An Energy Efficient Clustering Using K-Means and AODV Routing Protocol in Ad-hoc Networks

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Abstract: Mobile Ad-hoc Network (MANET) is a collection of wireless mobile hosts that create a temporary network without the help of centralized administration or particular support services. Energy consumption is the most critical issue in the MANETs, since the superior part of the mobile hosts work on inhibited battery resources. Reduction in the energy consumption results in the increase in the lifetime and throughput of the network. The performance of existing strategies is less in terms of energy conservation issues. To overcome these limitations, this paper uses an energy consumption method incorporate with a proactive MANET routing protocol. The routing protocol depends on the energy level and the movement of the nodes. Estimation of energy cost is performed based on the calculation of the energy consumption level of the node, using K-Means clustering along with AODV (Ad-hoc On Demand Distance Vector) optimized with Ant Colony Optimization (ACO). The performance of the proposed "K-Means-AODV-ACO" model is compared with the existing Energy Efficient Hybrid Routing Protocol (EE-HRP) and Mobile Agents based Reliable and energy efficient routing protocol (MAREERP) MANETs. From the comparison result, it is clearly seen that the proposed model accomplished better execution in terms of number of Packet delivery ratio (PDR), end-to-end delay, delay, drop and energy consumption.

Keywords: Ant colony optimization, Ad-hoc on demand distance vector, Centralized administration, End-to-end delay, Mobile ad-hoc network, Packet delivery ratio, Secure data transmission.

1. Introduction

Mobile ad-hoc network (MANET) is designed with mobile wireless nodes, which communicate over the wireless links of the distributed fashion in the absence of centralized access point or fixed physical infrastructure [1]. Ant Colony Optimization (ACO) technique chooses the multiple routes of MANET based on the maximum path preference [2]. Link and node instability of MANET avoided by developing the multipath multicast routing with the benefit of reliable neighbour selection mechanism [3]. The Residual-Energy based Reliable Multicast Routing (RERMR) protocol maintains the reliable multicast routing that improves the connectivity and stability of the network and this RERMR protocol mainly depends on the threshold value [4]. An energy efficient routing algorithm Secure Three Fish

Distributed Meaning (STFDR) creates the route from source to destination that provides the collision awareness and security [5]. The self-adaptive genetic algorithm developed for routing between the nodes under the dynamic topology environment [6].

In power heterogeneous MANETs, the free virtual clustering based RP presented for minimizing the obstruction caused by high power nodes and Authenticated Anonymous Secure Routing (AASR) developed for defending against potential active anonymous attacks [7-8]. In mobility state adaptive routing, the routing is achieved by using either ETX or the MF metric, which is identified based on a detected mobility state. The PDR model doesn't show better results in both static and mobility scenarios while reducing the number of dropped packet [9]. The information about the local link connectivity is identified by an adaptive HELLO messaging scheme to observe the link status among

the nodes as well as the dynamic on demand routing protocol is utilized for minimizing the energy consumption. Then this adaptive HELLO messaging method reduced the unwanted hello messages. The Hello interval can't be enlarged without reduced detectability of a broken link and affect overhead and energy. [10 - 11]. An energy efficient route over the MANET is made by utilizing a vague set estimation strategy in an energy effective RP. The interval based membership function is used in the vague set measurement technique. The network lifetime based on the different parameters as vague set and deciding some fitness threshold statistic are not mentioned [12].

In the Temporally Ordered Routing Algorithm-Routing Protocol (TORA-RP), the Binary Particle Swarm Optimization (BPSO) algorithm includes the element of the energy awareness. This BPSO-TORA considers the routes length and energy level while establishing the route. The total delivered data, network lifetime and system lifetime are low [13]. AODV based clustering and routing is presented in the MANET and this protocol is used for integrated routing and message delivery complete the clustered networks. The algorithm didn't provide more speed and transmission rate in the simulation [14]. An Anonymous Location based Efficient RP (ALERT) is declared for proposing high anonymity security at low cost. If the delay increase, it affects the overall presentation of the network. The reinforcing ALERT in an attempt, active attackers are not up to level [15]. The Ad-hoc on demand multipath distance vector used a fitness function (FF-AOMDV) to generate the optimum path from source to destination. The fitness function considers only two parameters such as distance and energy. The fitness value with bandwidth as another fitness value is not mentioned [16]. To overcome the above mentioned problems the k-means clustering with ACO optimized AODV routing for selecting the optimal path to transfer the data over the network is introduced. Hence, "K-Means-AODV" methodology provides better results in delay (6%), DelRatio (7%), energy consumption (8%), and drop (5%) compared to EE-HRP (22) and MAREERP (23).

The rest of this paper is organized as follows: Section 2, reports on Literature survey. Section 3, presents a review on "K-Means-AODV-ACO" Methodology in MANET. Section 4, describes the results and discussion of overall "K-Means-AODV-ACO" methodology.

2. Literature review

G. Singh, N. Kumar, and A. K. Verma [17] introduced the Ant Colony Optimization (ACO) based Routing Algorithm (ANTALG) that considered the random election of the transmitter (source) and Receiver (Destination) nodes and also it replaced the agents among them. The nodes trip time was recorded by creating the pheromone tables and data structures while moving the ants (agents). ANTLAG algorithm had the best phereme value in their agents and this algorithm used the global updation to identify the effective route. The network declares the transmission path as a broken path, when the transmission time of HELLO packet is more. The security features of communication among the nodes not performed.

S. Chettibi, and S. Chikhi [18] presented a RP called as Dynamic Fuzzy Energy State based AODV (DFES-AODV). The forwarding probability of route requests was decided by using the Mamdani fuzzy-logic system in each node. The mobile node's residual battery level and the energy drain rate were the inputs for the FLS. In addition, an FSARSA-AODV algorithm was implemented with the fuzzy extension of the critic architecture for SARSA RL algorithm. This DFES-AODV is an energy efficient method and it is self-adaptive. FSARSA-AODV requires an empirical adjustment of several functional parameters. Number of nodes/user are less in the simulation.

W. Liu, and W. Kim [19] presented the Stability Considered Density Adaptive Routing (SDR) in MANET to create a stable route and it reduced the routing overhead. In SDR various routing tactics were performed according to the related density of vicinity and this routing was selected as two modes. Those are dense mode (D-mode) and sparse mode (S-mode). The routing overhead minimized by considering the stability value of each node while performing re-routing.

R. M. Kuchaki, and H. Fatemidokht [20] adopted the nature inspired (swarm intelligence) algorithms named as FBeeAdHoc for offering the secure routing among the MANET. The attacks from the malicious nodes were overcome by FbeeAdHoc secure routing protocol. Transmission efficiency of FbeeAdHoc is less compared to the BeeAdHoc algorithm. The optimizing of fuzzy membership function and finding selfish node is to be further enhanced.

W. Jabbar, A. M. Ismail, and R. Nordin [21] presented the Multi-Path Battery and Mobility Aware Routing scheme (MBMA-OLSR) which is influenced by the MP-OLSR. The metric of Multi

Criteria Node Rank (MCNR) was used in the MBMA-OLSR and this MCNR includes the node's speed and the residual battery energy. The stability of the links was ranked by link assessment function and then it selected the stable and efficient path for data transmission. MBMA-OLSR used an Energy and Mobility Aware Multi Point Relay (EMA-MPR) selection mechanism for locating the nodes inclination. The energy efficiency was achieved by transmitting more packets at low energy cost per packet. The work doesn't evaluate in the large-scale network deployments and also in similar multi-hop networks such as WSNs and WMNs.

3. Kmeans-AODVACO methodology

The nodes in the MANET have limited power capabilities; it leads to link failure while transmitting the data packets from source to destination. In order to overcome that, the k-means clustering with AODV routing is utilized in the MANET. Then the AODV routing is optimized with the help of ACO to select the optimal path to send the data packets via the network. The overall process of this proposed scheme is given in the flowchart as shown in Fig. 1.

- Initially, the sensor nodes are arbitrarily organized in the interested area.
- K-means clustering is applied in the sensor nodes to cluster the network into a number of clusters. Then the Cluster-head is selected from each cluster.
- AODV with ACO routing is applied to create the optimal path from source to destination.
- From the routing, an optimized node is selected to form the route from source to destination.
- If the selected node has required energy to transfer the data means, it delivers the data from one node to another node or else it selects another optimal node for transferring the information.
- After creating the path from source-to-destination, it sends the data to the destination.
- This proposed method predicted the optimal path for data transfer under the power constraint nodes in a MANET.
- At last, the performance of this proposed method is analysed in terms of throughput, end-to-end delay, and packet-delivery-ratio and energy consumption.

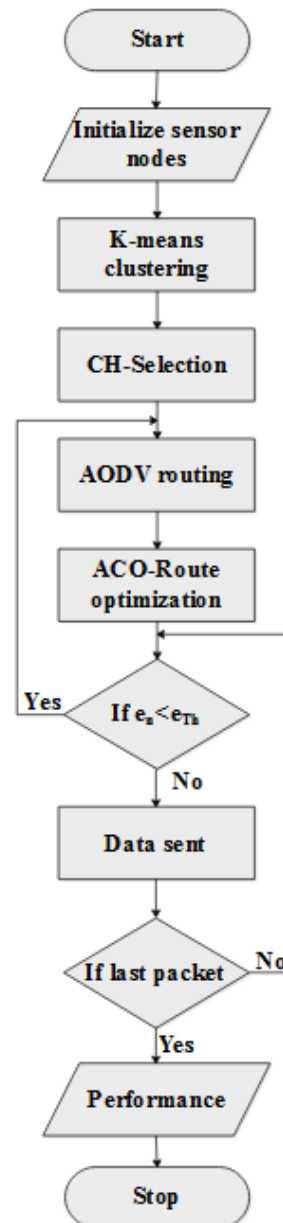The following session summarizes the "Kmeans-AODVACO" methodology.

Figure. 1 Flowchart for the proposed scheme

3.1 Kmeans clustering

K-Means might be computationally quicker than hierarchical grouping with larger number of variables by producing tighter clusters than hierarchical clustering. K-means algorithm is followed three steps.

Initialisation: Set common centre points

- Assign each object to the cluster with the closest centre point
- Calculate centre points as the centroids of the clusters of the current divider (i.e. mean point of the cluster)
- Turn back to step 1, stop when no newer obligation of nodes.

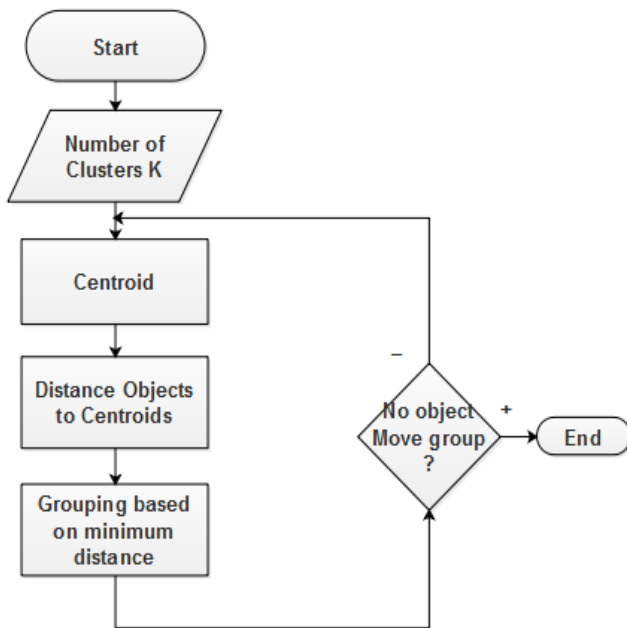The Fig. 2 describes about the K-means clustering algorithm.

Figure. 2 K-Means algorithm

The clustering algorithm makes the transmission in a local domain and transmit the forwarding nodes (gateway-nodes). A group of nodes forms a cluster and the local co-operations between cluster members that are controlled through a CH. The following steps designates, how the clustering of networks takes place;

A k number of clusters are produced from the n number of SNs, the fitness function is minimized by the algorithm. The fitness function that is used in this k-means clustering is squared error function and it is given in Eq. (1).

$$F = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i - c_j \right\|^2 \qquad (1)$$

Where, the centre of jth cluster is represented as c_j, data point of ith sample is denoted as x_i and the distance from the each SN to the cluster centre is represented by $\left\| x_i - c_j \right\|^2$.

There are four main steps performed in K-means clustering algorithm.

Step 1:
Firstly, the k clusters are formed from the SNs by compelling the k number of centroids at random places.

Step 2:
The Euclidean distance from each SN to the centroid is computed for making the k initial clusters. Consider each node is closest to the centroid. The Euclidean distance from one node to another node is given in Eq. (2).

$$Euclidean\ distance = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \qquad (2)$$

Where, the co-ordinates of x and y axis is represented as x_1, x_2 and y_1, y_2 respectively.

Step 3:
The situation of every node is checked from the previous position and each cluster areas are again generated in a network.

Step 4:
If the location of centroid becomes changed, then again go to step 2 for attaining the efficient clusters else the clustering progression to end. At last, the centroid, which is assigned from the K-means clustering as an ideal CH for a group in the networks.

After the clustering of nodes, the routing process takes place using AODV Routing Protocol, which is explained below.

3.2 AODV routing protocol

The AODV is a reactive routing protocol; subsequently routes are resolved only when needed. Fig. 3 exhibits the message exchanges of the AODV RP. Hello messages might be employed by every active node in which its occasionally broadcasts a Hello message to its neighbouring nodes. Since nodes occasionally send Hello messages, if a node neglects to get a few Hello messages from a neighbour, a connection break is distinguished. Exactly when a source has data to transmit messages to an unidentified destination, it conveys a RREQ for that destination. A RREQ message receive a route from the source that is created at each intermediate node. If the receiving node has not received this RREQ previously, then it is not the destination and does not have a current course to the destination that it rebroadcasts the RREQ. In the event that the accepting node is the destination or has a current course to the destination, it delivers a RREP. The RREP is uni-cast in a hop-by-hop form to the source. Each intermediate node creates a route to the destination as the RREP stimulates. It records the route to the destination and can start sending information, when the source gets the RREP. It generates a RREP, if the receiving node is the destination node or has a current route to the destination. Each intermediate node makes a route to the destination as the RREP engenders. The route with the shortest path is chosen if different RREPs are received from the source.
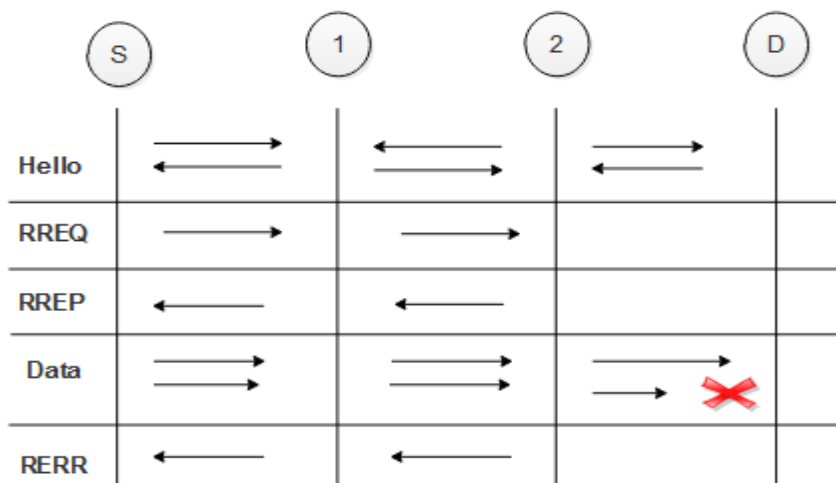
Figure. 3 AODV protocol message

Each node along the route informs the timers linked with the routes to the source and destination by maintaining the routes in the routing table. A node cannot make certain route updates, whether the route is still valid accordingly by expelling the route from its routing table. A RERR is sent to the source of the information in a hop-by-hop fashion, if the information is streaming and a connection break is recognized. Each intermediate node invalidates route to any unreachable destinations as the RERR broadcasts towards the source. When the source of the data/information admits the RERR, it reversals the route and reinitiates route discovery if essential. AODV routing protocol is optimized using ACO.

3.3 Route optimization using ACO

ACO is a part of the larger field of swarm intelligence in which scientists study the behaviour patterns of bees and other social insects in order to simulate processes. The main source of motivation is found in the capacity of certain kinds of ants to search the shortest path between their nest and a food sources using Pheromone (Impulsive Chemical Substance). Ant leave traces of pheromone as they migrate between sources to destination. Ants specially go in the course of high pheromone intensities in search of food. The higher levels of pheromone is received, when minimum paths are finished faster. The positive strengthening process allows the colony as a whole to touch on the shortest path.

4. Results and discussions

The "K-Means-AODV" method is implemented in the NS2 simulation tool. The simulations parameters are shown in Table 1. The simulation starts and end time is denoted as 0.0001-50.0000

correspondingly by varying the number of static nodes as 20, 40, 60, 80 and 100. The MAC Type is 802_11 with Omni Antenna model. This section gives a detailed view of the results that are obtained using "K-Means-AODV" method for providing efficient energy and ACO optimization, which reduces the total energy consumption in the network by minimizing the lifetime in mobile ad-hoc networks by giving better performance compared with the existing methods. The performance is calculated by measuring the delay, routing overhead, energy and drop parameters. The performance metrics is given below.

4.1 Packet delivery ratio (PDR)

Based on a total amount of packets established in a ratio by a total number of destination packet sent by the source node, which is given in Eq. (3).

$$\text{DelRatio} = \frac{(\text{no. of packets send} - \text{packets lost})}{\text{no. of packets send}} \times 100 \quad (3)$$

4.2 Energy consumption

A number of nodes is equivalent to the amount of received energy consumption. A node drops a specific amount of energy for every packet transmission and received, which is given in Eq. (4).

$$Energy = \frac{amount\ of\ energy\ for\ every\ packets}{total\ simulation\ time} \quad (4)$$

4.3 Delay

The difference between sending time of packets and receiving time of packets is known as delay, which is given in Eq. (5).

$$Delay = Time\ spend\ on\ Hop1 +$$
$$time\ spend\ on\ Hop2 +$$
$$\cdots..+time\ spend\ on\ Hop\ n \qquad (5)$$

4.4 Packet drop/packet loss

Total amount of packets sends and packet established is known as the packet drop/packet loss, which is given in Eq. (6).

$$Drop = \frac{(Total\ no.of\ packets\ send - Packet\ received)}{Total\ number\ of\ simulation} \qquad (6)$$

Table 1 shows the delay by changing different nodes such as 20, 40, 60, 80, and 100 of fixed Nodes. Hence, K-Means-AODV" Methodology shows better results than that EE-HRP and MAREERP.

The evaluation of nodes vs. delay between Kmeans-AODV-ACO and existing method is plotted in Fig. 4. The value of delay is diminished in Kmeans-AODV-ACO method compared to the EE-HRP method with different 20, 40, 60 80 and 100 Nodes.

Table 2 shows the DelRatio by changing different nodes such as 20, 40, 60, 80, and 100 of fixed Nodes. Hence, K-Means-AODV-ACO" Methodology shows better results than that EE-HRP and MAREERP.

The Evaluation of Nodes vs. DelRatio between Kmeans-AODV-ACO and existing method is plotted in Fig. 5. The value of DelRatio is increased in Kmeans-AODV-ACO method compared to the EE-HRP method with different 20, 40, 60 80 and 100 Nodes.

Table 1. Delay by varying number of nodes

QoS	Delay				
Nodes	20	40	60	80	100
EE-HRP [22]	1.656479	3.106972	3.532987	4.324796	4.523796
MAREERP [23]	1.312789	2.245609	2.689076	3.107033	3.888776
Kmeans –AODV	1.179187	1.359974	1.801087	1.184184	1.683421
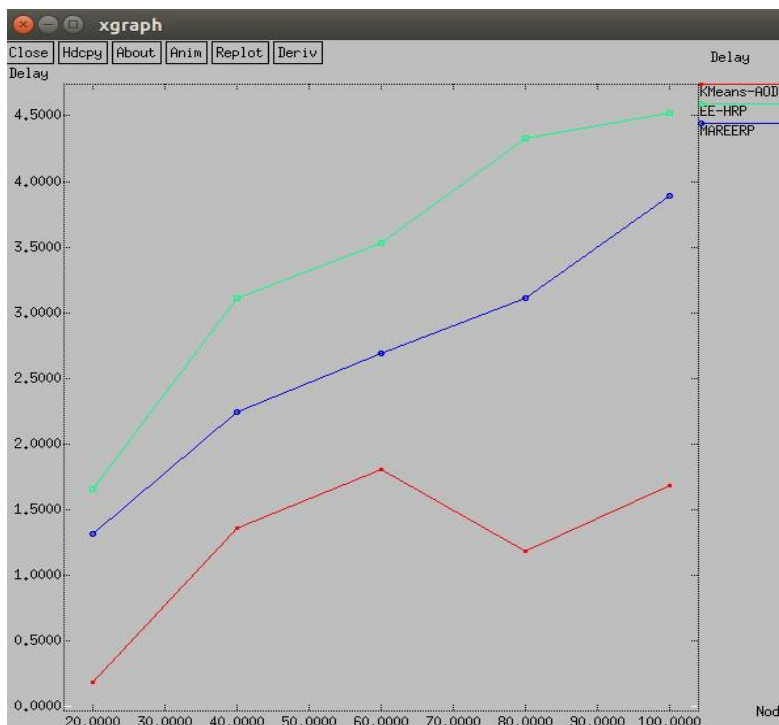
Figure. 4 Number of nodes vs. delay

Table 2. DelRatio by varying number of nodes

QoS	DelRatio				
Nodes	20	40	60	80	100
EE-HRP [22]	332.73	259.05	229.35	210.37	112.67
MAREERP [23]	334.56	267.89	245.78	229.89	168.78
Kmeans –AODV	382.75	289.95	265.35	237.38	197.75

Table 3 shows the Energy by changing different nodes such as 20, 40, 60, 80, and 100 of fixed Nodes. Hence, K-Means-AODV" Methodology shows better results than that EE-HRP and MAREERP. The Evaluation of Nodes vs. energy between Kmeans-AODV-ACO and existing method is plotted in Fig. 6. The value of energy is decreased in Kmeans-AODV-ACO method compared to the EE-HRP method with different 20, 40, 60 80 and 100 Nodes.

Figure. 5 Number of nodes vs. DelRatio

Table 3. Energy Consumption by varying number of nodes

QoS	Energy Consumption				
Nodes	20	40	60	80	100
EE-HRP [22]	24.241127	22.431217	22.217316	22.176739	22.567896
MAREERP [23]	24.17114	22.16345	21.94356	22.06782	22.34789
Kmeans –AODV	24.062211	22.011249	21.725402	21.974539	22.238232
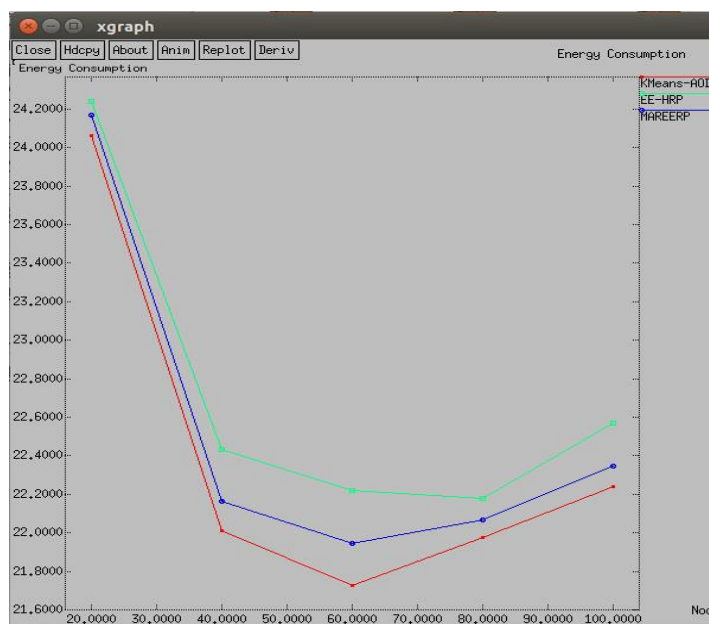
Figure. 6 Number of nodes vs. energy

Table 4. Drop by varying number of nodes

QoS	Drop				
Nodes	20	40	60	80	100
EE-HRP [22]	1267	1226	1251	1345	1366
MAREERP [23]	1290	1256	1278	1373	1386
Kmeans –AODV	1256	1204	1235	1302	1350

Figure. 7 Number of nodes vs. drop

Table 5. Simulation Parameters of K-Means-AODVACO

Clustering technique	K-Means
Routing technique	AODV
Optimization techniques	ACO
Simulator used	NS2
Simulation start time	0.0000000001
Simulation End time	50.000000000
Number of mobile nodes	20, 40, 60, 80 and 100
Antenna Model	Omni Antenna
Minimum speed	28 ms
Network Interface types	Wireless
MAC Type	MAC/802_11
Initial Transmit Power	0.660
Initial Receive Power	0.395

Table 4 shows the drop by changing different nodes such as 20, 40, 60, 80, and 100 of fixed Nodes. Hence, K-Means-AODV" Methodology shows better results than EE-HRP and MAREERP.

The Evaluation of Nodes vs. drop between Kmeans-AODV-ACO and existing method is plotted in Fig. 7. The value of delay is decreased in Kmeans-AODV-ACO method compared to the EE-HRP method with different 20, 40, 60 80 and 100 Nodes.

The simulation parameters are shown in Table 5. The simulation starts and end time are denoted as 0.0001-50.0000 respectively by varying the number

of static nodes as 20, 40, 60, 80 and 100. The MAC Type is 802_11 with Omni Antenna model

5. Conclusion

This section describes the conclusion of the proposed energy conservation mechanism. The energy is calculated based on the prediction of the energy consumption level of the node. The energy computation method is performed using the Kmeans clustering along with the AODV routing with ACO optimization by selecting the shortest path in the network. The "Kmeans-AODV-ACO" model handles network state related constraints such as energy consumption of nodes in the ad-hoc networks. The performance of the proposed "K-Means-AODV-ACO" model is compared with the existing EE-HRP models and MAREERP. The proposed model achieved better PDR (7%), end-to-end delay (6%), drop (5%) and energy consumption (8%) in ad-hoc networks. Improvement in the choosing shortest path in ad-hoc networks can be established in the future improvement.

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