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Research Article

Efficient Coherent Trust based Location Aware Clustering for Communication in Mobile Ad Hoc Networks

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ABSTRACT

Mobile Ad Hoc Networks (MANETs) are the emerging technology for communication and it is used in maximum of the application hence it is noticed by the academic and industrial sectors. Due to the mobile nature of the nodes in MANETs it is complicated to transfer the ecological information. During communication in maximum of the cases link failures and high energy consumption occurred. In order to overcome this issues clustering techniques are introduced in earlier days which is the group of nodes into cluster and each cluster consists of a cluster head (CH) and the other nodes which are present in that coverage area is termed as cluster members (CM). Due to this method the energy efficiency of the network is increased but the current drawback is selection of effective CH. Improper CH selection reflects in ineffective communication. For that purpose in this paper Efficient Coherent Trust based Location Aware Clustering (ECTLAC) approach is proposed for the selection of CH in MANETs. The approach is sub divided into two sections. They are effective coherent trust calculation and location aware clustering. Through this process an effective CH is chosen the greatly increase the performance of MANETs. The simulation is performed in NS2 and the parameters which are calculated for the performance analysis are energy efficiency, energy consumption, packet delivery ratio, and end-to-end delay. The results are compared with the earlier approaches such as HAMBO and CAPIC. From the results it is understood that the proposed ECTLAC approach produce high energy efficiency and packet delivery ratio as well as lower energy consumption and end to end delay when compared with the earlier works.

1. INTRODUCTION

Mobile Ad-hoc Networks (MANETs) is one among the infrastructure less network model where the nodes are moving from the one place to another independently as well as these can also to deploy in a certain area to perform certain operation. MANETs are designed in terms of transferring the information from one place to another using the intermediate hop nodes [1]. In case if the number of intermediate nodes are more in certain transmission there is a possibility for the occurrence of link failure and delay that's leads to increase the energy consumption of the data transmission. As so to address this drawback an effective technology is introduced in earlier days called clustering in MANETs where the entire network is segmented into certain groups called clusters and one the node among the cluster is chosen randomly as cluster head (CH) and the others are declared as cluster members (CM) as well as the nodes inside the clusters are completely controlled by the CH [2-3]. The CH perform inter cluster communication and intra cluster communication to transfer the information from the source to the destination. The process is effective but the major complexity here is the effective CH selection process hence the improper way of CH selection results in ineffective communication in the network that's greatly affect the performance of MANETs [4]. To overcome this flaw several techniques are introduced in MANETs but it still need improvement in choosing the highly effective trust worthy node as CH. For that purpose in this paper efficient coherent trust based location aware clustering is proposed. The contribution of the research is described.

- In order to improve the effectiveness of MANETs communication, Efficient Coherent Trust based Location Aware Clustering (ECTLAC) approach is proposed and it perform two operations such as trust based CH selection and cluster formation with maintenance.
- Trust calculation is performed using effective coherent trust calculation process using the parameters such as degree difference, residual energy, link stability, proclivity and effectiveness of the node.

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- The node with highest trust score is chosen as CH and it proceed with the process of cluster formation and cluster maintenance.
- This approach greatly increased the energy efficiency and the packet delivery ratio of the MANETs.

The rest of the paper is listed as follows. In section 2 the related learning about MANETs are discussed. In section 3, the proposed ECTLAC approach is detailed. In section 4, the performance analysis of the proposed is ECTLAC approach calculated. In section 5, the results are discussed. In section 6 the conclusion and the future works are shown.

2. RELATED WORKS

In [5] the authors presented a novel method to avoid communication overhead and improve the link stability in Mobile Adhoc networks using clustering algorithm. This algorithm is divided into two stages, one is clustering stage, where it selects the resource directory index node and second is maintenance algorithm called network clustering adaptive adjustment algorithm, which is used to improve the link stability but it fails to reduce the routing overhead during data transmission. In [6] the authors proposed cluster-dynamic TDMA slot assignment protocol in mobile adhoc networks. In clustering technology data has allocated based on traffic flow and gate way nodes. This method easily changes the network topology compare with previous technique. However is fails achieve high packet delivery ratio during data transmission. In [7] the authors developed cross layer reliable opportunistic routing algorithm for efficient routing and fuzzy logic topology has used for improving the life time of network. In order to improve the efficiency of the network, link lifetime prediction algorithm is used. Finally, LEACH protocol is included to reduce the energy during transmission. This method achieves high efficiency but the packet delivery ratio is moderate. In [8] the authors proposed chunk top path selection using swarm optimization technique. This enhanced work use enhanced monkey inspired optimization algorithm to select the cluster head. To find the optimal path, improved pattern search algorithm is used. The overall performance achieved by this method is moderate.

In [9] the authors introduced coherent cluster head selection based on pinnacle weight to improving power constrain. Cluster head is mainly used for the process of re-connection and topology changes and to solve the communication overhead. This method achieves high efficiency but failed to achieve maximum packet delivery ratio. In [10] the authors proposed a RSSI based low energy utilization in routing protocol to improve the energy efficiency called LE-AODV. This protocol greatly increased the network lifetime and battery utilization but fails to achieve high packet delivery ratio. In [11] the authors developed two schemes to improve the network security, one is clustering scheme next is trust scheme. Cluster scheme increased the stability of the network by passing the trust information and the trust scheme find the malicious node and avoid its information into the network. The overall results achieved by this method are moderate. In [12] the authors developed LEACH Relay with cache strategy to improve the communication reliability. This technique calculates residual energy for each node and neighbor node by successive approximation approach. The cluster head is selected in LEACH-R to balance the energy consumption but it fails to achieve high packet delivery ratio. In [13] the authors proposed AOMDV routing protocol based on genetic algorithm in fitness function. This protocol provides better life time by finding the shortest path using high fitness value. To find the efficient route in this network the TCP congestion control mechanism is used but it fails to achieve high efficiency and packet delivery ratio.

In [14] the authors developed a novel approach to increase the energy efficiency of the MANETs called HAMBO which is the combination of Artificial Bee Colony algorithm and Monarch Butterfly Optimization algorithm with clustering approach. This method greatly increased the energy efficiency of the network but fails to reduce the data loss and overhead during the process of communication between the nodes. In [15] the authors proposed an effective CH selection approach for MANETs called Contention-based Access Protocol with intra clustering communication. Through this method the delay is reduced and throughput of the network is increased but however it fails to achieve high packet delivery ratio during communication. After analysis the earlier clustering based researches of MANETs it is understood that the network has to improve its trustworthiness to perform effective communication. For that purpose in this paper efficient coherent trust based location aware clustering is introduced and it elaborated in the upcoming sections.

3. PROPOSED HBO-ECHS APPROACH

In MANETs, in order to improve the efficiency and trust worthiness of the nodes Efficient Coherent Trust based Location Aware Clustering (ECTLAC) is introduced. The proposed work is subdivided into two sections they are Efficient Coherent Trust model and Location Aware Clustering approach. The workflow of the proposed ECTLAC approach is shown in the Figure 1.

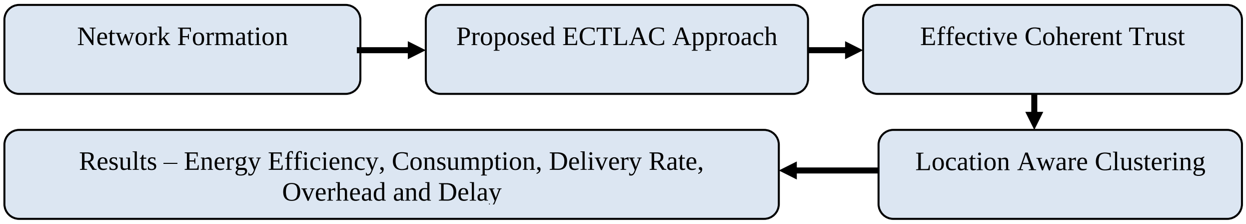

Fig. 1. Systematic process of the proposed ECTLAC approach

3.1 Efficient Coherent Trust model

This efficient coherent trust model is used to perform the Cluster Head (CH) selection for MANETs in an effective manner. Through this method the best node to become the CH is chosen and followed by that the cluster formation and maintenance is performed. The efficient coherent trust is measured based on the parameters such as degree difference (D_n), residual energy (RE_n), link stability (LS_n), proclivity(P_n) and effectiveness (E_n) of the node. Coherent trust is measured using the weight factors $W_1, W_2, W_3, W_4\ and W_5$ and its values are $W_1 = 0.3, W_2 = 0.4, W_3 = 0.3, W_4 = 0.3\ and W_5 = 0.4$ respectively. At the initial stage, the node degree difference is defined as it is the subtraction of ideal node degree (ID_n) from the actual node degree (AD_n) and it is expressed in the equation (1).

$$D_n = \|AD_n - ID_n\| \quad (1)$$

The residual energy (RE_n) of the node is defined as the remaining energy of the node at the end of the data transmission and it is the subtraction of consumed energy (CE_n) of the node from its initial energy (IE_n) and it is mathematically expressed in the equation (2).

$$RE_n = IE_n - CE_n \quad (2)$$

Link stability among two nodes is measured according to the transmission history and the success rate of transmission among those nodes and it is expressed in the equation (3).

$$LS_n = \frac{\sum_{d=1}^{k} DR_{(n_1,n_2)}}{\sum_{d=1}^{k} DT_{(n_1,n_2)}} \quad (3)$$

In equation (3), the terms $DR\ and\ DT$ denotes the data received and data transmitted among two nodes. The proclivity(P_n) of the node is measured using the parameters such as node coverage area(CA_n), initial energy (IE_n) and it is expressed in the equation (4).

$$P_n = \frac{CA_n}{IE_n} \times 1000 \quad (4)$$

Finally the effectiveness of each node (E_n) to become CH is measured using the parameters such as residual energy (RE_n) and the maximum energy that can be controlled by the node $(EMAX_n)$ and it is expressed in the equation (5).

$$E_n = \frac{\alpha * RE_n}{EMAX_n} \quad (5)$$

In equation (5) the term α is represented as a constant value which is used for the experimental purpose. By using the equation (1) to (5) the effective coherent trust value of the node (ECT_n) is calculated and it is expressed in the equation (6).

$$ECT_n = \frac{(W_1 * D_n) + (W_2 * RE_n) + (W_3 * LS_n) + (W_4 * P_n) + (W_5 * E_n)}{5} \quad (6)$$

According to the equation (6) the effective coherent trust value of the node is measured and this process is described in the pseudo code below.

Algorithm 1. HBO-ECHS approach

START
Parameters used for trust calculation are degree difference (D_n), residual energy (RE_n), link stability (LS_n), proclivity(P_n) and effectiveness (E_n)
Degree Difference (D_n) = $\|AD_n - ID_n\|$
Residual Energy $(RE_n) = IE_n - CE_n$
Link Stability $(LS_n) = \frac{\sum_{d=1}^{k} DR_{(n_1,n_2)}}{\sum_{d=1}^{k} DT_{(n_1,n_2)}}$
Proclivity$(P_n) = \frac{CA_n}{IE_n} \times 1000$
Effectiveness $(E_n) = \frac{\alpha * RE_n}{EMAX_n}$
Node effective coherent trust $ECT_n = \frac{(W_1*D_n)+(W_2*RE_n)+(W_3*LS_n)+(W_4*P_n)+(W_5*E_n)}{5}$
STOP

3.2 Location Aware Clustering Approach

Cluster formation is performed after the selection of cluster head (CH) using the equation (6). The node the highest effective coherent trust value is selected as a CH and the cluster is formation according to the coverage area of the CH. The nodes which are present in the coverage area of the CH becomes it cluster member (CM). All the transmission inside the cluster is controlled by the CH. Through CH both inter-cluster communication and intra-cluster communication is performed. Once after the CH is chosen the CM's are determined using certain condition. They are, the node sends the request message to the CH to joins inside the cluster and once after receiving its declaration message from the CH it become its CM.

Through the cluster maintenance process the node leaving the cluster and joining into the new cluster are properly monitored. Hence the nodes are mobile in nature this process will happen periodically all this details are stored in the routing table of the respective CH. In case if the CH moves to another cluster then the next best node with highest value will become a new CH for that particular location. If any node quit the respective cluster then the particular node get detached from the neighbor table and the routing list of all the nodes in the cluster. The process of the ECTLAC approach is shown in the figure 2.

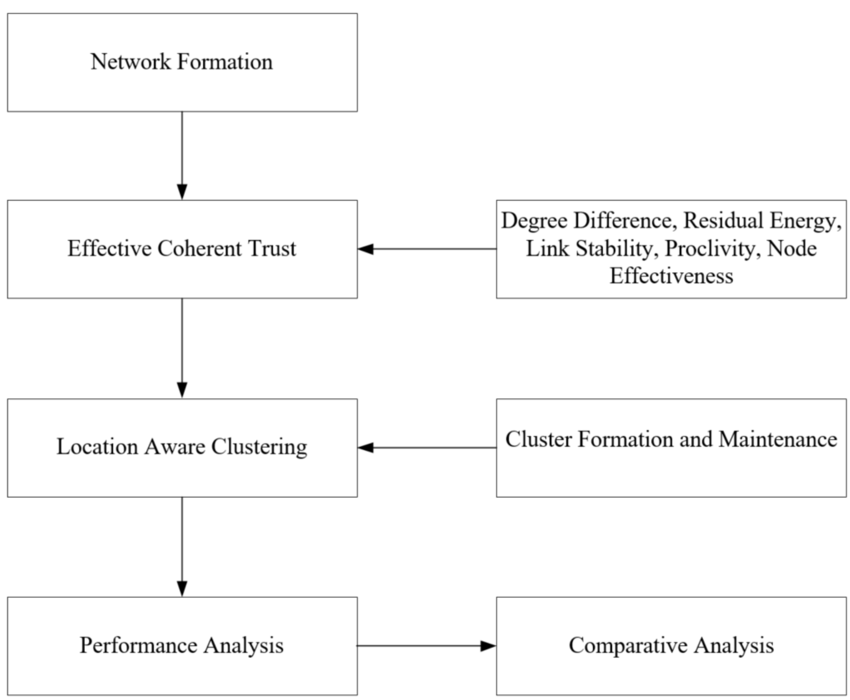

Fig. 2. The process of ECTLAC approach

4. SIMULATION ENVIRONMENTS AND RESULTS CALCULATION

In this section, the performance evaluation of the proposed ECTLAC approach is measured using software NS2 under the Ubuntu Operating system with SUMO. The network topography consists of 200 nodes with the field dimension of 1000m*1000m respectively. The number of CH determined to cover those nodes are 4 CH and the coverage area of each CH is 250m. The outcome of the proposed ECTLAC approach is compared with the earlier scheme such as HAMBO [14] and CAPIC [15]. To perform the performance analysis all those methods four parameters are considered. They are energy efficiency, energy consumption, packet delivery ratio, and end-to-end delay. The input parameters which are considered for the process of implementation of the Efficient Coherent Trust model and Location Aware Clustering approach are shown in the Table 1.

TABLE I. SIMULATION PARAMETERS

Input Parameters	Values
Simulation Run Time	200 ms
Field Dimension	1000m*1000m
No of Nodes	200 nodes
No of CHs	4 CHs
Cluster Coverage	200m
Initial Energy	100 Joules
Transmission Power	0.500 Joules
Receiving Power	0.050 Joules

4.1 Energy Efficiency Calculation

Figure 3 demonstrate the energy efficiency measurements of methods such as HAMBO, CAPIC, and the proposed ECTLAC. Energy efficiency is otherwise named as the residual energy of the node and it is calculated by the subtraction of the consumed energy from the initial energy of the node. In order to achieve better performance, it is very essential to reach maximum energy efficiency. From the figure, it is observed that energy efficiency of the proposed ECTLAC approach is higher than the earlier methods and it is achieved using the effective CH selection process.

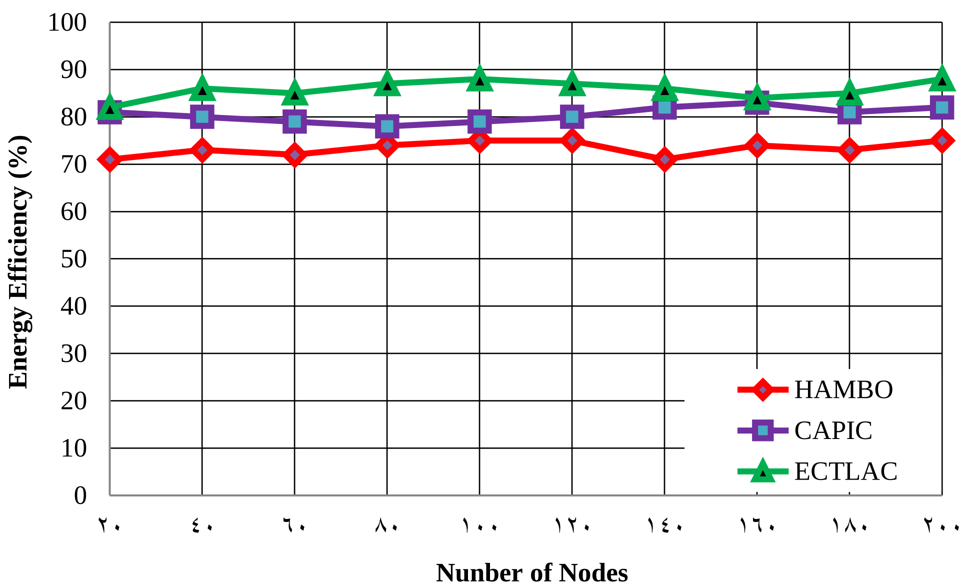

Fig. 3. Energy Efficiency Calculation

4.2 Energy Consumption Calculation

Figure 3 determine the energy consumption measurements of the methods such as HAMBO, CAPIC, and the proposed ECTLAC. Energy consumption of the node is the cumulative sum of the energy which gets spent by the node during the process of data transmission and movement. The main objective of the proposed work is to reduce the energy consumption of the node and for that purpose the effective coherent trust model-based CH selection it performed. As the results energy consumption of the proposed ECTLAC approach is lower than the earlier methods.

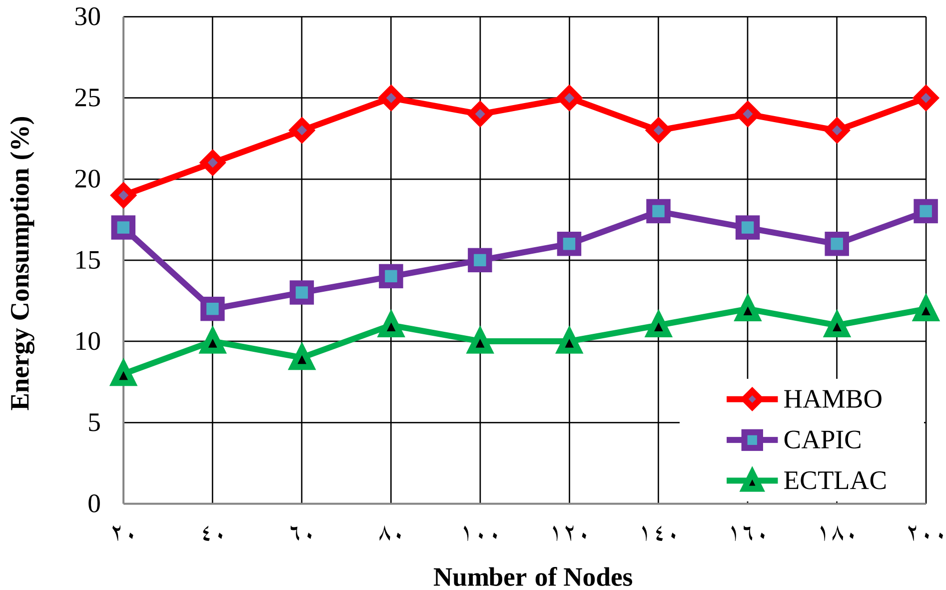

Fig. 4. Energy Consumption Calculation

4.3 Packet delivery ratio calculation

The figure 5 represents the packet delivery rate of the proposed ECTLAC approach and the compared methods such as the HAMBO, and CAPIC. The packet delivery ratio is defined as the ratio of the amount the information received by the destination to the amount of information transferred from the source. Achieving maximum delivery ratio is the primary goal of the network. From the figure, it is observed that the proposed ECTLAC approach is more effective than the previous approach in terms of packet delivery ratio.

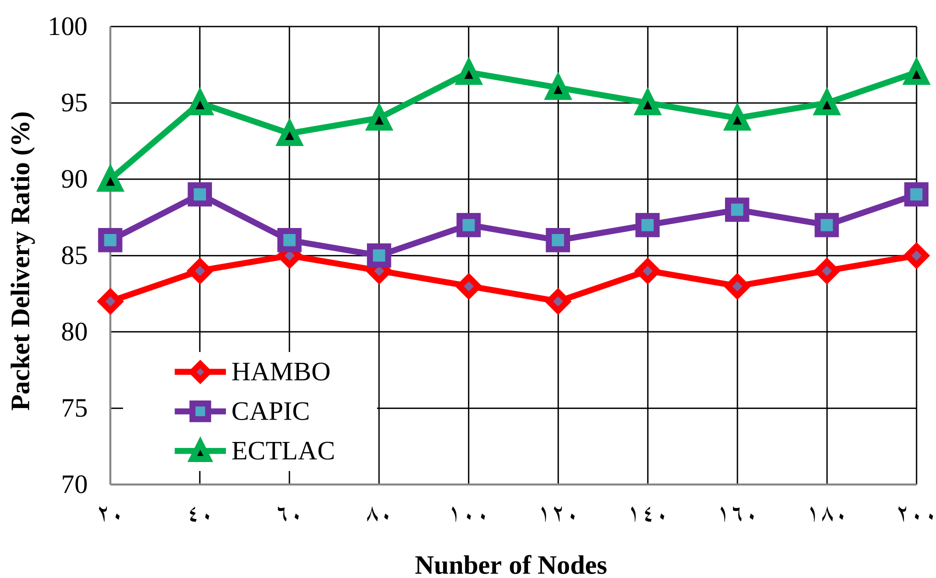

Fig. 5. Packet Delivery Rate Calculation

4.4 End-to-End Delay Calculations

Figure 6 represents the end-to-end delay measurements of methods such as the HAMBO, CAPIC approach and the proposed ECTLAC approach. It is the delay time which is calculated during at each data transmission among the nodes in the network. To achieve effective performance in communication it is essential to reduce the delay among the nodes at the time of transmission. From the figure, it is observed that the end-to-end delay results of the proposed ECTLAC approach are lower than both HAMBO, and CAPIC approaches.

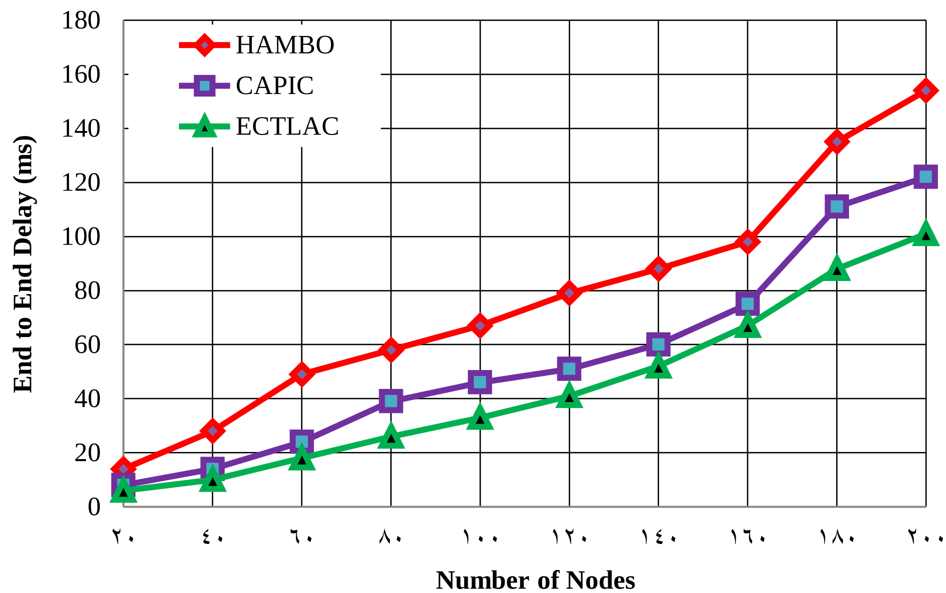

Fig. 6. End to End Delay Calculation

5. COMPARATIVE ANALYSIS AND DISCUSSION

In this section, results comparison of the methods such as HAMBO, CAPIC, and the proposed ECTLAC approach is performed in terms of energy efficiency, energy consumption, delivery ratio, and end-to-end delay. The measures of those methods are given in Table 2.

TABLE II. RESULTS ANALYSIS AND MEASUREMENTS

Parameters / Methods	HAMBO	CAPIC	ECTLAC
Packet Delivery Ratio	75%	82%	88%
Energy Efficiency	25%	18%	12%
End to End Delay	85%	89%	97%
Routing Overhead	154ms	122ms	101ms

The energy efficiency achieved by the proposed ECTLAC approach is 88% whereas for the earlier methods such as HAMBO, and CAPIC it reaches up to 75% and 82% respectively. So the energy efficiency of the proposed ECTLAC approach is 13% greater than HAMBO and 6% greater than CAPIC. The energy consumption of the produced by the proposed ECTLAC approach is 12% whereas for the earlier methods such as HAMBO, and CAPIC it stretches up to 25% and 18% respectively. So the energy consumption of the proposed ECTLAC approach is 13% lesser than HAMBO and 6% lesser than CAPIC. The packet delivery ratio reached by the proposed ECTLAC approach is 97% whereas for the earlier methods such as HAMBO, and CAPIC it extends up to 85% and 89% respectively. So the packet delivery rate of the proposed ECTLAC approach is 12% greater than HAMBO and 8% greater than CAPIC. The end-to-end delay proposed by the proposed ECTLAC approach is 101ms whereas for the earlier methods such as HAMBO, and CAPIC it extends up to 154ms and 122ms respectively. So the end-to-end delay of the proposed ECTLAC approach is 53ms lesser than HAMBO and 21ms lesser than CAPIC. The overall performance of the proposed ECTLAC approach is higher than the earlier methods and is achieved with the help of the effective coherent trust based CH selection, cluster formation and maintenance process.

6. CONCLUSION

In this paper to improve the effectiveness of communication among the nodes in MANETs clustering technology is proposed as the results the energy consumption issues and the delay issues are reduced. The proposed approach is called as Efficient Coherent Trust based Location Aware Clustering (ECTLAC) approach and through this method the effective CH selection is performed in MANETs. At the initial stage the node with highest trust value to become the CH is chosen by considering the parameters such as degree difference, residual energy, link stability, proclivity and effectiveness of the node. Secondly the highest trust node is chosen as CH and the further operations such as cluster formation and cluster maintenance is performed. The simulation is carried out in NS2 and the output is analysis used the parameters such as energy efficiency, energy consumption, packet delivery ratio, and end-to-end delay. The results are compared with the earlier approaches such as HAMBO and CAPIC. From the results it is proven that the proposed ECTLAC approach proposed 13% high energy efficiency, 13% lower energy consumption, 12% higher packet delivery ratio and 50ms lower end to end delay when compared with the earlier approaches. IN the future direction to increase the density of the MNAETs drones are introduced.

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Conflicts Of Interest

The author's disclosure statement confirms the absence of any conflicts of interest

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