Energy Efficient Multihop Cooperative Transmission Protocol for Large Scale Mobile Adhoc Networks

D. Praveen Kumar, P. PardhaSaradhi, M. Sushanth Babu

Abstract: Cooperative Communication (CC) is implemented extensively in mobile Ad hoc networks to leverage the benefits of CC technique. Energy consumption and routing are major challenges for large scale Cooperative Mobile Ad hoc Networks (LC-MANET) since each node in the network have mobility. To address these challenges, a hybrid multi-hop cooperative routing algorithm is formulated by combining clustering and location-based routing strategies. The main idea of our algorithm is to establish communication between similar mobility nodes to reduce the mobility effect since the link between (approximately) equal mobility nodes was reliable. All the equal mobility nodes are grouped to form a cluster; one of the nodes in this is selected as a cluster head based on its location. Further, we optimize the number of transmitters and receivers in every hop; and an optimal number of cooperative relays are obtained in every hop thereby reducing the end-to-end energy utilization. The evaluation result shows that the proposed algorithm saves energy consumption by up to 53.42% compared to traditional algorithms.

Keywords:Energy-efficient routing, large-scale MANET, relay selection, energy optimization, cooperative routing, clustering.

I. INTRODUCTION

Cooperative Communication (CC) is an effective technique to combat the fading effects by providing spatial diversity using multiple single radio terminals at the transmitter and/or receiver (MIMO) using broadcast nature of wireless communication. In this, relay nodes retransmit the replica of data from the source and then destination combines the replica for better decoding of original data. Because of implementing virtual MIMO, the CC technique improves network performance in terms of throughput, capacity, and reliability [1][2].The performance of three-stage cooperative communication attracts the researchers to extend this to large scale networks. But the increase of neighbor transmission links leads to high interference and thus degrades the network performance even worse than direct communication (without cooperative communication). With the improvements in modern wireless technologies, electronic devices supporting the IEEE 802.11 network standard [3] can be equipped with multiple radio terminals, and their cost is reduced. The effect of interference can be mitigated by supporting neighbor transmission over multiple orthogonal channels and thus improves the network capacity [4]. Energy consumption is a key issue for MANETs. Due to high data rate applications, there is a rapidly increasing demand for high capacity, which will further increase energy consumption, decrease the network lifetime and reliability. Clustering routing techniques address these challenges [5]. The Low Energy Adaptive Clustering Hierarchy (LEACH) is one among the most popular clustering routing schemes. A number of enhanced LEACH routing schemes have been proposed over the recent years, by focusing on network topology modified cluster-heads (CHs) selection, and network expansion [6]. In [7], the authors have proposed a virtual cooperative MIMO transmission mechanism and obtained an analytical expression for the optimal number of cooperative nodes for two-stage cooperative networks. A low complexity cooperative routing algorithm was proposed in [8] and presented an optimal power allocation strategy. To minimize the network energy, the authors in [9] have proposed routing algorithms by enhancing the performance of Physical, MAC, and Network layers. For this, the authors have proposed a cooperative automatic repeat request (ARQ) mechanism at the MAC layer. A cooperative routing algorithm based on Quality of Service was presented in [10], to minimize energy consumption. But all the aforementioned authors considered the network, where all the nodes are equipped with a single radio terminal.The authors in [11] have proposed an opportunistic cooperative packet transmission (OCPT) scheme for multi-hop cooperative networks. In OCPT, before the transmission, a cluster head selects the transmitter and receivers to form MIMO. Because of multiple transmitters and receivers in each hop, the energy utilization of the network is considerably high. A two-stage cooperative routing strategy was proposed in [12] to enhance energy efficiency and network lifetime. Therefore this work has considered the effect of cooperation into link cost evaluation, and then obtains the optimal path based on link cost. But to obtain the best possible path, this scheme needs to evaluate the effect of cooperation and update link cost periodically.The remainder of this paper is prepared as follows. In section II, Literature survey is presented in detail. Our proposed Energy-efficient hybrid cooperative routing and optimization of cooperative nodes are presented in section III.

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In section IV, we present the simulation results, and finally, we concluded the paper in section V.

II. LITERATURE SURVEY

Muhammad Asshad et al [13] presents the performance evaluation of the Rayleigh and Weibull fading channels with the best technology
for relay selection for the non-regenerative wireless cooperative network. The signal-to - noise (SNR) of the moment generation feature (MGF) at the target node comes with the Weibull fading parameter. We also calculate the lower bound value and probability of failure of the symbol using MGF. In order to verify the derivation accuracy, analytical and simulation results for the probabilities of a split and symbol error rates are given under different relay nodes using the max-min relay selection technology. Yet, a few larger relay nodes which diminish the accuracy of the analytical design and unwanted resource usage.BojieLv et al [14] created a basis for an asymptotically optimum solution by converting the original problem into a fixed stage number equivalent Finite-Horizon Markov Decision process (MDP). A modern method is then introduced to solve the dimensionality burden, which offers empirical representations of estimated value functions. The exact value attribute and approximation error also derive our analytic limits. Many device statistics, including the distribution of the consumer, rely on the approximated value functions. For the case where these data are unclear, a reinforcement learning algorithm is suggested. In addition, this function often includes energy consumption. Yuan Gao et al [15] presented with the modern approach of machine learning based discovery of node and distribution fusion. We first derive the condition of mobile devices with thermal patterns, then suggest the deep learning approach for showing the condition of each node and optimizing the choice of the target node, and finally carry out a multi stage transfer to improve spectrum effectiveness in wireless information fusion. Often, the core network and the wireless link provide high pressure if many users request the same data.Mehdi Sdeghzadeh et al [16] suggested a plan for physical layer protection in downlink massive MIMO system wireless connection, a systemized block diagonalization precoding that use the Artificial Noise (AN) strategy. We extract for the proposed scheme the privacy standard and the asymptotic confidentiality factor. The optimum allocation of power for permissible users and the AN indicator for optimal asymptotic hidden sum is derived in a closed form. Our analyses demonstrate that it is more effective to minimize eavesdropper performance than to boost legal usage output in order to achieve the best results. They even analyze the effect of channel assumptions on the device and in this case they extract closed-form SINR and confidentiality total rate statements. However, the packet error rate power (PER), maximization of the confidentiality rate, or compliance with such service quality metrics are not regulated.Mohammad Ragheb et al [17] suggested a new Optimum Power Assignment Method (OPA) to improve the cooperative Wireless Network's instantaneous secrecy limit. The studied network architecture consists of a multi antenna source, a multi antenna destination, one untrusted relay and a passive Eves antenna. A new safe communication method is designed to avoid the vulnerable relay and inactive Eves from overhearing the source packet. On the basis of this system, the destination sends the untrusted relay artificial noise (AN) and, at the moment, the source is required to devote part of its power to transmit AN in order to keep the knowledge private from the Eves. Nonetheless, a low convergence rate and an ineffective solution is attained by this method.JianPing Yao et al [18] described horizontally as two separate homogeneous Possion Point processes (PPPs), the permissible destination and eavesdropper are dispersed, and each UAV is located just above its respective permissible destination for effective secrecy transmission. We also assume a path-loss model for the air-to-ground (A2 G) wireless networks for height-angle-dependent line-of - sight (LoS)/non-LoS (NLoS) and the confidentiality communication wiretap code is employed. In this set-up, the connection probability (CP), secrecy outage probability (SOP) and secrecy transmission capacity(STC) are first defined in ways that can be plotted with a statistical traction. However, these terms are all too complex mathematically for intuitionThough [13] affect the accuracy of the analytical model because of large fewer relay nodes, [14] major issues are routing and energy consumption, [15] the wireless connection and the central network will accommodate high pressure when the same data is applied by multiple users, [16] does not control the power of packet error rate (PER), enhancing the security, [17] obtains a poor solution and low convergence rate and [18] too complicated for mathematical expressions to draw insights. From the aforementioned issues, it is essential to develop a new technique of routing algorithms for energy consumption in a cooperative network.

III. HYBRID MULTI-HOP COOPERATIVE ROUTING ALGORITHM

In recent years, collaboration on wireless networks was becoming increasingly attractive since the particularly severe channel impairments resulting from multi-way diffusion could be alleviated. To further enhance structure and performance, the MANET and co-operative transmissions are used. However, energy consumption for MANETs is a crucial issue. Due to applications of high data rate, the demand for high capacity is increasingly growing, which in turn increase energy utilization, reduce the lifespan of the network. Mobile ad hoc networks are the purest form of decentralized systems and thus place numerous challenges on cooperative communication. As a result, much ad hoc research on the network has focused on investigating fundamental algorithms for routing and clustering. Specialized protocols for embedded nodes have been built to diminish the process's energy utilization as well as to hit the entire system with high probability in the shortest possible time. Thus there is a great need to develop a new routing algorithm to reduce energy consumption.

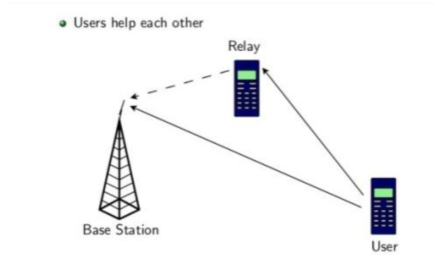

Figure 1: Cooperative Communication

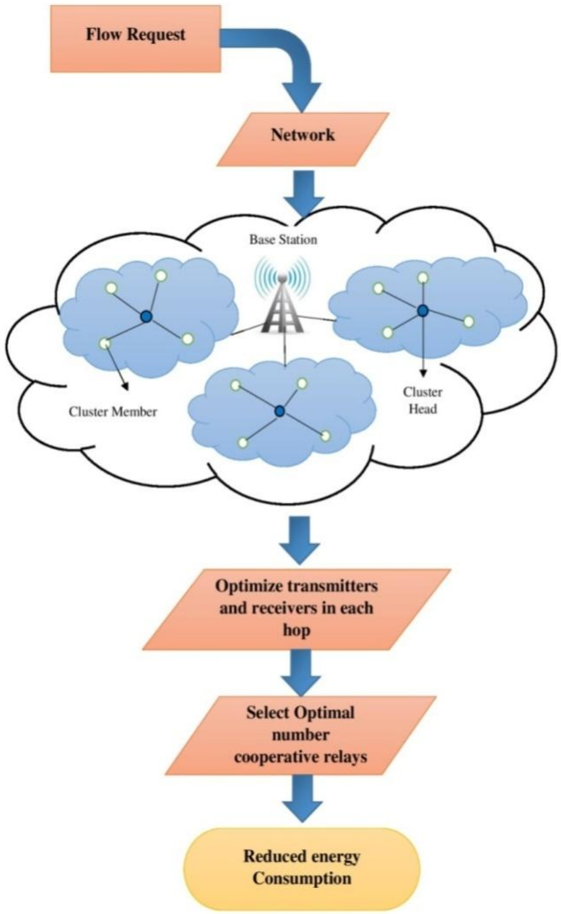

Figure 2: Hybrid Multi-Hop Cooperative Routing Algorithm

Therefore, we proposed a novel hybrid multi-hop cooperative routing algorithm for large scale cooperative networks is proposed by combining clustering and location-based routing strategies in this paper. When a flow request arrives, the network divided into clusters via cluster heads. The formation of cluster considers various metrics which includes link Signal to Noise Ratio (SNR), relative distance, and relative mobility. After forming the cluster, one of the nodes in this is selected as a cluster head based on its location. Further, we optimize the number of transmitters and receivers in every hop; and obtain an optimal quantity of cooperative relays in every hop to reduce the end-to-end energy utilization. It is shown in Figure 2.

3.1 Large Scale Cooperative MANET

Large Scale Cooperative Mobile Ad hoc Network (LC-MANET) consider as a network, where N nodes are uniformly distributed over an area of LxL m2,as shown in figure1. Every node in the network is assumed to be self-organized and employs the Decode and Forward (DAF) relay protocol. We consider that every node in the network contains M radio terminals; a power control mechanism, which changes the power transmitted based on the distance.Randrdenotethetransmissioncoverageareaandtransmissionradius,respectivelyandRiisthenodesin the transmission region of node i (Ni) which can communicate directly with a probability of error (Pe) lower than or equivalent to a predefined threshold. Assume that, all the nodes in LC-MANET are equipped with encoding and decoding capabilities, ideal channel evaluation and synchronization; and Maximum Likelihood (ML) detection at the destination. We consider the channel between nodes is Rayleigh fading. Let a node i broadcasts the information X, which can be successfully decoded by another node $j \in R_i$. The received information (yi) at node j is given by [13]:

$$y_i = \sqrt{P} h_{ij} X + \zeta_j \quad (1)$$

Where h_{ij} represents the channel coefficient between nodes i and j designated as complex Gaussian random variable i.e., $\left|h_{ij}\right|^2 = \mu_{ij}^2 d_{ij}^{-4};\ \mu_{ij}^2 \ and \ d_{ij}$ are the variance and distance between i and j; X represents the compressed encoded data transmitted by node $i \ and \ \zeta_j$ represents zero-mean additive Gaussian noise with the variance σ^2.

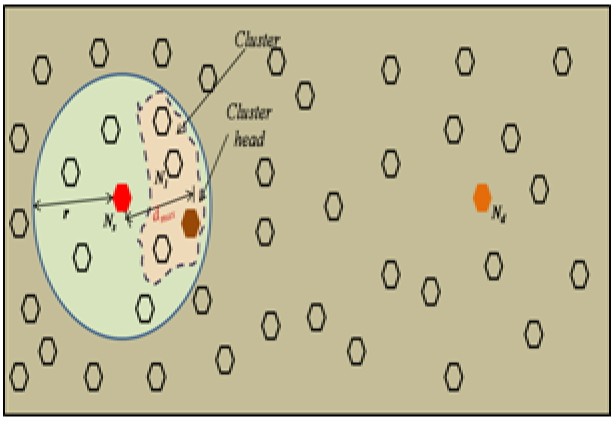

Figure 3: Large Scale Cooperative MANET

Every node can obtain its location using GPS and neighbor nodes location by exchanging beacon signals periodically (i.e., for every β sec). Based on these beacon signals, every node obtains parameters like link Signal to Noise Ratio (SNR), distance, and relative velocity. The link SNR between node p and node q is evaluated as

$$\zeta_q = \frac{P\left|h_{pq}\right|^2}{\sigma_q^2} \quad (2)$$

Depending on the SNR value, node p measures the relative distance to the node q as:

$$\delta d_{pq} = \left(\frac{P\delta_{pq}}{\sigma_q \delta\zeta_{pq}}\right)^{1/4} \quad (3)$$

Where $\delta\zeta$ is the relative SNR, it is obtained as

$$\frac{1}{\delta\zeta_{pq}} = \left| \frac{1}{\zeta_p^{t_2}} - \frac{1}{\zeta_q^{t_1}} \right| \tag{4}$$

and $t_2 - t_1 = \beta$ The relative velocity of the nodes can be given as:

$$\delta v_{pq} = \frac{\delta d_{pq}}{\beta} m/\sec \tag{5}$$

After the cluster has been created, with the SNR then one of the nodes in this is chosen as a cluster head based on its position. The following section explains the routing algorithm.

3.2. Energy-Efficient Hybrid Cooperative Routing Mechanism

We first describe the proposed energy-aware hybrid cooperative routing scheme for LC-MANET and then the optimization of cooperative nodes to minimize energy consumption in this section.

3.2.1 Cooperative Routing Algorithm

If a new flow arrives from source node Ns to destination node Nd , node Ns finds the set of nodes in its transmission coverage region, and measures the metrics; link SNR and relative velocity as mentioned in system model using periodically exchanged beacon signals. Based on measured metrics, the source node forms a cluster and determines the Cluster head (Nh), where $N_h \in R_s$. The source node broadcasts the compressed encoded data $\tilde{X}$ along with destination and cluster head ID.

Algorithm: Energy Efficient Hybrid Cooperative Routing

Input: A new flow arrival source (N_s) to destination (N_d)

Output: Routing path from source to destination with each next hop's Cluster Head and/or Cooperative relay nodes.

1. While source $\neq$ destination do
2. The source node measures the metrics using periodically exchanged beacon signals.
3. Find a set of nodes (R_s) in its transmission coverage area R.
4. If $N_d \in R_s$ then
5. Cluster head=destination
6. else
7. The source forms a cluster with the nodes which are having the relative velocity (with source) less than a predefined threshold i.e.,

$$V_h = \left\{ l \,\middle|\, \left(\max\left(\delta v_{si}\right) - \delta v_{si} \right) < v_{r;} \,\middle|\, l \in \left(R_h - R_{h-1}\right) \bigcup N_{h-1} \right\}$$

8. From the above cluster, source selects cluster head for the next hop as:

$$N_h = \arg\max_{l \in V_h} \left\{ d_{N_{h-1},l} \right\} \forall h \geq 2$$

9. end if
10. The other nodes in the cluster cooperate with the source to forward the data to the cluster head.
11. Source node= cluster head
12. end while

It denotesh^{th}hop cluster head and set of cluster nodes as N_h and V_h respectively. The $(h+1)^{th}$transmission required only when the destination node is not in the range of transmission of N_h i.e., $N_d \notin R_{N_h}$.

3.3. Energy Utilization Analysis

In this section, present a cooperative MISO transmission scheme and developed an energy consumption model for a single hop. Based on this model, we obtained an optimal number of cooperative nodes.The source node (Ns) forms a cluster (as described in Algorithm), and transmit the data in two phases.

3.3.1. Phase I

In the first phase, the data is broadcasted to all the nodes in the cluster. Consider that there are n nodes in the cluster. The average energy utilization for MQAM modulation can be expressed as [14]:

$$E_{P_1} = \frac{\xi}{\eta} Q_0 \overline{E_{b,P_1}} r^2 + \left(P_{tx} + nP_{rx}\right) \Big/ bB \tag{6}$$

Where,

$$Q_0 = \frac{(4\Pi)^2 M_l N_f}{G_{tx} G_{rx} \lambda^2}, \xi = 3\frac{2^{b/2} - 1}{2^{b/2} + 1}; G_{tx} \text{ and } G_{rx}$$

are the gains of source and destination respectively.

M_l is the link margin, N_f is the receiver noise figure, λ is the carrier wavelength, $\overline{E_{b,P_1}}$ the average received energy pet bit in phase 1, bis the transmission bit rate, B is the modulation Bandwidth, P_{tx} and P_{rx} are the transmitter and receiver circuit powers respectively.

The average number of nodes in the cluster is

$$n = \frac{\Pi r^2 N}{L^2} P(\delta v) . \tag{7}$$

After phase 1 broadcast the cluster then it processes phase 2 with n nodes for transmitting the data to the cluster head.

3.3.2. Phase II

In phase 2, n nodes(n-1 cluster nodes and source node) are used for data transmission to the next-hop cluster head. The average energy consumption can be given by

$$E_{P_2} = \frac{\xi}{\eta} Q_0 \overline{E_{b,P_2}} d_{\max}^2 + \left(nP_{tx} + P_{rx}\right) \Big/ bB \tag{8}$$

The average energy consumption per bit of every hop is $E_h = E_{P_1} + E_{P_2}$.

The upper bound $\overline{E_{b,P_2}}$ can be obtained by Chertoff upper bound with several receiving antennas equal to one.

$$\overline{E_{b,P_2}} \le \frac{2\left(2^b-1\right)N_0 n}{3b}\left(\frac{4}{bP_e}\right)^{1/n} \quad (9)$$

$\overline{E_{b,P_2}}$ can be obtained by substituting n=1. By approximation equation (10) as equality, we obtained closed-form of expression for the average energy consumption per bit as:

$$E_h = C_b\left[\frac{C_e L^2}{\pi NP(\delta v)} + (C_e)^{1/n} d_{\max}^2\right]n + C_p(n+1) \quad (10)$$

Where,

$$C_b = \frac{\xi Q_0 2\left(2^b-1\right)N_0}{3b\eta}, C_e = \frac{4}{bP_e} \text{ and } C_p = \frac{P_{tx}+P_{rx}}{bB}.$$

According to the proposed algorithm, hthHop cluster head should be in the transmission coverage area of $(h-1)^{th}$ hop cluster head. Hence the distance among the two cluster heads $(d_{\max})$ should be $d_{\max} \le r$.

The average number of nodes in a cluster becomes

$$n \le \frac{\pi N d_{\max}^2 P(\delta v)}{L^2}. \quad (11)$$

Where $P(\delta v)$ the probability of the node having relative mobility difference is less than the threshold. We approximate the optimal value of n to minimize the average energy consumption per bit $E(h)$ when $d_{\max}^2 \ge \frac{nL^2}{\pi NP(\delta v)}$ as:

$$\min_n E_h \ s.t. 2 \le \frac{\pi N d_{\max}^2 P(\delta v)}{L^2} \quad (12)$$

Otherwise, n=1 transfers the data in the SISO transmission scheme. We obtain the critical value of a function E_h by differentiating concerning n is:

$$d_{\max}^2 (C_e)^{1/n}\left[n - 1n(C_e)\right] + \left[\frac{C_e L^2}{\pi NP(\delta v)} + \frac{C_p}{C_b}\right]_{n=0} \quad (13)$$

Since the above equation is positive, n should be less than $\ln(C_e)$. Let the positive real-valued solution of the above equation is n_p. Then the optimal value of E_h is obtained as:

$$n_0 = \begin{cases} \lceil n_p \rceil & if \ 2 \le n_p \le \frac{\pi N d_{\max}^2 P(\delta v)}{L^2} \\ 2 & if \quad n_p < 2 \end{cases} \quad (14)$$

Thus the proposed routing algorithm reduces the energy consumption with the analysis of multi-hop channels.

IV. RESULTS AND DISCUSSION

This section clearly explains the feasibility of our proposed method by evaluating and contrasting the experimental results obtained with traditional methods. Specification tools for implementation are given below.

4.1 System Specification

The methodology proposed is described in section 3 above and is analyzed in detail in this section. The suggested approach is applied with the following device specification in the MATLAB work platform

Platform	**MATLAB 2019a**
OS	**Windows 8**
Processor	**Intel core i5**
RAM	**8 GB RAM**

4.2. Simulation Results

Simulation analysis of the proposed algorithm is presented in this section. We simulated our algorithm using MATLAB with the parameters listed in table 1:

Table 1: Parameters for Simulation

Notation	*Meaning*	*Value*
N	Number of Nodes	[100 1000]
P	Transmitted Power	1mW
N_0	Noise power spectral density	-171dBm/Hz
B	Modulation Bandwidth	10KHz
	Combining Strategy	MRC
β	Periodic interval	$1\mu s$
M_l	Link Margin	40Db
N_f	Noise figure	10dB
P_e	Target BER	10^{-3}

G_{tx}, G_{rx}	Transmitter and receiver gain	5dBi
P_{tx}	Transmitter circuit power consumption	97.8mW
v_T	Velocity threshold	5m/sec
P_{rx}	Receiver circuit power consumption	119.8mW

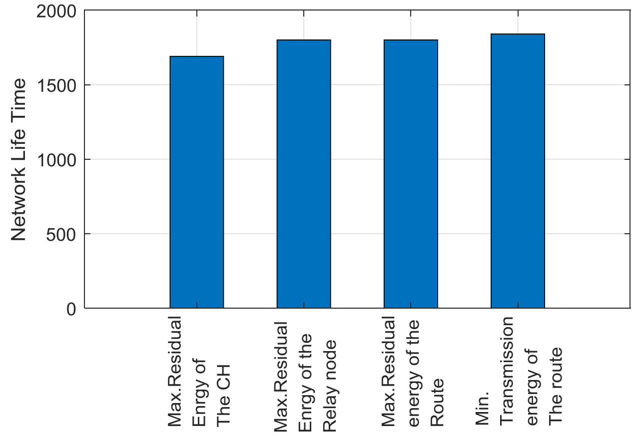

Figure 4: Comparison of four fitness criteria's network lifetimes

Figure 4 demonstrates a network span with the maximum cluster head residual energy, maximum relay node residual energy, maximum path residual energy, and minimal energy transmission of path. Criterion 4 is the longest possible life. This implies that criterion 4 is fair and holds a balance of load. Consequently, Criterion 4 is used for the fitness of hybrid multi-hop cooperative routing.

Table 2: Network lifetime

Fitness function	Network Life Time
Max.Residualenergy of the CH	1690
Max.Residualenergy of the relay node	1800
Max.Residual energy of the Route	1800
Min.Transmission energy of the route	1840

Table 2 demonstrates the network life in which the overall residual energy of CH is 1690, the overall residual energy of the relay node network lifespan is 1800. The network lifetime is 1800, Min. Residual energy of the path. Network life is 1840 with transmitting energy from the path.

4.3 Comparison Analysis

In this section we are comparing the lifetime and residual network energies of the EECC (energy-efficient cooperative communication method) sensor nodes [21] and of the HEED (hybrid-energy efficient distributed clustering approach) [23], and SOSAC [Self-Organized and Smart Adaptive Clustering] [22], which are the most common inter cluster routing.

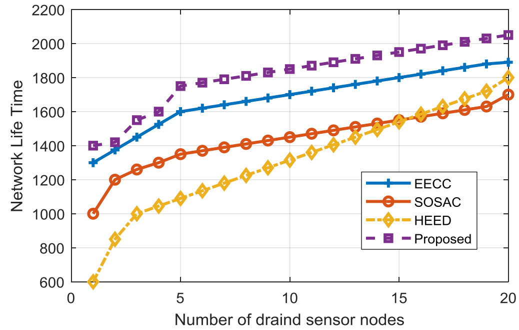

Figure 5: Comparison of the network lifetime of the proposed algorithm

The network lifetime relation is shown in Figure 5. We compare the lifetimes of the EECC network (use of relay nodes), SOSAC (without relay nodes), and HEED, to claim the legitimacy of the collaborative method of communication.

Table 3: Comparison of network lifetime

Number of drained nodes	Network Life Time			
	EECC	SOSAC	HEED	Proposed
1	1300	1000	600	1400
2	1375	1200	850	1420
3	1450	1260	1000	1550
4	1525	1300	1045	1600
5	1600	1350	1090	1750
6	1620	1370	1135	1770
7	1640	1390	1180	1790
8	1660	1410	1225	1810
9	1680	1430	1270	1830
10	1700	1450	1315	1850
11	1720	1470	1360	1870
12	1740	1490	1405	1890
13	1760	1510	1450	1910
14	1780	1530	1495	1930

15	1800	1550	1540	1950
16	1820	1570	1585	1970
17	1840	1590	1630	1990
18	1860	1610	1675	2010
19	1880	1630	1720	2030
20	1890	1700	1800	2050

Table 3 indicates that the network life time of EECC is about 1,300 while the first node is exhausted and, relative to that of the SOSAC network life, about 1890 after the 20th node has been exhausted. For SOSAC when the first node is drained the lifetime is 1000 and 1700 when the last node is drained. Then for HEED, the first node drained value is 600 and the last node drained value was 1800. However, our proposed work drained the first node the lifetime is 1400 and the last node drained lifetime is 2050 it is greater when compared with the above techniques. The experimentation stated the coordination of the CH and relay nodes, by reducing energy consumption and preserving load balance, intensifies the network's life.

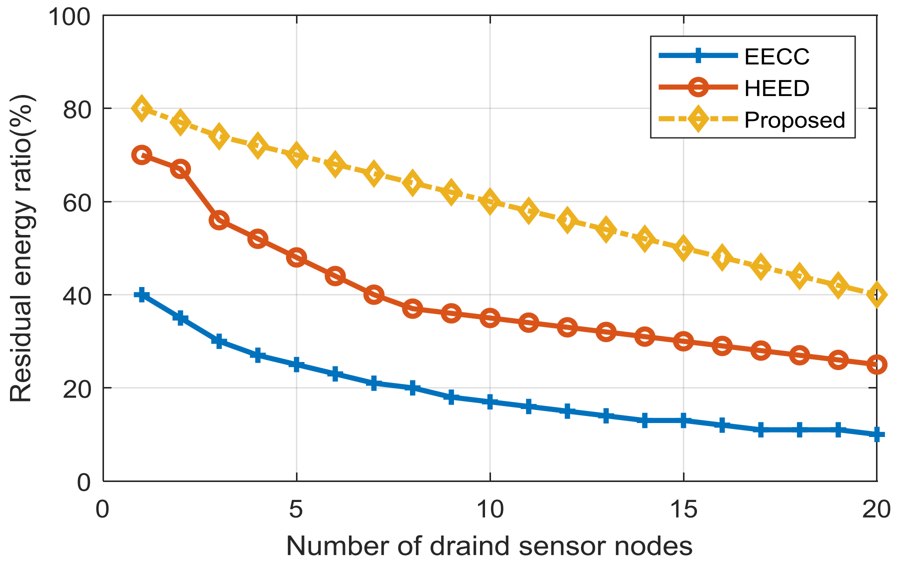

Figure 6: Experimentation on the residual energy ratios of various techniques

Figure 6 shows the comparison graph for the experimentationupon residual energy ratios of various techniques such as EECC (using relay nodes), SOSAC (without relay nodes), and HEED (hybrid-energy efficient distributed clustering approach) with the proposed algorithm.

Table 4: Comparison of Residual Energy Ratio

Number of drained sensor nodes	Residual energy ratio (%)		
	EECC	HEED	Proposed
1	40	70	80
2	35	67	77
3	30	56	74
4	27	52	72
5	25	48	70
6	23	44	68
7	21	40	66
8	20	37	64
9	18	36	62
10	17	35	60
11	16	34	58
12	15	33	56

13	14	32	54
14	13	31	52
15	13	30	50
16	12	29	48
17	11	28	46
18	11	27	44
19	11	26	42
20	10	25	40

Table 4 compares EECC, HEED's mean residual energy ratios, which range from 40% (when the first node is exhausted) to 10% (when the twentieth node is exhausted). The HEED ratio is between 70% (when draining the first node) and 25% (when draining the twentieth node). This means that the energy utilization of all EECC sensor nodes is more equal than the energy utilized by HEED.

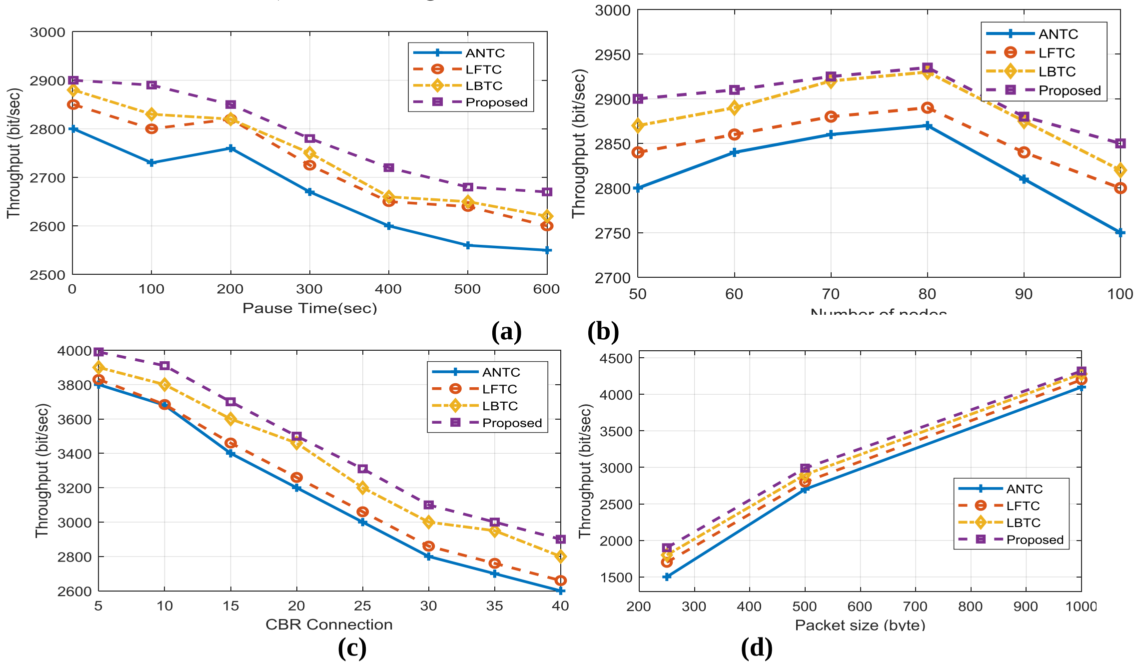

Figure 7: Network Throughput

The above figure 7 depicts the network throughput in which figure 7(a) depicts throughput versus pause time, figure 7(b) plots the throughput versus some nodes, figure 7(c) shows throughput versus CBR connection, and figure 7(d) shows the throughput versus packet size. The compared techniques are ANTC (Adaptive Neighbor-based Topology Control), LFTC (Learning-based Fuzzy-logic Topology Control), and LBTC (Location-Based Topology Control with Sleep Scheduling). Figure 7 demonstrates that the proposed achieved higher throughput. The improvement in network life through an effective power change is attributed to higher efficiency.

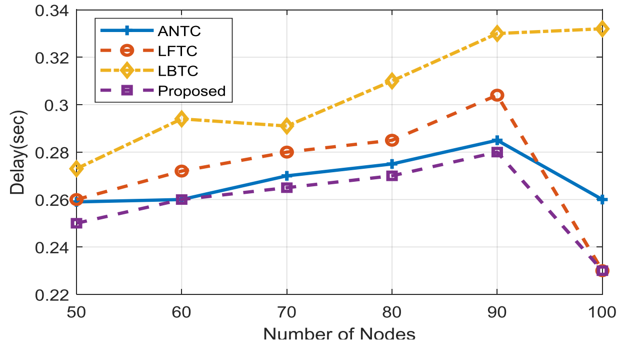

Figure 8: Delay versus Number of nodes

Figure 8 shows the End-to-end Delay versus amount of nodes with the methods like ANTC, LFTC, and LBTC. It is clear that in comparison to LFTC and ANTC, LBTC has a higher end-to - end delay. This is because hop count increases as lower power transmission nodes.

Table 5: Comparison of End-to-End delay

Number of Nodes	Delay(sec)			
	ANTC	LFTC	LBTC	Proposed
50	0.259	0.26	0.273	0.25
60	0.26	0.272	0.294	0.26
70	0.27	0.28	0.291	0.265
80	0.275	0.285	0.31	0.27
90	0.285	0.304	0.33	0.28
100	0.315	0.23	0.332	0.23

In order to appraise the overall comparison of our proposed algorithm with the existing system, the following approaches are taken into an account likead hoc on-demand distance vector (AODV) routing algorithm [24], Opportunistic Cooperative Packet Transmission (OCPT) [25].

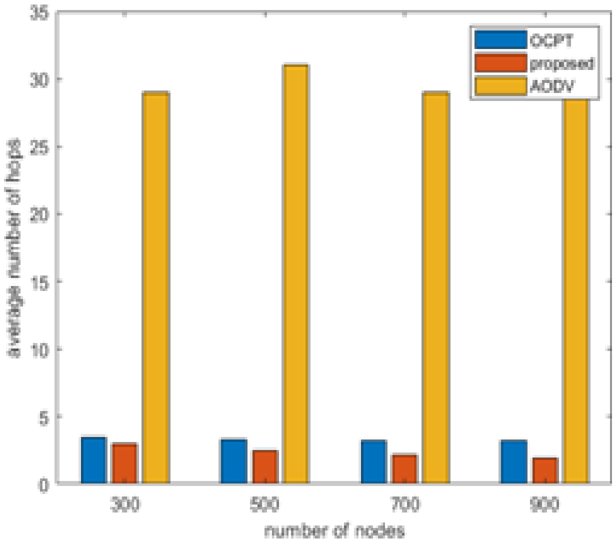

Figure 9: Average Number of hops

Figure 9 displays the total number of hops depending on the number of nodes for different routing schemes. The proposed routing scheme needs fewer hops than AODV and OCPT schemes, since the possibility of removing a node from the source also increases with the increase in network node density and transfers the data to the destination with minimal path length i.e., in a minimum number of hops.

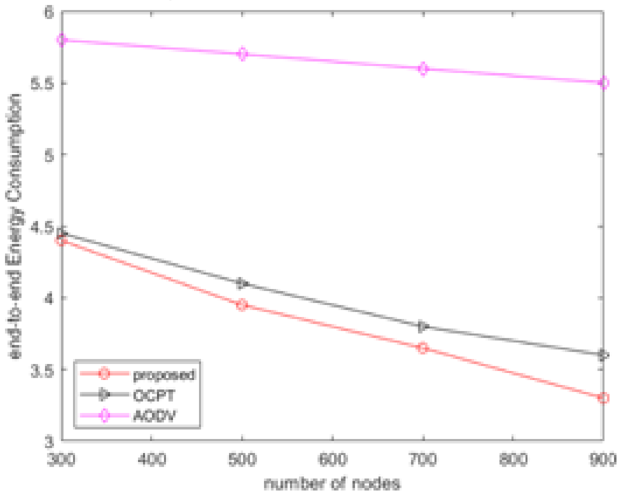

Figure 10: End-to-End energy consumption

Figure 10depicts the comparison of end-to-end energy consumption over the number of nodes for various routing schemes. Since we obtain the optimumamount of cooperative nodes in each hop, the energy consumption of the path will decrease. Our algorithm requires a less number of hops with increased node density; the energy utilization is even minimized by 53.42% as compared to traditional AODV routing algorithms at N=700 and L=1000.

V. CONCLUSION

Cooperative communications enable the efficient use of communication resources by allowing communication network nodes or terminals to collaborate in the transmission of information. This paper presented a hybrid multi-hop cooperative routing algorithm for LC-MANET. We combined clustering and location-based strategies to mitigate the mobility effect and reduce the average number of hops. In every hop, we incorporated optimization mechanisms and obtained an optimal number of cooperative nodes by jointly optimizing the number of transmitters and receivers. Implementation outcomes showed that hybrid multi-hop cooperative routing algorithm saves energy utilizationup to 53.42% in contrast with the conventional routingstrategy.

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