET was presented. We called them soft computing based cluster head selection (SCBCHS).

Related work: There are many clustering algorithms given in literature based on different criteria like node distance, velocity, mobility, battery and remaining energy of a given node to select cluster head. Some of clustering algorithms have advantages but some have limitations too. These are representing as follows.

Singhal and Daniel[7] proposed approach for "cluster head selection protocol using AI techniques" in this proposed model cluster head is selected by various 3 parameters node degree, goodness factor and competent level. For evaluation the matrices fuzzy logic is used. Advantage of this approach is reduced re-selection time of cluster head resulting in less communication overhead, better selection of nodes of cluster head and drawback is more energy consumption.

Gupta *et al.*[8] introduced method for cluster-head election using fuzzy logic for wireless sensor network. This method introduces another era of constant installed framework with restricted calculation energy a memory assets. A part of broad assortment of use where classical networking framework is physically speculative. It enhance energy proficiency and system lifetime, the issues are shakiness of network and lacking use.

Nguyen *et al.*[9] proposed model for chosen of CH in MANETs, explain clustering schema and provide a physical mode of offering scalability while handling the large and dense MANETs. With the help of this paper, the problems of CH selection were investigated: (i) Separation compelled determination in which each node within system is situated inside a specific distance to the closest CH and (ii) Size-obliged choice in which individual group is just permitted to have a predetermined number of members. These techniques will enhance the soundness of cluster and it additionally diminishes the quantity of re-grouping, the issues are number of cycle required for CH decision and cluster formation nor specified.

Subbaiah and Naidu[10], proposed different approach for CH election using FLC in MANET. According to proposed approach categorized the network region into several smaller area called cluster. CH choice depends on the range of the centroid of a cluster and the closet one is elected as CH. The advantage of using this proposed approach is to optimize routing efficiency.

Gao *et al.*[11] proposed energy-efficient CH determination idea based on MCDM for wireless sensor network. The MCDM trapezoidal fuzzy analytical hierarchy process and hierarchical fuzzy undivided have been founded in clustering. In this paper, for build up a distribution-energy efficient clustering techniques using 3 parameters: Status of energy, quality of service area.

Soro and Heinzelman[12], presented the idea of coverage preservation which is the basis of quality of services requirements for WSN. It aims on the application where preserving of the coverage of full network is the main requirement. It favours the node deployment over densely populated network areas as better candidate for active sensor node cluster-head node and routers. It increases the time at which full coverage of the monitor area can be maintained anywhere.

Table 1: Comparative analysis

Authors name	Techniques	Parameter used	Benefits	Drawback
Shinghal and Daniel[7]	Artificial Intelligence	Node degree, goodness factor, competent level	minimize overhead, minimum delay, better choice of node of cluster head	Energy consumption is more
Gupta *et al.*[8]	Fuzzy logic approach	Energy, concentration and centrality	Decrease energy consumption, enhance the life time of network	Not suitable for a network with biased distribution of nodes
Nguyen *et al.*[9]	Logarithmic approach	Distance constrained, size constrained	Solve the congestion problem	Doesn't deal with the topology changes and management of node mobility
Subbaiah and Naidu[10]	Fuzzy logic system	Distance of the centroid, maximum battery capacity, Degree of mobility	Optimize routing efficiency, optimize intra-cluster energy consumption, network lifetime increase	Limit effective communication range of the sensor nodes
Gao *et al.*[11]	AHP and Multiple criteria decision making	Energy status, QoS impact, location	Optimize operational efficiency of network, reduce traffic and save energy	Time synchronization, fault tolerant
Soro and Heinzelman[12]	Boolean satisfiability, integer linear programming (ILP)	Residual energy, distance, mobility	Better intra-cluster communication, better multi-hop connection, enforcement of coverage constraints	It doesn't ensure ideal number of chose heads
Devi and Buvana[13]	Fuzzy multiple parameter decision making	Residual energy, number of neighbours and location	Maximizing the connectivity, localizing high intensity traffic within a cluster, more robustness	More time consuming
Talapatra and Roy[14]	Topology based selection	Efficient information flow, insensitivity to mobility to cluster head failure	The recurrence of CH re-selection and normal briefest path length from CH diminish	More stabilizing needed, message complexity have to analyze

Devi and Buvana[13] proposed framework for "energy effective cluster head plan based on FMPDM for MANETs". This approach is based on various criteria decision making, to find weightage value of every node they used fuzzy analytical hierarchy process (FAHP). There are various parameters used i.e. initial energy, residual energy, energy consumption rate and average energy of network. The benefits of this approach is maximizing the connectivity, localizing high intensity traffic within a cluster, more robustness.

Talapatra and Roy[14], proposed approach for topology depends on CH election in wireless ad-hoc network. In this method fundamental thoughts of this approach is to abstain move choosing nodes found near the system partition border as such nodes are more likely to move out of the partition, thus causing a cluster header-election. They introduced component depends on nearby topological data just and don't require geological information.

Yu and Chong[15] provided a comprehensive study for clustering scheme in MANET. This study provided descriptions of the mechanism, evaluation their performance and cost. Clustering is a critical research subject in MANET since clustering ensure the fundamental level of throughput, framework execution and postponement, within the sight of both no. of mobile terminals and mobility.

As reviewed in the literature survey mentioned above several authors works for the CH selection in MANET using different techniques but they also faces some limitations as shown in Table 1, the energy consumption is more and the lifetime of network is low, so we have proposed a novel approach of soft computing based cluster-head selection. According this approach three parameters are used i.e., residual energy, hop-count and centrality, which results in the better CH selection and lifetime of the network in also increased.

PROPOSED WORK

A design of Soft Computing based Cluster Head Selection in MANET (SCBCH) with the help of Fuzzy Inference Control System (FICS) was proposed.

In proposed approach, a model for fuzzy based CH selection in MANET was presenting. In this approach, threshold value was set for every nodes and find membership function. After it taking three parameters i.e., residual energy, centrality and hop-count. Calculate all criteria and find rule base using fuzzy logic system.

Fuzzy Inference System (FIS): The FIS is the principle part of the proposed framework and its fundamental components are appeared in Fig. 3 Fuzzy system (FS) are utilized to approximate functions. It can be utilized to demonstrate any constant framework or capacity.

In fuzzy logic control (FLC), the nature of approximation for the fuzzy system relies on the standard of the rule set. The outcome depends on the approximation of various unknown non-direct capacity that may change in time. The FS is a linguistic theory that shows the reason for unclear thumb rule and some common sense.

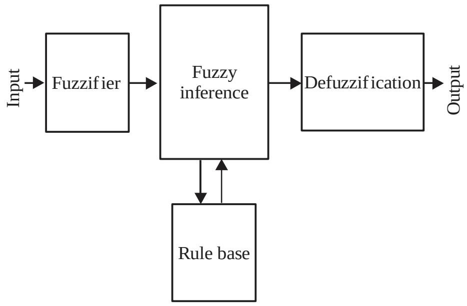

Fig. 3: The structure of a fuzzy logic system

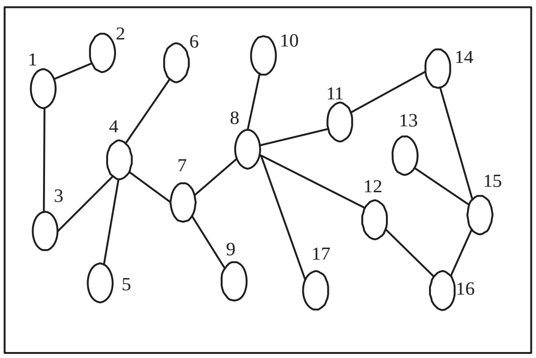

Fig. 4: Initial topology of nodes

For the approximation of fuzzy function if-then rule are the basic unit. In fuzzy function if-then rule set are used to design input value to output value. A fuzzy inference technique (FIS) known as MAMDANI, for its simplicity were used. The entire procedure was depicted in 4 steps that are as follows:

Fuzzifier: It converts the crisp set input the variable which is linguistic with the help of membership function which are stored in fuzzy knowledge base. In other way fuzzification is to depict the inputs from a set of sensors range from 0-1 using a set of input membership functions.

Inference engine: If-then sort fuzzy rule change over the fuzzy input to the fuzzy output.

Fuzzy rule base: Input are applied to a set of if/then control rules e.g., IF temperature is very hot, THEN set fan speed very high.

Defuzzifier: In this procedure the contribution for the defuzzification procedure is FS and the output we get is a number which is single. Comparable to the fuzzier the process of changing the output of the fuzzy to crisp using inference engine and membership function is analogous. At defuzzification process the points where the line would found which is vertical cuts and total set are distributed into 2 equivalent wrecks. In process, the COG (centroid of gravity) is computed and assessed over an example of focuses on the total membership function's output, given by the following formula[8].

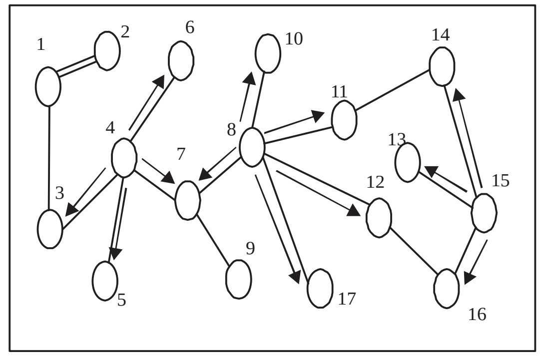

Fig. 5: Initially cluster heads are identified as 4, 8 and 15

$$\text{COD} = \frac{\left(\sum \mu_B(y) \times y\right)}{\sum \mu_B y}$$

Where, μ_B (y) is membership function of set B.

The main idea of this paper was to apply a CH selection scheme which depends on fuzzy. In this proposed study, CH considering three factors such as residual energy, centrality and hop-count was selected.

In this approach, it is divided in to 2 parts:

- Cluster formation
- Cluster head-selection

Cluster formation: In Fig. 4 there are many nodes in network which are connected to each other.

In Fig. 5, node 4 send hello packet to node 3, 6, 5 and 7. Node 8 send hello packet to node 7, 10, 11, 17 and 12 and node 15 send to node 13, 16 and 14.

In Fig. 6, Node 3, 6, 5 and 7 is cluster member of cluster A, node 7, 10, 11, node 12 and 17 is member of cluster B. All nodes have been connected to our one hop rout and generate cluster.

Cluster-head selection

Parameters for cluster-head selection

Residual energy: The energy utilized as a part of imparting procedure a given message by a node is known as dissipation energy and the energy left with a node after deducting the diffused energy from the node energy for delivering a given

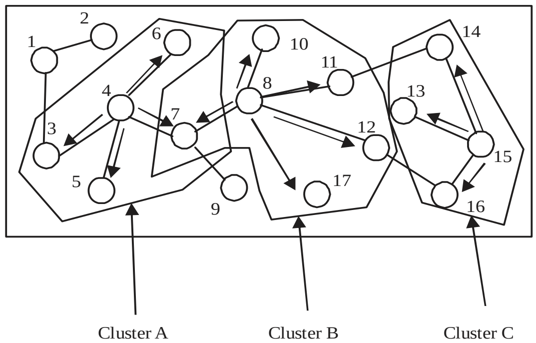

Fig. 6: Clusters are formation

message is known as a residual energy. It's depends on energy prediction model in below equation[8].

$$E_{TX}(l_i, d_i) = \begin{cases} l_i * E_{el} + l_i * \varepsilon_{fs} * d_i^2, \text{if } d_i \le d_o \\ l_i * E_{el} + l_i * \varepsilon_{mp} * d^4, \text{if } d_i > d_o \end{cases}$$

Where,
d_i = Distance between node and cluster
l_i = Energy utilization for reception circuit

є is amplifier parameters of amplifier power.

$$d_o = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$$

The consumption of receiving 1 bit is.

$$E_{RX}(l_i, d_i) = m * E_{el}$$

Node i of residual energy is:

$$E^i_{current} = E^i_{current} - E_{TX}(l_i, d_i) - E_{RX}(l_i, d_i)$$

Residual energy's membership function (μ_A) using fuzzy logic as,

$$\mu_A(RE_i) = \begin{cases} 1 \text{ if } RE_i > (TH_2) \\ \frac{(RE_i - TH_1}{(TH_2 - TH_1)} \text{ if } TH_1 < RE_i < TH_2 \\ 0 \text{ if } RE_i < TH_1 \end{cases}$$

Where:
TH_1 = Min threshold value and
TH_2 = Max threshold value

Centrality: The distance between the two nodes from centre that is shown with D variable is computed through the equation.

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

Centrality's membership function (μ_B) using fuzzy logic as:

$$\mu_B(C_i) = \begin{cases} 1 \text{ if } C_i \ge (TH_1) \\ \frac{(C_i - TH_1}{(TH_2 - TH_1)} \text{ if } TH_1 < C_i < TH_2 \\ 0 \text{ if } C_i \ge TH_2 \end{cases}$$

Hop-Count (expected transmission count (ET_X)): Number of expected transmission of a packet essential for it to be received without error at its target. An ETX of one allude a prefect transmission carrier, where an ETX of infinity describe a completely non-functional link. This number changes from 1 to infinity.

$$ETX = \frac{1}{1 - e_{pt}}$$

The ETX metric is another way metric for assessing most extreme throughput way is multi-hop wireless network.

The ETX way is the normal aggregate no. of packet transmission fundamental for effectively convey a packet with that way.

Path with minimum ETX has the highest throughput.

Centrality's membership function (μ_C) using fuzzy logic as:

$$\mu_C(H_i) = \begin{cases} 1 \text{ if } H_i \ge (TH_1) \\ \frac{(H_i - TH_1}{(TH_2 - TH_1)} \text{ if } TH_1 < H_i < TH_2 \\ 0 \text{ if } H_i \ge TH_2 \end{cases}$$

Proposed model shown in Fig. 7. This model have some nodes as an input who's directly connected with our all parameters i.e. residual energy, centrality and hop-count. Every node has own id and direct communicate with each other. After this it goes to fuzzy inference system where following terms are apply: Rule base, inference engine, fuzzy output and defuzzifier output which is give highest chance whose node become cluster-head.

Algorithm for soft computing based cluster head selection in MANETs.

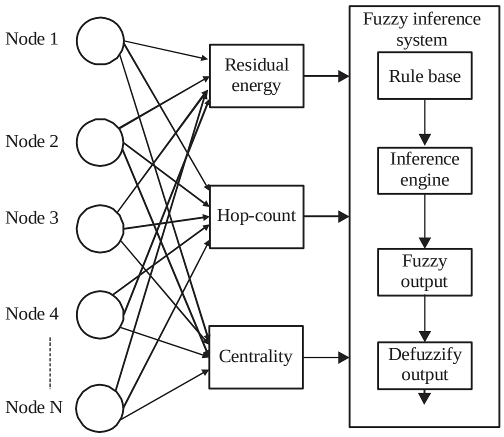

Fig. 7: Working model of proposed approach

Table 2: Fuzzy rules for proposed system

Residual energy	Hop-count	Centrality	Chance
Less	Less	Close	Less
Less	Less	Medium	Less
Less	Less	Far	Less
Less	Avg	Close	Medium
Less	Avg	Medium	Less
Less	Avg	Far	Medium
Less	High	Close	Medium
Less	High	Medium	Less
Less	High	Far	Medium
Avg	Less	Close	Less
Avg	Less	Medium	Medium
Avg	Less	Far	Medium
Avg	Avg	Close	Less
Avg	Avg	Medium	Medium
Avg	Avg	Far	Large
Avg	High	Close	Medium
Avg	High	Medium	Medium
Avg	High	Far	Large
High	Less	Close	Less
High	Less	Medium	Medium
High	Less	Far	Large
High	Avg	Close	Medium
High	Avg	Medium	Medium
High	Avg	Far	Large
High	High	Close	Medium
High	High	Medium	Large
High	High	Far	Large

Linguistic Parameters and their term set, Residual energy = (low, average, high), Hop-count = (low, average, high), Centrality = (close, medium, far) and Chance (possibility) = less, medium, large

Step 1: Initialize network ()

Step 2: On the basis of hello packet forwarding broadcast hello packet by every nodes

Step 3: if (range) {Node become neighbor update routing Table}

Step 4: Set threshold value of every nodes

Step 5: Calculate all various parameters

Step 6: Calculate residual energy:
Residual energy = initial energy-lost energy

Step 7: Calculate distance location

$$D = \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2}$$

Step 8: Calculate estimated transmission count:

$$ETX = \frac{1}{1 - e_{pt}}$$

Step 9: With the help of fuzzy logic system find rule set between all parameters

Step10: If (energy>high), (centrality>>close) and (Hop-count>low)
{Node become cluster head}

Step 11: Exit

IMPLEMENTATION OF FUZZY LOGIC

It was utilized that fuzzy logic application to pick the cluster-head depends on three parameters. These criteria are the input of FL which offers CH as an output select chance and the node with the more chance is selected as CH. So, we need setup $3^3 = 27$ rule for this fuzzy inference system. The fuzzy rule base shown in Table 2. In case, if event residual energy is maximum, hop-count is less and node centrality is minimum, then CH selection probability node is high. The semantic factor is used to replicate the residual energy and hop-count is categorized into 3 scales: Less, high and average individually and consists of 3 scales to speak the centrality of the nodes: Less, medium and high. The result to show the node cluster-head selection chance was differentiated into three levels: Less, medium and large.

Fuzzy logic framework with three input information creating output chance capacity. Figure 8, represents FIS in MATLAB with 3 input rule base along with fuzzy inference engine, followed by chance. The chance generated from the FIS has to be defuzzify and for this centroid method of defuzzification was used. Further, in Fig. 9 describe a screenshot from MATLAB which represent the triangular membership function for a parameter.

Simulation setup: The simulation model, have taken 100 mobile nodes over an area of 200*200 m, using fuzzy inference system and 27 rule to find highest chance to select CH (Table 3).

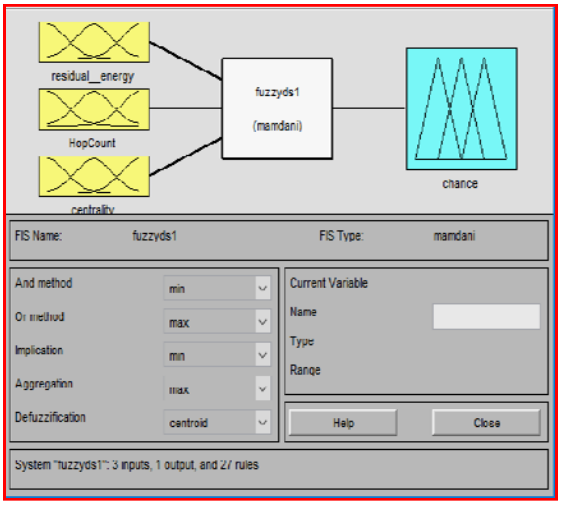

Fig. 8: Membership function of the inputs for the fuzzy system

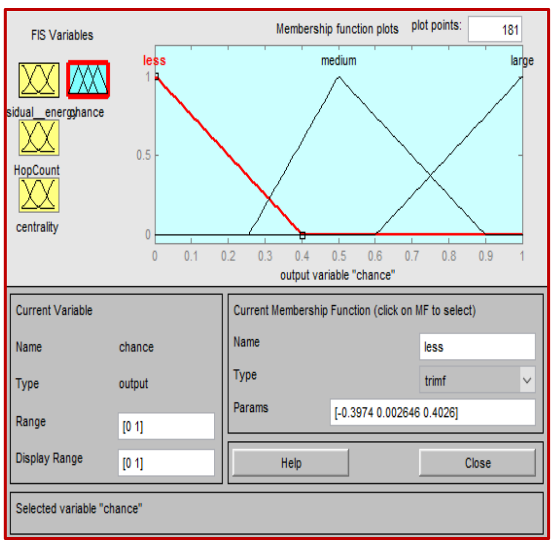

Fig. 9: Membership function of the outputs for the fuzzy system

VALIDATION AND ANALYSIS

There are 12 nodes in sub network shown in an Fig. 10. On the basis of centroid method the set are, distance of node when close from centrality = None, distance of node when median from centrality = {1, 3, 4, 6, 7, 10, 11 and 12} and distance of node when far from centrality = {2, 8}.

According to priority define above nodes in centrality.

Eight nodes 1, 3, 4, 6, 7, 10, 11 and 12 are chosen for CH choice process on which use fuzzy logic.

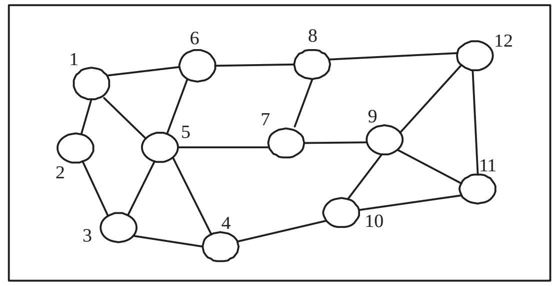

Fig. 10: Sub networks in MANET

Table 3: Simulation parameter for proposed approach

Name	Value
X-axis dimension Xm	200 m
Y-axis dimension Ym	200 m
Fuzzy rule	27
Radio dissipates (E_{el})	0.5000
Receiver Electronics (ERX)	5.0000e-08
Number of nodes	100
Fuzzy Inference Model	Mamdani
Input variable	Residual energy, Hop count, Centrality
Transmitter Electronics (ETX)	5.0000e-08
	1.30000e-15
Max round	1200

Assume node of residual energy is:

$$RE = \{0.2, 0.3, 0.3, 0.5, 0.6, 0.7, 0.8, 0.8\}$$

assume node of hop-count is:

$$H = \{0.1, 0.2, 0.2, 0.3, 0.4, 0.5, 0.7, 0.8\}$$

and assume node of centrality is:

$$C = \{0.2, 0.2, 0.3, 0.5, 0.6, 0.6, 0.7, 0.9\}$$

In membership function an efficient level depends on remaining energy at individual node and it is depicted in the form of graph in Fig. 11.

A distance of node from centre as membership function depends on centrality at individual node and it's depicted in the form of graph in Fig. 12.

An estimated transmission count of each node as membership function based on hop-count and it's depicted in the form of graph as shown in Fig. 13.

Now the membership degree of residual-energy, centrality and hop-count were evaluated. We are taking the mentioned membership function for all of the inputs in Table 4.

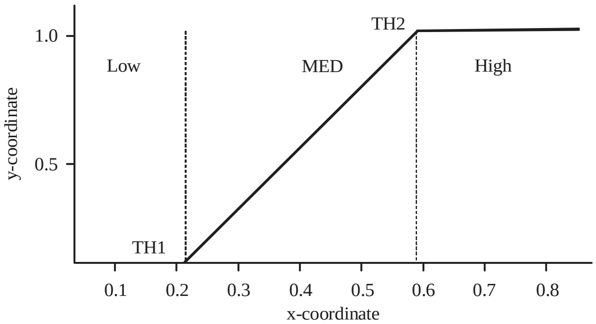

Fig. 11: Graph showing membership function for input variable (residual energy)

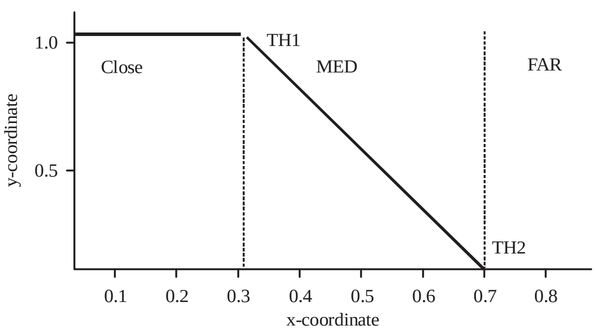

Fig. 12: Graph showing membership function for input variable (centrality)

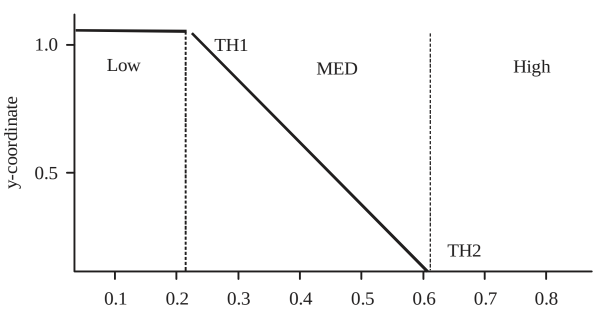

Fig. 13: Graph showing membership function for input variable (hop-count)

Table 4: Residual Energy's membership degree

Residual energy	Degree of membership
0.2	0
0.3	0.2
0.3	0.2
0.5	0.7
0.6	1
0.7	1
0.8	1
0.8	1

In Table 4 for the energy factor {0.2, 0.3, 0.3, 0.5, 0.6, 0.7, 0.8 and 0.8} the degree of membership are {0, 0.2, 0.2, 0.7, 1, 1, 1 and 1}. As per the Fuzzy output the membership of the above residual energy are:

Table 5: Centrality's membership degree

Centrality	Degree of membership
0.2	1
0.2	1
0.3	1
0.5	0.5
0.6	0.7
0.6	0.7
0.7	0
0.9	0

Table 6: Hop-count's membership degree

Hop-count	Degree of membership
0.1	1
0.2	1
0.2	1
0.3	0.2
0.4	0.5
0.5	0.7
0.7	0
0.8	0

{0.2|low, 0.3|medium, 0.5|medium, 0.6|high, 0.7|high, 0.8|high}

In Table 5, for the distance factor {0.2, 0.2, 0.3, 0.5, 0.6, 0.6, 0.7 and 0.8} the degree of membership are {1, 1, 1, 0.5, 0.7, 0.7, 0 and 0}. As per membership of fuzzy output of the above centrality are:

{0.2|close, 0.3|close, 0.5|medium, 0.6|medium, 0.7|far, 0.8|far}

In Table 6, for the estimated transmission factor {0.1, .02, 0.2, 0.3, 0.4, 0.5, 0.7, 0.8} the degree of membership are {1, 1, 1, 0.2, 0.5, 0.7, 0.7, 0, 0}. As per the membership of fuzzy output hop-count are:

{0.1|high, 0.2|high, 0.3|medium, 0.4|medium, 0.5|medium, 0.7|low, 0.8|low}

Now the fuzzy relation among the member function of residual energy and centrality were creating. The consequences of and operation of residual energy of membership value and centrality mentioned in Table 7.

Fuzzy relation between member function of hop-count and centrality. The output of AND operation process on membership value of hop-count and centrality in Table 8.

The possible combination of residual energy and centrality with highest membership value in Table 9.

The possible combination of hop-count and centrality with higher membership value in Table 10.

The membership degree of residual-energy, hop-count and centrality component is mentioned in Table 11.

Table 7: Result after fuzzy operation

C/E	0.2	0.2	0.3	0.5	0.6	0.6	0.7	0.9
0.2	0	0	0	0	0	0	0	0
0.3	0.2	0.2	0.2	0.2	0.2	0.2	0	0
0.3	0.2	0.2	0.2	0.2	0.2	0.2	0	0
0.5	0.7	0.7	0.7	0.7	0.7	0.7	0	0
0.6	1	1	1	0.5	0.7	0.7	0	0
0.7	1	1	1	0.5	0.7	0.7	0	0
0.8	1	1	1	0.5	0.7	0.7	0	0
0.8	1	1	1	0.5	0.7	0.7	0	0

C: Centrality, E: Residual energy

Table 8: Result after fuzzy operation

H/C	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8
0.2	1	1	1	0.2	0.5	0.7	0	0
0.2	1	1	1	0.2	0.5	0.7	0	0
0.3	1	1	1	0.2	0.5	0.7	0	0
0.5	0.5	0.5	0.5	0.2	0.5	0.5	0	0
0.6	0.7	0.7	0.7	0.2	0.5	0.7	0	0
0.6	0.7	0.7	0.7	0.2	0.5	0.7	0	0
0.7	0	0	0	0	0	0	0	0
0.9	0	0	0	0	0	0	0	0

H: Hop-count, C: Centrality

Table 9: Possible combination of residual energy and centrality

C/E	0.2	0.2	0.3
0.6	1	1	1
0.7	1	1	1
0.8	1	1	1
0.8	1	1	1

Table 10: Possible combination of hop-count and centrality

H/C	0.1	0.2	0.2
0.2	1	1	1
0.2	1	1	1
0.3	1	1	1

Table 11: Output table with degree of membership

Residual energy	Degree	Hop-count	Degree	Centrality	Degree
0.6	High	0.1	High	0.2	Close
0.7	High	0.2	High	0.3	Close
0.8	High	0.3	Med	0.5	Med

The outcome chance for these criteria is "largest" as "Residual-Energy" is maximum, "Hop-count" is low and for "Centrality" is near. The formation for the cluster-head selection among the chosen nodes can be taken by any above combination. But the better combination among all combination is residual energy = 0.8, hop-count = 0.1 and centrality = 0.2, who will be the perfect node for the formation of CH.

SIMULATION RESULTS

Experimental result showed the recreation result for proposed demonstrate. The model we chose the quantity of value set via completing numerous simulations.

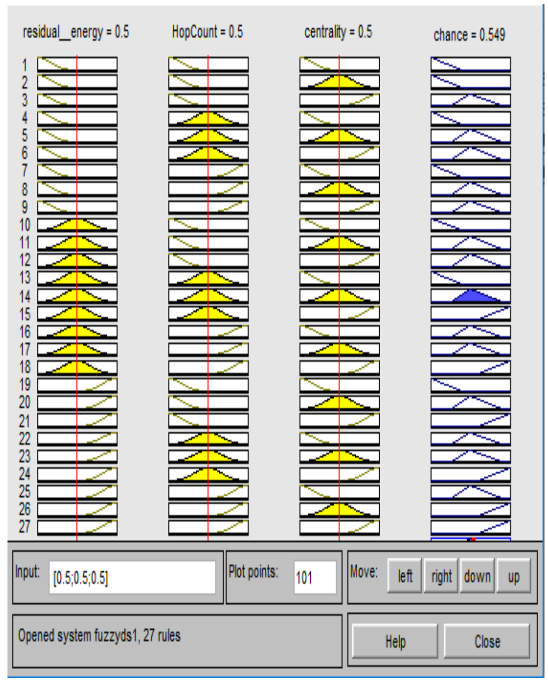

Fig. 14: Demonstration of inference engine decision making

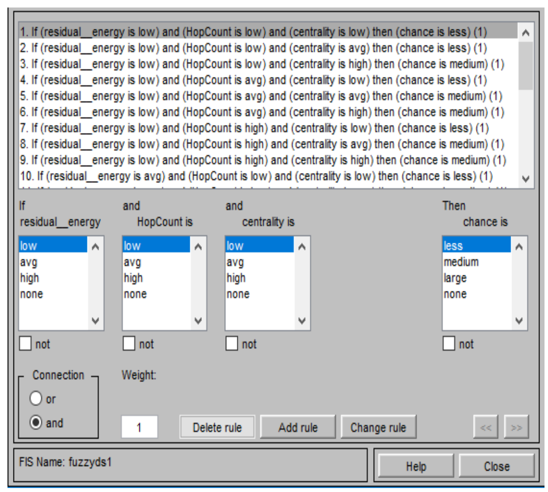

Fig. 15: Screen-shot of rulebase in MATLAB

To run FL system on MATLAB, three parameters for each node were used. Utilizing FL device on MATLAB, we receive output chance of determination of node as a cluster-head. Highest chance node is named as cluster-head of related cluster. Create rule viewer with the help of all parameters of node in MATLAB tool shown in Fig. 14.

Utilizing Fuzzy Logic device in MATLAB, a connection is set up between hop-count, residual energy and centrality with chance output in fuzzy rule base viewer in Fig. 15. We

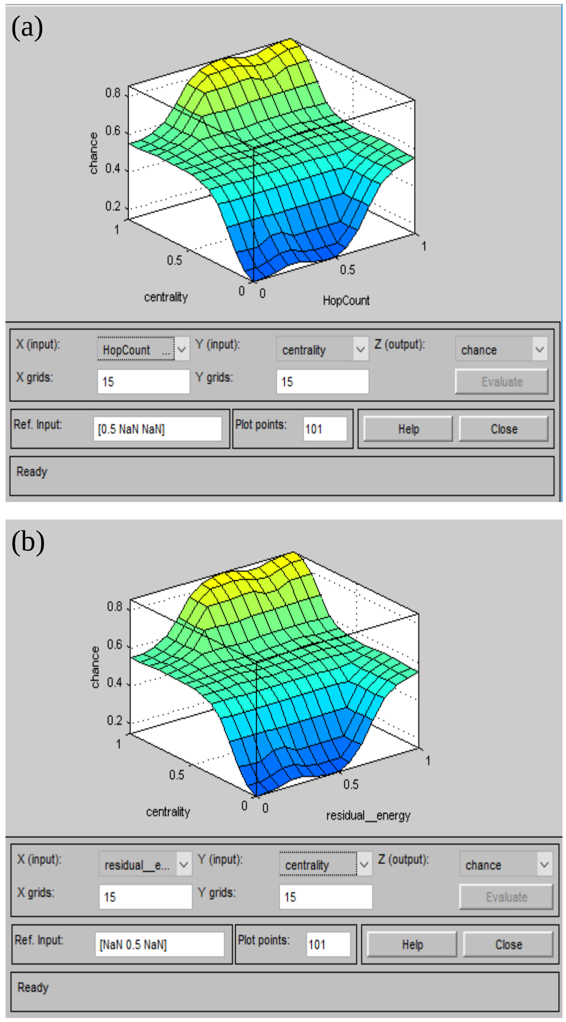

Fig. 16(a-b): (a) Correlation between input (centrality and hop-count) and output chance variables and (b) Correlation between input (residual-energy and centrality) and output chance variables

implement fuzzy rules and find the possibility of each node to be a cluster-head.

Relationship between residual energy, centrality and hop-count of nodes and chance output is displayed on surface view in Fig. 16a and b. In Fig. 16a graph x-axis presents residual energy, y-axis presents centrality and z-axis presents chance to selection of cluster-head. In this surface view 2 different criteria which is define whose nodes have highest.

In Fig. 16b, presents the relationship between hop-count and centrality of nodes. In this graph hop-count lie on x-axis, centrality lie on y-axis and z-axis present to chance or probability of selection of nodes as a cluster-head.

The final selection of cluster-head as shown in Fig. 17, we implement fuzzy based cluster-head selection which is depends on their own criteria and find highest chance of each node to be a cluster-head.

After CH selection corresponding clusters are also generated which is clearly shown in Fig. 18. This shows that the CH is a leader node for their respective cluster. CH contains all the information regarding the cluster members and it forward this information to other CH or base station.

Figure 19 represents performance of node, this graph indicate the No. of dead nodes (consider in percentage) in x-axis and the No. of rounds in y-axis, when rounds are increases dead nodes will occur. The round at which network fails that have maximum No. of rounds. It means nodes have not sufficient energy to transmit the data packet.

Figure 20 represents comparison graph between proposed work and both existing study. This graph shows

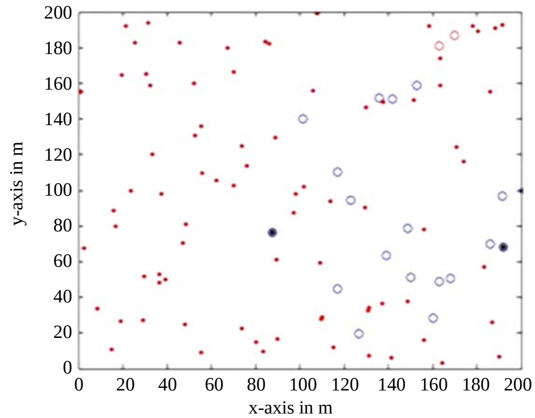

Fig. 17: Cluster-head selection

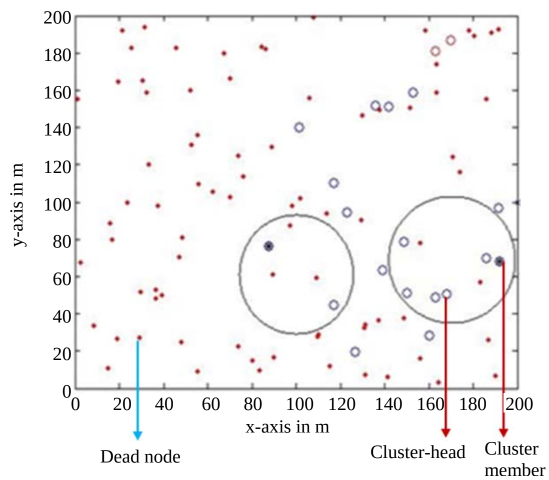

Fig. 18: Cluster-head with clusters

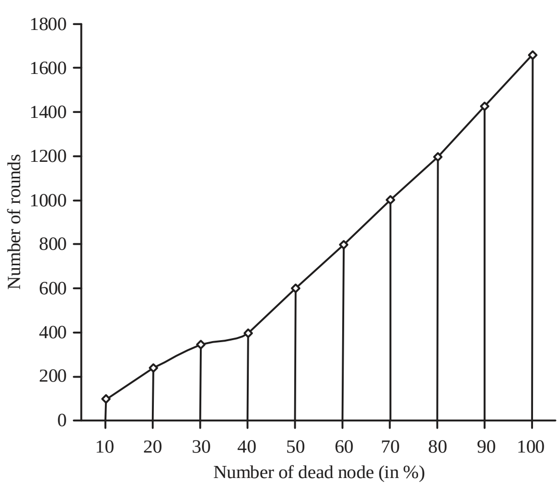

Fig. 19: Performance of node

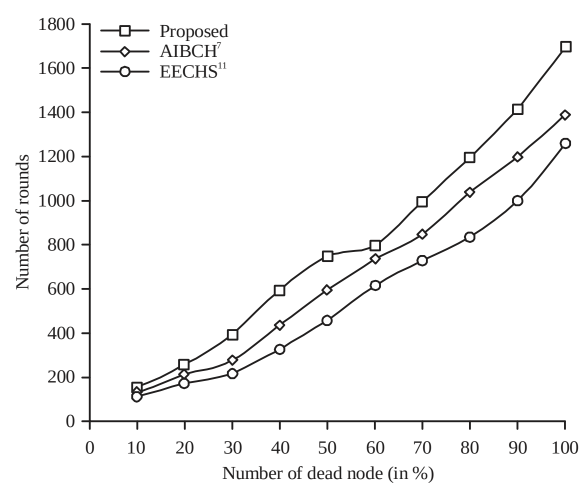

Fig. 20: Performance graph for network lifetime

performance of network lifetime. With the help of all parameters i.e., residual energy, centrality and hop-count find maximum no. of rounds of network, in x-axis represents No. of dead node and y-axis represents No. of rounds. From this graph it can say that the performance of proposed work is better than both existing work and also it increases network lifetime.

DISCUSSION

Performance of SCBCH is compared with AIBCH[7] and EECHS[11]. Simulation parameters are shown in Table 3. In this proposed study, for cluster head selection all parameters have used in fuzzy inference system shown in Fig. 3 which is based on MAMDANI method. Shown in Fig. 19, performance of nodes of proposed approach and Fig. 20 show comparison of existing researchers and proposed studies. This graph contains no. of nodes (in %) in x-axis and no. of rounds in y-axis. Comparison graph show network lifetime of all nodes in the network for 1200 rounds. It is maximum for SCBCH because of the following reasons: It choose cluster head which are having residual energy is high, centrality is close, hop-count is low and network lifetime is increases because of in proposed work number of rounds in network is maximum.

CONCLUSION AND FUTURE RECOMMENDATIONS

In this study, introduction of MANET, application, challenges, characteristics and various approaches for cluster head selection were introduced. Fuzzy based cluster-head selection using fuzzy inference system with the help of three parameters i.e., residual energy, centrality and hop-count is proposed. For the cluster-head selection the residual energy must be high, hop-count must be low and centrality must be close. The all parameters are used in fuzzy logic control and use IF-THEN rule to find highest chance to selection of cluster-head. It also represents the analytical model which consist the degree of membership function of all the parameters and perform the AND operation using this we computed all possible combination among all parameters. Then the node having the maximum chance is elected as CH. The benefits of this approach is reduce overhead, improving performance of cluster node in MANETs and also increases network lifetime. The future study might be using mobility as fourth parameters for cluster-head selection that helps in improving the performance of the network better.

SIGNIFICANCE STATEMENTS

This study discovers a novel approach for the cluster head selection in mobile ad-hoc network (MANET) which is based on fuzzy logic system. That can be beneficial to increase network lifetime of nodes and it takes lesser energy for data transmission. It will help the researches to uncover new parameters for cluster head selection using fuzzy logic. Thus it provide a new concept for efficient cluster head selection in MANET using fuzzy logic and further it can be extended using other parameters like mobility and trust etc. to improve the performance further.

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