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ORIGINAL RESEARCH

An efficient clustering approach for optimized path selection and route maintenance in mobile ad hoc networks

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Abstract

Mobile ad hoc network (MANET) is arranged with multiple nodes that communicate wirelessly. However, MANET communication suffers from various issues such as inadequate security, low stability, high power consumption, and a lack of specific infrastructure of the network. Moreover, the route failure happened in the network due to the unrestricted node movement, which has increased energy utilization, delay, and reduced lifetime of the nodes. To overcome these issues, the novel Eagle Based Density Clustering (EBDC) approach is developed in this research that predicts the link failure and increased the lifetime of the nodes. Here, the developed EBDC approach is utilized for clustering and route maintenance in MANET for that it creates the nodes using the star topology. Initially, the developed approach selects the Cluster Head and transmits the message through the created path. Subsequently, the link failure is detected by the EBDC model, and it creates a new reference layer to replace the exhausted layer. Hence, the developed EBDC model has enhanced the network lifetime and reduced energy utilization. Furthermore, this model is implemented using Network Simulator 2, and the parameters like accuracy, energy consumption, Packet Delivery Ratio, network lifetime, end-to-end delay, and throughput are calculated. Additionally, the attained outcomes are compared with prevailing methods for evaluating the efficiency of the developed approach.

Keywords Mobile ad hoc network · Routing protocol · Route maintenance · Star topology · Clustering · Network lifetime

1 Introduction

In general, the mobile ad hoc networks are arranged with several quantities of nodes that are communicating in a wireless manner (Tilwari et al. 2020). The MANET network is not having centralized supervision or particular infrastructure, and the nodes have the ability to move continuously in nature (Vatambeti 2020). Here, the information is passed from one place to the target location using wireless nodes that act as routers (da Costa Bento and Wille 2020). Normally, the mobile nodes in the MANET are communicated with each other without the need of base stations. Moreover, the routing protocols in the MANET are employed to regulate the routes that can be provided better communication through the nodes (Bhardwaj and El-Ocla 2020). The MANET is utilized for many applications because of its proliferation of smart devices, improvements in transmission, and flexibility (Sudhakar et al. 2020). Subsequently, the MANET is arranged by clusters that act as the cluster-head, and the rest of the communicating nodes are mentioned as cluster-members (Nivedita and Nandhagopal 2020). Moreover, the clustering method is employed for separating the entire network into the interrelated substructures that are named clusters (Mirsadeghi et al. 2020). Also, each cluster in the network has a node that is denoted as cluster-head, which performs the function of coordinator (Rajkumar and Jeyakumar 2021).

The routing protocol based on clustering methods is responsible for better communication in the network that involves inter-cluster and intra-cluster (Krishnan et al. 2020a, b). Additionally, when the cluster node is performing

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the member of neighboring clusters and having greater than one cluster-head, then that acts as the gateway node (Sufian et al. 2020). However, developing reliable clusters in MANET is utilized more time because of the nature of the wireless nodes (Nagendranath and Babu 2020). Additionally, the cluster-heads required a large amount of energy than the cluster-members (Regin and Menakadevi 2020). The clustering-based routing approach should be selecting the stable and exact cluster-head for enhancing the lifetime of the network (Dhindsa and Bhushan 2020). Also, the power consumption should be reduced for attaining effective communication.

In general, the MANET network is arranged with several numbers of nodes that are associated wirelessly. Moreover, the MANET nodes act as the router while transmitting the packets in the network. However, these networks have attained several concerns such as low stability, low security, and high energy utilization. Also, the network is affected by path failures because of the frequent movement of nodes that reduced the PDR and network lifetime (Srinivasa and Kamalesh 2020). Several routing protocols like ad hoc on-demand distance vector (AODV), Zone routing protocol (ZRP) (Shanthy and Padma 2020), Optimized Link State Routing (OLSR) (Ibrahim and Shanmugaraja 2020), Location Aided Routing (LAR) (Kumar et al. 2020), etc., are used to enhance the MANET communication, which are not attaining the accurate level for predicting link failure (Majd et al. 2019). Hence, the novel protocol is developed in this research to predict the link failure effectively and to enhance the lifetime of the nodes.

The developed method is utilized for diminishing the number of message transmissions while detecting the link failures in earlier. Moreover, the cluster head selection is efficiently reduced the unnecessary transmission, which is utilized lower energy for transmitting packets between the nodes. Subsequently, the main objective of this research is to enhance the lifetime of the network while predicting the path failures based on the selection of cluster heads. Here, the MANET network is developed based on the star topology, and the developed model is utilized for route maintenance while predicting link failure in the network. Finally, the proposed approach creates the reference layer when the route is failed that increased the lifetime of the nodes.

This research is ordered in the following sections. The related work of the developed proposed model is detailed in Sect. 2, the problem definition and system model is elaborated in Sect. 3. Moreover, the developed methodology is described in Sect. 4, and the obtained outcomes are discussed in Sect. 5. At last, the conclusion part of the developed model is mentioned in Sect. 6.

2 Related work

Some existing clustering methods in MANET is detailed as below.

Generally, the MANET is utilized for several applications that increased the great attention of researchers. However, routing of the packets in MANET is one of the difficult tasks because of the mobility of the MANET nodes. Prashant Dixit et al. (2020) developed the routing approach for MANET based on Lightweight Effective Cluster (LWEC) for enhancing the lifetime of the cluster-head. In this, the process of refugee node is developed for decreasing the complexity to preserve the procedure of the number of clusters in the developed network.

The mobility of the mobile nodes in the MANET can increase the difficulties in channel sensing, stability, and scalability that are reduced with the use of clustering algorithms. Moreover, the casting clustering issues are reduced using the Game theory that is based on the Minimum Weighted Inner Edge Straddling Tree (MWIEST), which is developed by Thong Nhat Tran et al. (2020). Furthermore, the developed clustering-based game theory is employed to create clusters with high stability.

Harold Robinson et al. (2019) developed the Reliable Routing Protocol (RRP) for attaining high Quality of Service (QoS) that is reduced the routing overhead in MANET. Here, the recognized node strength is utilized for calculating the bandwidth based on signals, and the message transmission is done through the created path. Consequently, Loose Virtual Clustering (LVC) and Neighbor Knowledge-based Rebroadcast (NKR) are developed for diminishing the routing overhead. Thus, it provides better results in routing overhead, data broadcasting, and network traffic.

The energy consumption and optimizing the routing are the challenging parts in MANET that are overcome with the use of optimal routing approaches, which are enhancing the efficiency of the network with an increased lifetime of nodes. Here, Sharifi and Babamir (2020) developed the novel clustering approach named Evolutionary Algorithms based on Imperialist Competitive Algorithm (EA-ICA) that are utilized for diminishing the overhead. Thus, this model attained better outcomes in stability, efficiency, convergence, and reproducibility.

To improve the system's consistency, Saravanan Kalaivanan (2020) developed the Energy Effectual Ad Hoc on-Demand Routing algorithm (EEAODR). This model is processed based on the AODV that can arrange the nodes in the system. Moreover, the energy of the hubs is identified in the base level point. Thus, the developed EEAODR model accomplished using the optimal path for the active nodes that are improved the packet delivery ratio. Also, the link and path failures are detected using the novel Hello-based

Path Recovery (HBPR) method that is introduced by Sunil Kumar (2020). In this, the new path is created by the HBPR model when the transmission path is failed.

Moreover, the novel honey pot mechanism is developed for detecting the malicious nodes in the network. Additionally, Khudayer et al. (2020) described the route and link failure prediction approach based on the network zone, which is employed to regulate the route requests. Also, this model is developed to predict link failures for diminishing the packet drop while transmitting messages.

Subsequently, the link failures happened because of various attacks like black hole and grey hole attack that are reduced the lifetime of the nodes. Here, Ramesh Vatambeti (2020) described the Grey Wolf-based Trust Accumulation model (GWTA) to predict the malicious attacks in the network, which has improved the throughput and reduced packet loss. Theerthagiri (2020) developed the new approach as Futuristic Cooperation Validation (FCV) model to calculate the stability of links and node reliability. It is utilized the Markov model for calculating the influencing factor that attained a high PDR value while transmitting messages.

To detect and mitigate the interruption in MANET, the novel Smart Detection Model (SDM) is developed by Islabudeen and Devi (2020). In this, the user ID, biometric, and location of the mobile users are registered in the system for authentication. Here, the design of a unique hash chain is utilized for preventing interruptions. Saini and Sharma (2020) described the model based on Multipoint Relay Perception (MRP) for enhancing the quality, durability, and trust nodes while message transmission in MANET. Also, the selected relay has utilized the functions like reachability of messages, degree, and relative mobility of communication nodes. Sridevi et al. (2019) developed the meta-heuristic model that is named as Particle Swarm Optimization algorithm through Bat mechanism (PSO-BAT) for consuming lower energy. This model is developed for preventing malicious attacks and decreasing the energy drain rate. Thus, the PSO-BAT model reduced the execution time and enhanced the throughput.

Arindrajit Pal et al. (2019) developed the model for maintaining links as stable in a network using a temporal data investigation model. Here, an Autoregressive Moving Average (ARMA) statistical manner is utilized for forecasting the neighboring nodes, which are in a stable way. Thus, this approach developed the optimal link for attaining reliable and stable links for efficient data transmission. Also, Kumar (2019) developed the routing protocol based on the location of the nodes for maintaining routes in the network. Thus, this model reduced the link failures and increased the number of transmitted packets. Moreover, Darwish et al. (2019) described the Fruit Fly Optimization (FFO) mechanism for developing the shortest route to transfer messages in MANET, which provides better outcomes in execution time and scalability. The summary of literature based on related works is detailed in Table 1.

The important contribution of this research is detailed below.

- Initially, develop the MANET network based on a star topology.
- Moreover, the novel Eagle Based Density Clustering (EBDC) approach is developed in this research for attaining effective communication.
- Here, the developed EBDC approach is employed for clustering and route maintenance process for that it creates the cluster head for message transmission.
- It predicts the link failure based on the energy utilization of nodes, and it creates a new reference layer for efficient communication.
- Thus, the introduced EBDC approach enhanced the lifetime of the nodes and reduced the energy consumption while transferring messages.
- Moreover, the implementation of the developed approach is done with the use of NS-2 and the attained metrics like PDR, network lifetime, end-to-end delay, energy consumption, accuracy, and throughput are validated with prevailing methods.

3 System model and problem definition

In recent years, MANET communication is an efficient and exciting technology due to the rapid proliferation of devices in the wireless medium. Also, Ad hoc networks are utilized for many applications because it is more reliable for preserving the capability of the traffic load, robustness, and flexibility. Typically, the MANET system is arranged by many mobile nodes but that have restricted CPU power and battery. Also, the nodes in the network act as the router for transmitting packages, but the nodes have different mobility.

The problems have occurred in MANET communication while transferring messages through the routers, which are shown in Fig. 1. In that, the source node sends a request for all neighboring nodes. Also, the end node in the network transmits the reply message to the nearest nodes that are reached on the source site.

3.1 Problem formulation

In MANET, the routing protocols are utilized for enhancing the MANET communication but that are attained several security issues. Moreover, the link failures are happening because of the mobility of mobile nodes that are increased the energy utilization of nodes, routing overhead, and delay. Also, route maintenance is one of the critical issues in MANET that involves two parts that are route breakage

Table 1 Summary of related works based on MANET communication

Author	Method and process	Merits	Demerits
Dixit et al. (2020)	LWEC approach utilized the refugee node for reducing the difficulty during communication	It enhanced the lifetime of the cluster head	Energy utilization is high
Tran et al (2020)	MWIEST has utilized the game theory for developing clusters	It developed the clusters with high stability	Link failure may happen while transmitting data
Robinson et al. (2019)	RRP is performed based on the calculation of bandwidth for transmitted signals	This method attained better results in routing overhead, data broadcasting, and network traffic	The network lifetime is low
Sharifi and Babamir (2020)	EA-ICA approach is employed to identify the head clusters and calculates the direction of node movements	It provides enhanced outcomes in stability, efficiency, convergence, and reproducibility	It utilized more energy for data transmission
Kalaivanan (2020)	EEAODR manner calculates node energy in the base level point and uses the active nodes for data transmission	It improved the PDR value	Lower Stability
Sunil Kumar (2020)	HBPR manner is employed to predict the node failure based on the hello process	Effectively detect the malicious nodes	Transmission time is high
Khudayer et al. (2020)	The zone-based prediction model is employed to predict the link failure based on the location of nodes while regulating the route requests	Predict the link failure and reduce packet drops	The lifetime of nodes low
Ramesh Vatambeti (2020)	GWTA approach is employed to predict the harmful nodes in the network while transmitting messages	Predict the malicious activities and increased the throughput ratio	PDR and Throughput are not enough
Theerthagiri (2020)	FCV approach is performed based on the Markov model to compute the influencing factor	It attained a high PDR value	Malicious activities may present
Islabudeen and Devi (2020)	SDM model is calculated the unique hash chain to identify the interruptions in the network	Prevent interruptions	Link stability is low
Saini et al. (2020)	MRP model has selected the relay for message transmission	Improved the quality, durability, and trust nodes	High energy utilization
Sridevi et al. (2019)	PSO-BAT approach is processed on a dynamic routing protocol for maintaining and developing the routing path	It decreased the transmission time and energy	It does not detect the malware functions
Arindrajit Pal et al. (2019)	ARMA model is utilized to predict the stable neighbor nodes and develop a link between these nodes	It is maintaining stability	A high execution time is required
Kumar (2019)	The location-based routing protocol is developed for making a decision using the position of the failed link nodes	Maintaining the routes and reduced the link failure	Limitation in energy consumption
Darwish et al. (2019)	FFA method is developed for identifying the best shortest path for message transmission	Execution time is low	energy utilization is high when large numbers of nodes used

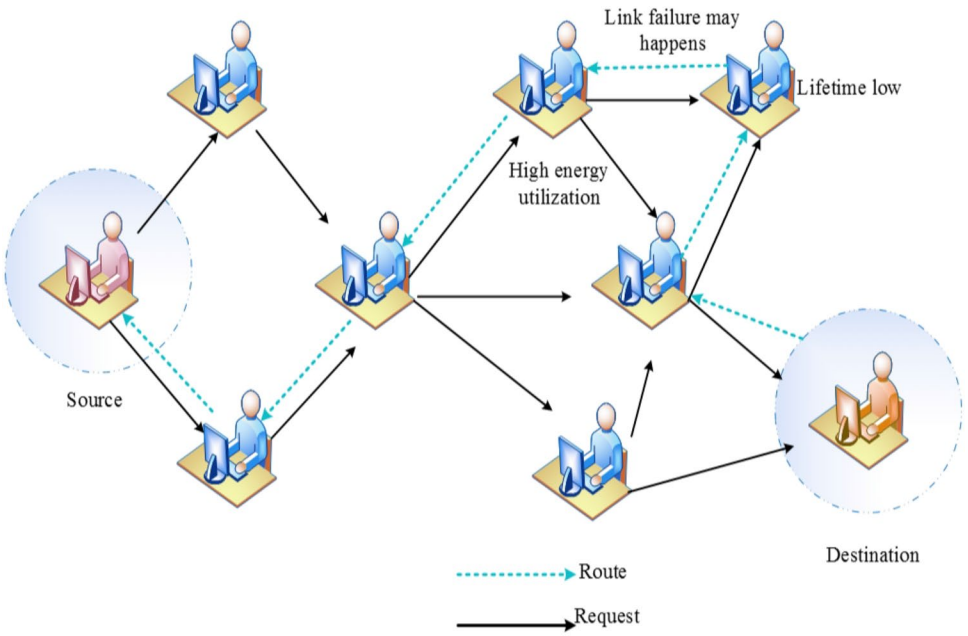

Fig. 1 System model for MANET

and deterioration. In MANET, several network nodes are utilized high energy to transmit the reply message, which creates the link failure and reduces the node lifetime. Thus an efficient algorithm is required for predicting path failure earlier. Hence, the novel clustering algorithm is developed in this paper for diminishing the energy utilization and improving the network lifetime. Therefore, the use of clustering algorithms can be managed by CH nodes that are energy-consuming while data transmitting in a wide range.

4 Proposed EBDC methodology

This research develops an innovative Eagle Based Density Clustering (EBDC) model for predicting link failure and developing an alternate path for transmitting data in MANET. This approach is focused on the clustering and route maintenance process in MANET communication. Primarily, the star topology is utilized for developing the MANET network to transmit the packets. Moreover, the developed EBDC model continuously monitors the network links during data transmission. If there is any link failure happens, then it created a new link that is named as a reference layer. Thus, the developed model transmits the message through the reference layer.

Here, the developed EBDC model diminishes the energy utilization and enhances the lifetime of the node. The process of the proposed EBDC is shown in Fig. 2 which is explained in the following section. The innovation of this work is that the utilization of the eagle optimization model in the density clustering approach can enhance the efficiency to detect link failure for effective communication, which improved the network's lifetime.

4.1 Process of EBDC model

The proposed Eagle-based Density Clustering approach is employed to predict the link failure in the network based on the energy utilization of nodes and develops the new reference layer for effective communication. In this approach, the star topology is designed for MANET communication in that the required amount of nodes is created. The star topology is referred to as every node in the network connected with the center node called the router. In this topology, every node is associated with the middle node mentioned as the cluster head. If any node in the network wants to transmit the data, it passed the data to the CH node that forwards the data to neighboring nodes. After developing nodes, the proposed EBDC model is designed to prevent link failure in a route.

The message transmission using CH is detailed in Fig. 3. Here, the star topology is utilized for developing the MANET network by arranging the required quantity of nodes. In that, the CH is selected for preserves the data that is related to its cluster, which includes the details about the number of nodes in the cluster and route to the nodes. Moreover, the gateway node acts as the gate between the cluster networks employed to protect the nodes in the network. Additionally, the remaining nodes in the network are considered cluster members. In this, the CH nodes create the path for data transmission. Here, the proposed EBDC is continuously analyzing the path to predict the link failure. The selection of cluster head is based on the energy threshold of the nodes.

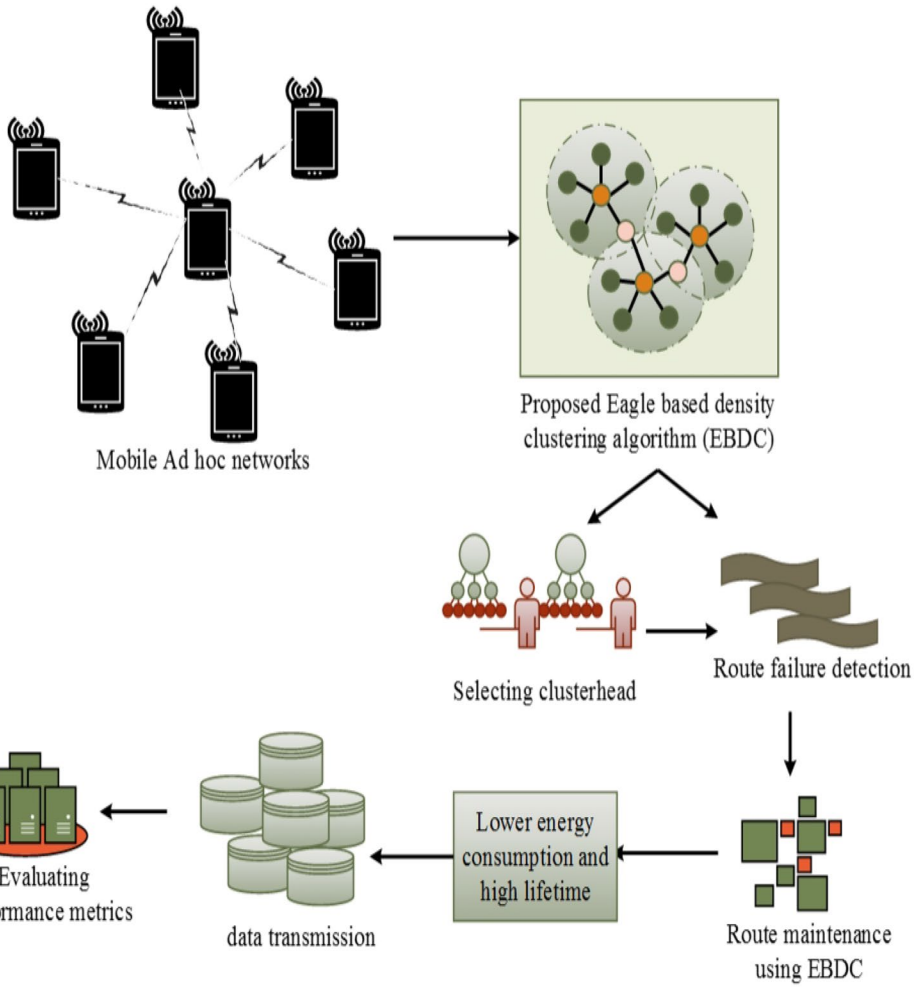

Fig. 2 Process of proposed EBDC

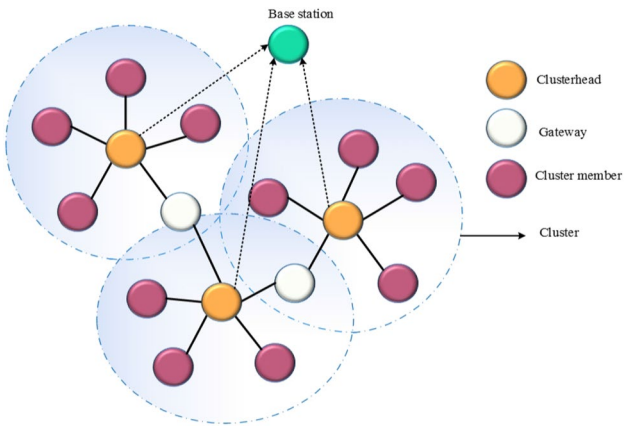

Fig. 3 Data transmission using proposed EBDC

In this research, the density clustering model has been processed on the network to predict the link failure. Also, the optimization approach is utilized to identify or create the alternate path (reference layer) when it predicts the link failure in the network. Also, it enhanced the prediction accuracy and throughput ratio. Initially, the developed EBDC manner creates the mobile nodes for communication-based on the star topology that is mentioned in Eq. (1),

$$g(x) = g(x_1), g(x_2), \ldots, g(x_n) \tag{1}$$

where node is represented as x and n numbers of nodes are developed in the network.

- Selecting cluster head.

  Additionally, the message is transmitted through the nodes in that the Cluster Head (CH) is identified based on the energy threshold range of every node in the network. Also, the energy threshold of each node is calculated using Eq. (2),

$$Ex_t = \sum_{x=1}^{n} g(x)[\varphi - \min \varphi] \tag{2}$$

where, φ denotes the kinetic energy for every node in the network. In this, the energy threshold of the nodes is considered as $Ex_t = \pm 0.5$. If the energy threshold is higher than 0.5, then the particular nodes are taken as CH. Here, the cluster members in each cluster are employed to collect the information from the sensors.

- Identify the path (k).

  Subsequently, the developed model calculates the distance between each node in the network for transmitting the data. Moreover, the proposed method has calculated the distance between the node N_1 and N_2 is calculated based on the (x, y) coordinates using Eq. (3),

$$k = \sum_{x=1}^{n} d(x_e - x_s) \tag{3}$$

  where, $d(x_e - x_s)$ denotes the distance between the end node and starting node. IN this approach, the distance between every two nodes is calculated and the shortest distance nodes are taken for message transmission. Here, the proposed density clustering function sets the distance value between the nodes as $d(x_e - x_s) = 0.2$ that is calculated by EBDC. Therefore, the distance between two nodes is 0.2, then it creates the path between the nodes. If the distance is greater than the particular condition, then the nodes are neglected.
- Route maintenance.

  Additionally, the developed model detects the route or link failure while transmitting data to the path (k). Here, the energy utilization of each node (Ex) will be calculated for identifying the link failure that is mentioned in Eq. (4),

$$Ex = Ex_1, Ex_2 \ldots Ex_n \tag{4}$$

Primarily, the developed EBDC sets the condition $E_x = 0.01J$ for each node in the path. If any node has utilized high energy, then it is considered a link failed node, i.e., $E_x > 0.01J \rightarrow link\_fail$. So, the new reference layer is developed by the developed manner of the fitness function. The EBDC model updated the path k and developed the reference layer as k + 1 that is utilized to transfer the data.

Hence, the developed model transfers the message with lower energy utilization that is increased the lifetime of the nodes. The process of introducing the EBDC approach is detailed in Algorithm 1, and the flow chart is represented in Fig. 4. Initially, the MANET nodes are developed based on the star topology and the energy threshold of each node calculated. In this, if the node has the highest energy threshold, then it is identified as the cluster head. Moreover, the proposed model creates a route based on the shortest distance between the neighboring nodes.

Consequently, the energy utilization of each node is calculated to identify the link or node failure. If any node in the network is utilized more energy for transmission, it is considered the link or node failure. Thus, the path is updated by the EBDC fitness model that creates the alternate shortest path to secure data transfer, which improves the lifetime of the network and uses less energy than other conventional methods.

Algorithm 1: EBDC for clustering and route maintenance

Start

{

Develop a MANET network based on a star topology

Initialize n numbers of nodes using eqn.(1)

// selecting cluster-head (CH)

Calculate Ex_t using eqn.(2) // Ex_t -energy threshold

Set the energy threshold range

$$Ex_t = \pm 0.5$$

If the energy threshold is equal to the condition, then it is selected as CH

$$Ex_t = \pm 0.5 \rightarrow CH$$

// identify the path (k)

Calculate the distance of every node from the CH

Path (k) is identified using eqn.(3)

$D_x < 0.2$ // D_x **-distance**

If the distance between the nodes is lower than 0.2 mm, then the message is transmitted through that nodes

// detect the link failure

Calculate the (Ex) of each node Ex - energy utilization

Set the energy utilization condition as,

$$E_x = 0.01J$$

If the energy utilization is high, then consider the link is failed

$$E_x > 0.01J \rightarrow link\_fail$$

// route maintenance process

Primarily consider $x^{k=0}$

while $\left(\left\|x^{k+1} - x^{k}\right\|\right) > tolerance$

Update $k = k + 1$

end if

$k+1$ denotes the reference layer **//alternate path**

data transmission

Calculate performance metrics

}

Stop

5 Results and discussion

The simulation of the developed EBDC process is done using NS-2 that is calculated the performance parameters like PDR, throughput, network lifetime, energy consumption, and delay. The simulation details using the proposed EBDC model are mentioned in Table 2. Initially, the developed approach creates the MANET network and selects the CH for message transmission.

Moreover, it performs the route maintenance process to create a new reference layer for transmitting the messages. Finally, the developed approach utilized lower energy and enhanced the lifetime of the nodes.

Table 2 Simulation details

Parameter	Value
Tool	NS2
Number of nodes	500
Communication range	100
Simulation area	2000 m

5.1 Case study

Let us consider the source node S, target node D, N1 to N16 are the neighboring nodes. In this proposed approach, the nodes are arranged based on the Star topology and here, the CH node is selected using the energy threshold of every

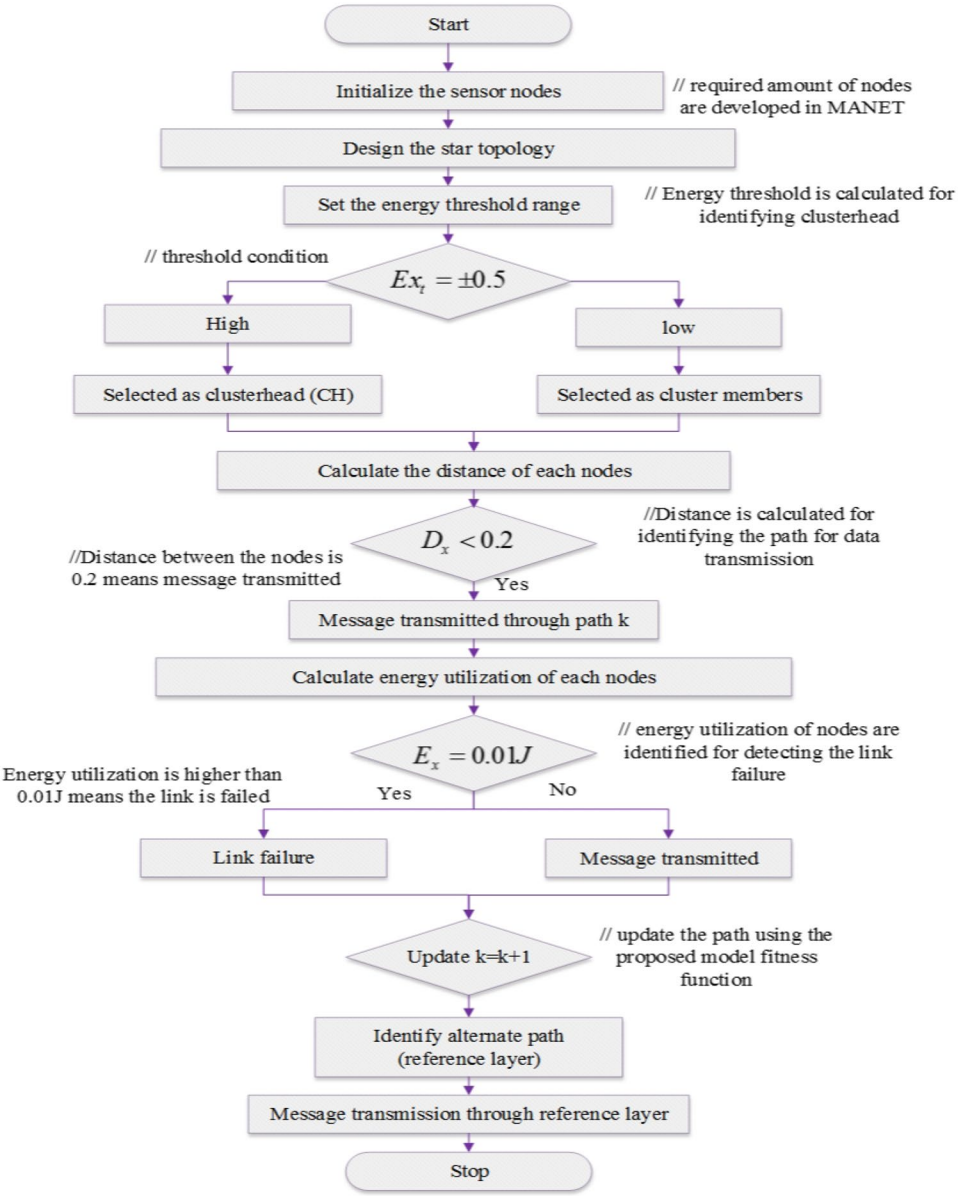

Fig. 4 Flow chart for proposed EBDC

node. Additionally, the energy threshold condition is taken as 0.5. If any node has an energy threshold is more than 0.5, then it is selected as CH and other nodes are considered as cluster members. In this, N is considered the base stations, N1, N7, N13 are taken as the CH node, and the remaining nodes are regarded as cluster members. Subsequently, the distance is computed between the CH and cluster members. The calculated distance is equal to 0.2, then the path is created between the nodes, and the message is transmitted through that path, which is represented in Fig. 5.

Subsequently, the energy utilization of each node is calculated that is utilized for determining the route faults. The proposed methodology set the energy utilization is 0.01 J for every node. If any node's energy utilization is higher than 0.01 J, then it is considered a link failure. Consequently, route maintenance is required for efficient communication that is attained by the proposed model fitness function. It generates one reference layer for transmitting the message in an efficient manner which is shown in Fig. 6.

Hence, the message has been transmitted through the alternate path, which means the reference layer. Moreover, the utilized nodes are consuming lower energy, so the lifetime of the node is high. Additionally, it provides better results in PDR, throughput, delay, and accuracy that are detailed in the following section.

5.2 Performance metrics

The proposed EBDC approach calculates performance metrics like accuracy, PDR, throughput, network lifetime, energy utilization, and delay. Here, the calculated metrics are evaluated using the existing approaches such as RRP (Robinson et al. 2019), EA-ICA (Sharifi and Babamir 2020), and Modified Zone-Based Intrusion Discovery Scheme (MZBIDS) (Krishnan et al. 2020a, b).

5.2.1 Accuracy

Accuracy is calculation is utilized for determining the efficacy of the developed EBDC approach. In this research, accuracy is calculated for identifying how effectively the proposed method detects the link failures and creates the route during message transmission, which is calculated using Eq. (5),

$$A = \frac{(Tn' + Tp')}{(Tn' + Tp' + Fn' + Fp')} \tag{5}$$

where Tn' is True negative, Tp' is denoted true positive, Fn' is represents false-negative value and Fp' is symbolizes false positive.

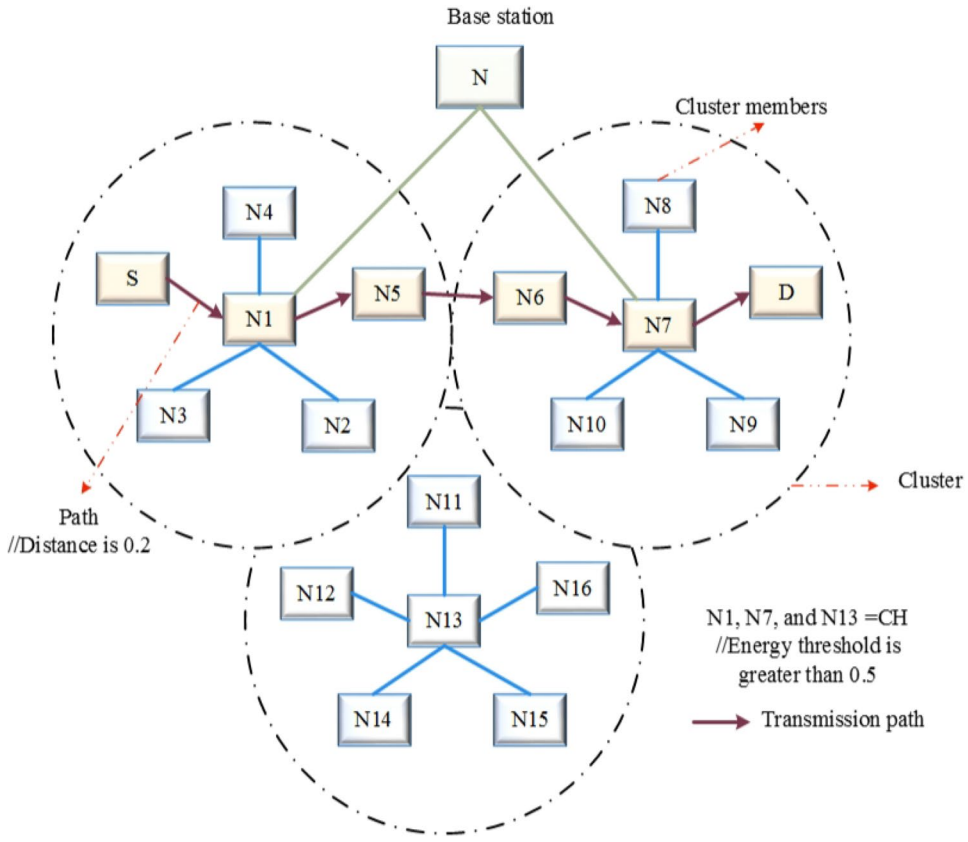

Fig. 5 Message transmission through a created path

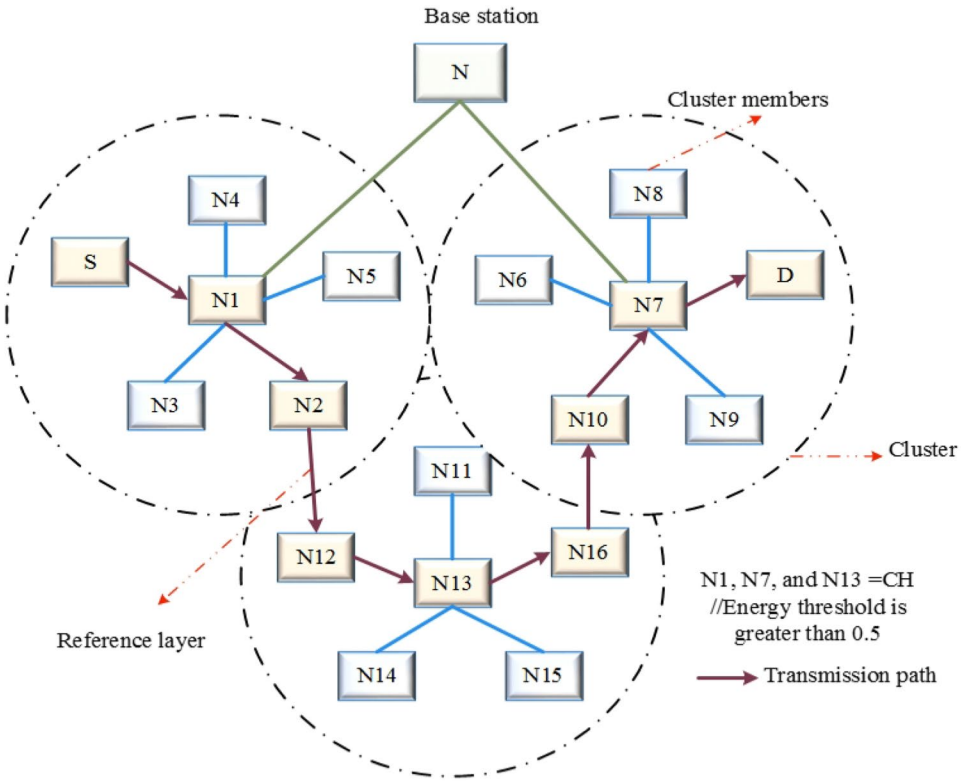

Fig. 6 Message transmission after route maintenance

Table 3 Evaluation of accuracy

No. of nodes	Accuracy (%)			
	RRP	EA-ICA	MZBIDS	EBDC [proposed]
100	86.59	95.65	87.67	99.90
200	83.97	94.76	83.98	99.89
300	82.04	93.59	83.10	99.85
400	81.87	93.06	82.78	99.83
500	80.67	92.84	82.56	99.78

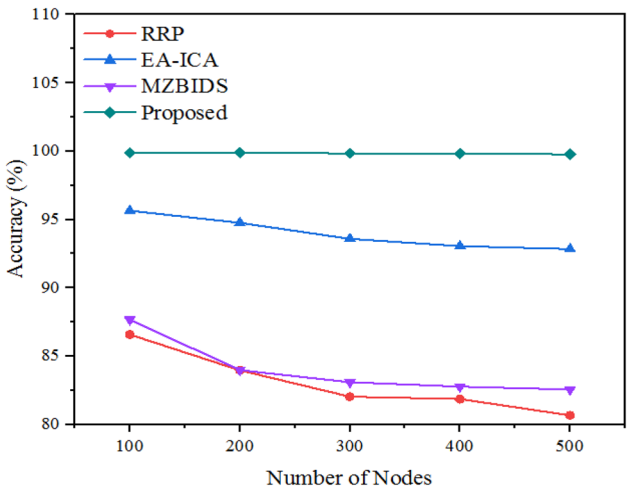

Fig. 7 Comparison of accuracy

The effectiveness of the proposed EBDC approach is calculated and evaluated using existing approaches like RRP, EA-ICA, and MZBIDS that are detailed in Table 3. Here, the existing methods like RRP and MZBIDS have attained nearly 86% and 87% accuracy. Also, the existing EA-ICA approach achieved almost 95% accuracy. Moreover, the proposed EBDC obtained a high accuracy value of 99.9% that is very efficient than other approaches, which are represented in Fig. 7. The developed EBDC model effectively predicts the link failures based on the energy utilization of the nodes.

5.2.2 PDR calculation

This calculation is based on the rate of the entire quantity of attained data packets and the transmitted data packets, which is computed using Eq. (6),

$$PDR = \frac{No.\ of\_attained\_datapackets}{No.\ of\_transmitted\_datapackets} \quad (6)$$

The PDR value of the proposed EBDC approach is evaluated using existing techniques like RRP, EA-ICA, and

Table 4 Evaluation of PDR

No. of nodes	Packet delivery ratio (%)			
	RRP	EA-ICA	MZBIDS	EBDC [proposed]
100	89.57	94.87	87.56	99.85
200	90.78	93.93	88.98	99.80
300	88.69	93.54	87.75	99.56
400	88.94	94	85.83	98.36
500	87.56	95.5	84.67	96.67

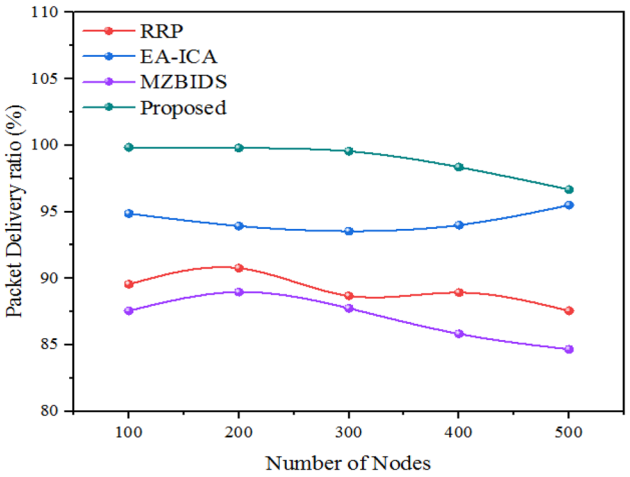

Fig. 8 Comparison of PDR

Table 5 Evaluation of throughput

Throughput (bps)				
No. of nodes	RRP	EA-ICA	MZBIDS	EBDC [proposed]
100	67	250	95	700
200	38	148	70	520
300	45	125	74	425
400	40	178	69	345
500	35	185	73	240

MZBIDS that are detailed in Table 4. Here, the existing methods like RRP and MZBIDS are attained nearly 87% and 89% PDR.

Also, the existing EA-ICA approach achieved almost 94% PDR. Moreover, the proposed EBDC obtained a high PDR value of 99.85% that is very efficient than other techniques, which are represented in Fig. 8.

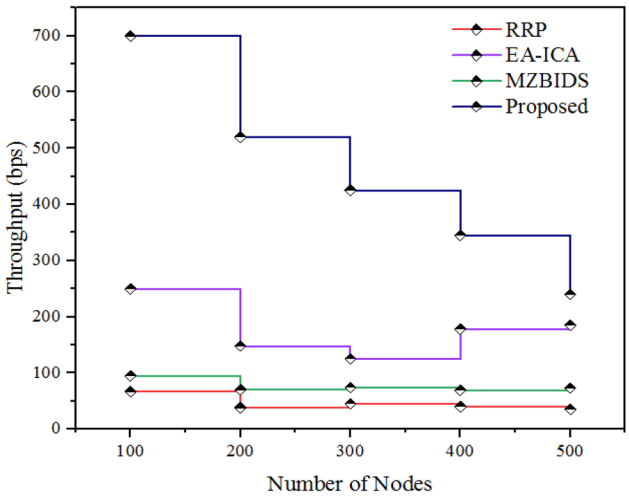

Fig. 9 Comparison of throughput

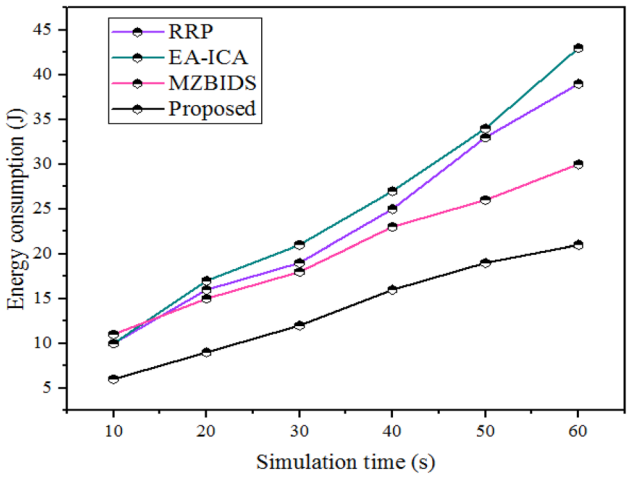

Fig. 10 Comparison of energy consumption

Table 6 Evaluation of energy consumption (J)

Energy consumption (J)				
Simulation time (s)	RRP	EA-ICA	MZBIDS	EBDC [proposed]
10	10	10	11	6
20	16	17	15	9
30	19	21	18	12
40	25	27	23	16
50	33	34	26	19
60	39	43	30	21

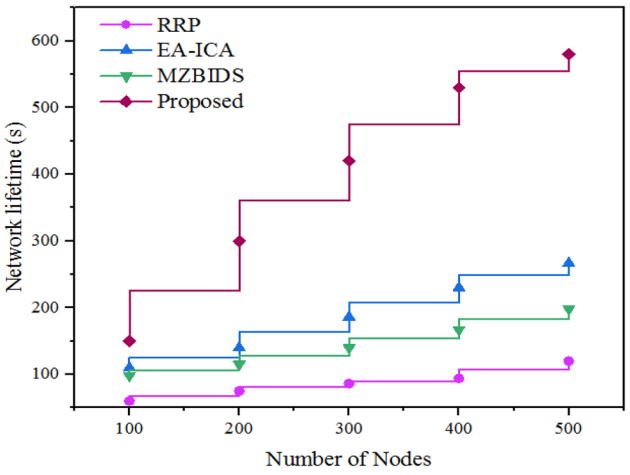

Fig. 11 Comparison of network lifetime

Table 7 Evaluation of network lifetime (s)

No. of nodes	Network lifetime (s)			
	RRP	EA-ICA	MZBIDS	EBDC [proposed]
100	60	110	98	150
200	75	140	115	300
300	86	186	140	420
400	94	230	167	530
500	120	265	198	580

5.2.3 Throughput

The data packets are transferred through the communication links between the nodes, and the throughput ratio is computed for calculating the rate of data transfer in the network. Here, the throughput ratio is calculated using Eq. (7),

$$Throughput\ (kbps) = \frac{Received\_packet\ (bytes) * 8}{1024 * (Endtime - startingtime)} \times 100 \quad (7)$$

The throughput value of the proposed EBDC approach is evaluated using existing strategies like RRP, EA-ICA, and MZBIDS, detailed in Table 5. Here, the existing methods like RRP and MZBIDS are attained nearly 67 bps, 97 bps throughput value. Also, the prevailing EA-ICA approach accomplished almost 250 bps throughput value. Moreover, the proposed EBDC obtained a high throughput ratio of 700 bps while transmitting messages through 100 nodes, which are represented in Fig. 9.

Table 8 Evaluation of end-to-end delay

Number of nodes	End-to-end delay (s)			
	RRP	EA-ICA	MZBIDS	EBDC [proposed]
100	20	9	18	1.5
200	37	16	25	2
300	49	25	36	2.3
400	55	29	49	3.8
500	66	34	55	9

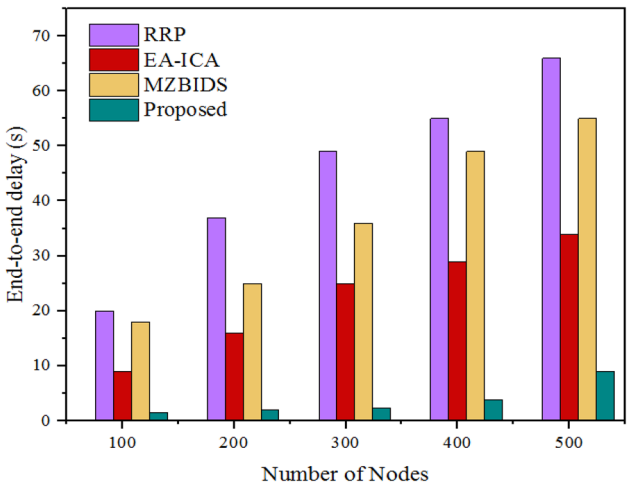

Fig. 12 Comparison of end-to-end delay

5.2.4 Energy consumption

The proposed EBDC model attained lower energy consumption because of the route maintenance manner. Here, the energy utilization of the nodes has been calculated based on the simulation time.

Moreover, every node in the transmission path is utilized sufficient energy, and the calculated values are represented in Fig. 10. Furthermore, the comparisons of energy consumption with existing methods are mentioned in Table 6.

5.2.5 Network lifetime

In MANET, network lifetime is one of the necessary metrics for attaining efficient communication. When the energy utilization of nodes is high, nodes cannot communicate, which can affect the lifetime of the network. In this proposed approach, the energy utilization is low, so the network's lifetime is improved.

Table 9 Comparison of state-of-art methods

Author	Method	Accuracy (%)	PDR (%)	Throughput (kbps)	Energy consumption (J)	Network lifetime (s)	End-to-end delay (s)
Prashant Dixit et al. (2020)	LWEC	87.3	89	68	20	50	45
Thong Nhat Tran et al. (2020)	MWIEST	93.4	92.56	120	9	85	38
Harold Robinson et al. (2019)	RRP	86.59	89.57	35	10	60	20
Sharifi and Babamir (2020)	EA-ICA	95.65	94.87	135	10	110	9
Saravanan Kalaivanan (2020)	EEAODR	90.08	89	140	7	80	15
Sunil Kumar (2020)	HBPR	97.67	95	550	9	120	40
R. Santhana Krishnan et al. (2020a, b)	MZBIDS	87.67	87.56	67	11	98	18
Ramesh Vatambeti (2020)	GWTA	99.15	98.2	88	8	130	5
Proposed method	EBDC	99.9	99.85	700	6	150	1.5

The network lifetime of the developed approach is calculated for several quantities of nodes that are validated with prevailing approaches, which is represented in Fig. 11. Here, the existing methods like RRP, EA-ICA, and MZBIDS have network lifetime 120 s, 265 s, and 198 s while transmitting messages through 500 nodes. Moreover, the proposed approach is attained a high lifetime of 580 s while sending messages through 500 nodes. Hence, the comparison is mentioned in Table 7.

5.2.6 End-to-end delay

Delay is calculated for identifying the time that is taken for reaching the transmitted data to the destination. It is the ratio of time that is occupied by received packets to the time taken by transmitted packets that are computed using Eq. (8),

$$End\_to\_end\text{-}delay = \frac{No.\ of\_received\_packets\_time}{No.\ of\_sent\_packets\_time} \tag{8}$$

The end-to-end delay value of the developed EBDC approach is estimated using prevailing strategies like RRP, EA-ICA, and MZBIDS that are detailed in Table 8. Here, the existing methods like RRP and MZBIDS are attained nearly 20 s and 18 s delay value.

Also, the existing EA-ICA approach accomplished 9 s delay value. Moreover, the proposed EBDC obtained a lower delay value of 1.5 s while transmitting messages through 100 nodes, which are represented in Fig. 12.

The proposed method has attained effective outcomes for predicting link failure and creating the new path for better transmission. Thus, it proved the comparison through prevailing methods, which is given in Table 9.

6 Conclusion

In MANET communication, link failure is happened because of various hackers, node mobility, and changing topology. So, this research developed the novel Eagle Based Density Clustering (EBDC) algorithm for route preservation and clustering in MANET. This model primarily develops nodes in the MANET that are arranged based on the Star topology, which reduced the packet loss because the message is stored in the cluster head. Initially, the developed manner finds the cluster head and path for message transmission. Subsequently, it detects the route (link) failure based on the calculation of the energy utilization of nodes. Hence, it creates a new reference layer for effectively transmitting messages. Accordingly, the developed reference layer is enhanced the lifetime of the nodes and network. The main advantages of the proposed EBDC approach are described as follows,

- It created a large number of nodes in the MANET network
- The proposed EBDC model effectively predicts the link failure while transmitting messages.
- Consequently, EBDC developed the reference layer for effective transmission.
- Thus, the developed EBDC approach enhanced the network lifetime and reduced the energy consumption due to the route maintenance and clustering process in EBDC.
- Also, it enhanced the PDR, throughput ratio, and reduced the delay, energy utilization.

Therefore, it attained 99.9% high accuracy for predicting link failure, 99.85% PDR, energy utilization is 6 J, high network lifetime as 150 s, and lower delay as 1.5 s while transmitting a message through 100 numbers of nodes. Moreover, the comparison result proves the effectiveness of the proposed approach. In the future, the proposed strategy will apply in real-time applications to provide efficient outcomes.

Also in future, other influencing factors will be considered for attaining effective communication.

Declarations

Conflict of interest The authors declare that they have no potential conflict of interest.

Ethical approval All applicable institutional and/or national guidelines for the care and use of animals were followed.

Informed consent For this type of study formal consent is not required.

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