Engineering Science and Technology,
an International Journal

journal homepage: www.elsevier.com/locate/jestch

Power Optimization in MANET using Topology Management

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ARTICLE INFO

Article history:
Received
Received in revised form
Accepted
Available online

Keywords:
MANET topology
Power
Energy
Gabriel graph
Mobility
Connectivity

ABSTRACT

Mobile ad-hoc network (MANET) is a wireless ad hoc network, which is quickly deployable and functions without any infrastructure. This work proposes a hybrid optimization algorithm, named Chronological- Earth Worm optimization Algorithm (C-EWA), for performing effective clustering and adjusts power and energy parameters using topology management. In this paper, initially a graph that is equivalent to the network is constructed, and then, clustering of the graph is performed to generate an optimal cluster head. The clustering of the graph is performed using the proposed C-EWA, which is developed by the integration of chronological theory in EWA, with the use of the objective function. Here, the objective function considers several factors that involve power, connectivity, mobility, link lifetime, and distance. After choosing appropriate clusters, each of the nodes that belong to the cluster constructs a Gabriel graph within the corresponding cluster. Once the Gabriel graph is constructed, each node updates the list of neighbor and maintains the graph connectivity and adjusts the power of transmission based on the connectivity. The performance of the proposed method shows superior performance in terms of remaining battery power, mobility, throughput, delay and connectivity with values of 21.960J, 0.729, 0.713, 0.295, and 5.256, respectively.

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1. Introduction

Mobile Ad-hoc Network (MANET) is an autonomous wireless ad hoc network that contains mobile nodes, which initiate transmission without considering base stations [1]. In wireless transmission, the user radios cooperate for creating its network. Whenever a radio is turned on by the user, the radio is responsible for following a protocol to announce its presence and to determine other participating radios. Networking is essential for the strategic networks, which are not depended on other infrastructures that involve disaster relief organizations and military [2]. The networking is suitable for inter-vehicular networks and sensor networks. Several challenges related to network protocols are presented in MANET [3]. The protocols should offer distributed solutions whenever the centralized control and the access points are absent. The node mobility influences the solutions to be temporary and thus, the communication between inter radios while maintaining network remains static throughout the network lifetime. The node mobility is inessential as compared to the routing protocols, which can track the topology of the network [4]. The surplus of routing protocols deployed for MANETs perform certain tasks for data transmission. There is a direct relationship between the protocol effectiveness and the administrative traffic quality to track the topology and increase the quantity whenever the volatility or size of the network is increased. But the wireless networks are controlled with respect to the capacity. The nodes present in this network produce user and application traffic, network control, and routing protocols. The changing topologies, network division, bandwidth, larger error rates, interference, power constraints, and collision are the issues in the network control for designing larger level protocols that involve routing and executing applications using the Quality of service (QoS) [5].

MANETs employ self-governed networks and do not contain any fixed infrastructures. The mobile participating in such type of networks poses the ability to communicate with each other using direct wireless links and multi-hop routing. The MANET is adapted in several applications that range from the battlefield to the user's living room. But, the mobile node with limited battery energy and increased network lifetime are the major challenges in MANET and has attracted many researchers. The traditional methods employed for conserving energy are the spotlights on controlling transmission power and the dynamic turning of active nodes in the network. The reduction of energy utilization is controlled by transmission power, which subsequently results in effective data transmission and prolonging network lifetime [6]. Power plays a vital role in MANET [27] [29] and requires fewer infrastructures and communication networks. The wireless links are used for initiating the communication between the nodes. Each node reacts like host and router for routing the information from one node to another. The routing becomes challenging due to varying topologies produced by the movement of the node, and thus, the routing is a center of attraction among researchers. The existing routing protocols, like Ad hoc On-Demand Distance Vector (AODV) [28], Temporally Ordered Routing Algorithm (TORA), and Dynamic Source Routing (DSR), do not fulfill the requirements of real time applications. The application requires the communication network to provide a guarantee regarding QoS parameters. The prolonged battery life is important due to the mobile nodes. The existing routing steps are not aware of energy consumption in spite the connections are considered for the shortest path. The existing works are performed by considering hop count and transmission power. The power received is an important parameter for initiating the communication in MANET [7].

The MANET nodes move freely from one place to another in a random manner. The topology of the network is changed unpredictably and rapidly. Multiple network hops are required for a node to interchange data with each other throughout the network due to the transmission range, which is less in wireless network nodes. The nodes inside the transmission range can directly exchange information with each other. The nodes that reside outside the transmission range should communicate indirectly by adapting the multi-hop routing protocol. Each node is responsible for the route discovery in a dynamic manner. Despite several clustering schemes, the organization of MANET into a hierarchy needs to be improved for increasing the efficiency of routing. Clustering is a technique adapted for reconfiguring all nodes into small clusters according to the regional vicinity and the cluster head, and the clusters are determined using the same rule. The cluster head is responsible for managing the cluster activities that involve handling cluster processes, routing table update, and route discovery. The nodes excluding the cluster head from the cluster are termed as ordinary nodes. The nodes with inter-cluster links having the ability to communicate with one or more clusters are known as gateway nodes. The ordinary nodes transmit packets to the cluster head, if the destination is within the cluster; else, it is transmitted to the gateway node. Thus, the cluster heads and the gateways participate in the propagation of route update or control messages. The routing overhead is significantly reduced and solves scalability issues in dense networks [8].

The main objective of this paper is the initiation of clustering algorithm using a hybrid optimization algorithm, named Chronological- Earth Worm optimization Algorithm (C-EWA), for power optimization using topology management. The proposed method undergoes two main steps, namely graph construction and graph clustering. Initially, a graph is built with respect to the network, and then, the clustering of graphs is done to obtain an optimal cluster head. Here, the clustering process is initiated using the proposed C-EWA algorithm based on the newly designed objective function that contain several parameters, which include power, connectivity, mobility, link lifetime, and distance. Once the optimal clusters are selected, a Gabriel Graph is built within the corresponding cluster. After the formation of Gabriel graph, each of the nodes updates and lists out the nearby nodes and handles the connectivity and adjusts the power transmission.

The major contributions of the paper are:

-Designing and developing an optimization algorithm, Chronological-Earth Worm optimization Algorithm (C-EWA), by the incorporation of Chronological concept in EWA for managing power and energy in an effective way.

-Designing a modified objective function, containing parameters that involve power, connectivity, mobility, link lifetime, and squared distance, for selecting the optimal cluster head using the proposed C-EWA.

The organization of the paper is: Section 1 explains the introduction related to MANET by considering power and energy parameters. Section 2 discusses the literature review based on eight existing techniques. Section 3 deals with the system model and section 4 presents the proposed C-EWA for clustering graphs. Results and Discussions are explained in section 5, and section 6 deals with the conclusion of the paper.

2 Motivations

2.1 Literature survey

This section elaborates eight existing techniques that contribute towards the topology management for performing effective clustering.

Rashmi Chaudhry and Shashikala Tapaswi [9] designed a method based on scalable clustering topology, named Optimized Power Control (OPC), for determining the optimal transmission power of nodes using a modified Gabriel Graph (GG) algorithm. The method is checked in terms of efficiency for several network metrics, like transmission power, network delay, and energy consumption per node and has shown good performance. But, the method failed to combine the OPC with a congestion control algorithm.

Xin Ming Zhang *et al.* [10] designed a modified AODV routing protocol for improving the reliability to transmit the data from one node to other node by consuming energy. The method uses the mobile node's energy based on the radio range for effective network usage. In this method, the modified AODV improves energy usage and consumes less energy. The modified AODV protocol reduces the average communication delay and routing overhead by addressing the issue of link breakage caused by the inadequate amount of energy.

Parisa Rahmani *et al.* [11] developed a learning automata-based topology control method within a cognitive method. This method adds cognition to the whole network protocol stack-wide and network-wide performance. In this method, two parameters are integrated with each node that includes transmission power control and channel control. The first parameter evaluates the probability of link control and the second parameter assigns a channel to each node by adapting learning automata. The cognitive network perspective for controlling the network topology has several benefits that involve self-aware, self-adaptive, and self-adjust topology control method, but the trade-off between energy efficiency and routing topologies is still an issue.

T. Santhi Sri *et al.* [12] developed a routing algorithm, named Position-based Opportunistic Routing (POR) algorithm, which handles a stateless property on an individual node, in which broadcast is performed using wireless communication in a time interval. The stateless property uses POR for consuming more energy to maintain route recovery, virtual destination, and backup communication on delivering data. Synchronization-based Efficient Energy (SEE) algorithm is used with POR protocol for distributed and randomized calculation without changing the network capacity. However, the network shows poor network performance while adapting cluster head in ad-hoc networks.

Hemalatha, S. and Mahesh, P.S [18] designed a protocol, named Directional Advanced Intruder Handling AODV protocol for routing packets by determining a new route whenever required. This method was adapted for identifying the blackhole attacker nodes from the network. The algorithm utilizes directional antenna transmission for optimizing the energy consumption in MANET.

Singh T *et al.* [19] developed an energy-efficient secured routing protocol, named Secure Optimized Link State Routing Protocol, for providing security for both link and message without depending on the third party. Each node selects multipoint relay nodes from one-hop neighbors to reach two-hop neighbors. The access control is used to provide security and verifies the nodes for transmitting data packets. The method failed to consider attack detection and mitigation methods for addressing the external attacks.

Sridhar, S., *et al.* [20] developed a protocol, named Trust and Energy Supported Ad-hoc On-demand Distance Vector (TES-AODV) routing protocol, which used trust, energy and security management and the nodes chosen for routing are based on trust and security values. Threshold values are selected for routing, and the nodes meeting the threshold values are selected for routing. The communications between nodes are secured due to a message digest algorithm that builds a specific identification for each node to provide reliable routing. But the method was unable to maintain energy levels for next transmission and thus, reduced the network lifetime.

Rao, M. and Singh, N [21] developed an algorithm, named hierarchical K-means cluster formation Firefly cluster head selection based MAC (KF-

MAC) routing protocol for mobile ad hoc networks. The method decreases the attentiveness of QoS parameters while transmitting data from one node to other. Initially, the clustering is done using K-means clustering technique, and then, the clustered nodes are categorized and optimized by applying optimized firefly algorithm. The method shows maximum delays, while using packet exchange protocols.

2.2 Challenges

-In [13], a Lowest ID (LID) clustering algorithm is developed for allocating a unique identity (ID) address for an individual node in the network and then, disseminates the ID to all surrounding nodes. But in this algorithm, the number of cluster heads becomes high in an undesirable manner.

-In [14], a Distributed Mobility-Adaptive Clustering Algorithm was built, in which weights are allocated to the nodes on the basis of suitability to be a cluster head node. The method shows poor performance on quasi-static networks, where the nodes are unable to move quickly.

-In [15], a Hybrid Cluster Routing (HCR) algorithm was designed, where each node contains a specific cluster head priority for selecting a cluster head. But this algorithm causes two cluster heads come within same transmission range and thus, reduces the functionality of cluster head.

-The existing methods used only a single metric for performing clustering and thus, the clustered topology shows better performance with a particular metric. The MANET is not suitable to reflect the situation due to the consideration of a single metric, and thus, it is a complicated and dynamic system [16].

-In [17], a Weighted Clustering Algorithm (WCA) is devised using a clustering technique based on weights to get a single-hop cluster. In WCA, a node having minimum radio distance, and mobility is selected as a cluster head. This process takes longer time and bandwidth and delays the cluster formation. Also, limiting the cluster dimension decreases the scalability while dealing with huge networks.

3. System model of MANET

Figure 1 System model of MANET

The MANET system model is depicted in figure 1, which elaborates the transmission of data from one node to target node. The model computes an optimized power to preserve the connectivity of the network even if the nodes move randomly. Assume a graph $G = \{U, V\}$ in a MANET, where $U = \{u_1, u_2, \ldots, u_g, \ldots, u_f\}; 1 \leq g \leq f$ denotes normal node set, where f denotes the total number of normal nodes and $V = \{v_1, v_2, \ldots, v_e\}$ denotes the link set, where e denotes the total number of links used for connecting two nodes u_g and u_h. The multi-objective functions, like power, connectivity, link lifetime, mobility and squared distance, are considered for designing the MANET. Assume T as a source node that sends data packets to the target node Z . Here, the set of cluster head is represented as $P = \{p_1, p_2, \ldots, p_h, \ldots, p_r\}$, where r denotes the total cluster heads such that $1 \leq h \leq r$. The cluster heads are selected utilizing the node weight and the individual nodes weight is calculated with the help of node degree, which is defined as the links used for connecting the neighboring nodes. Each node requires high power to transmit data among nodes. The optimization of transmitted power for each node within the cluster is performed by constructing a Gabriel graph. The Gabriel graph is adapted for initiating communication with an optimal power level. The selection of routes is presented on the basis of handling connectivity with less power consumption. Thus, the nodes having maximum power are selected for the transmission. While transmitting data from source node to target node, the distance parameter is considered as an important paradigm. The links used for the data transmission handle the connectivity and are used for determining the link lifetime. The mobility of nodes occurs due to varying network topologies. Thus, it is important to build a model considering power, connectivity, link lifetime, mobility, and squared distance.

4. Proposed C-EWA algorithm using multi-objective parameters for secure routing

This section describes the technique of topology management using the proposed C-EWA with multi-objective functions for power optimization. Figure 2 illustrates the block diagram of the proposed topology management system. Initially, the nodes in the network are organized as a graph and the clustering is performed using the proposed C-EWA. Here, the proposed method is designed considering power and energy parameters for yielding effective clustering. Then, the cluster head of each cluster is selected using the newly designed fitness function that is computed based on remaining battery power, mobility, connectivity, link lifetime and squared distance with respect to the neighboring nodes. The parameters like power, connectivity, and link lifetime should be greater, and squared distance and mobility must be minimized for determining the optimal cluster head. For maintaining the connectivity. Gabriel graph is constructed within each cluster. The proposed method computes an optimized power level for attaining secured network connectivity while nodes move in a random manner. The proposed C-EWA based power optimization technique is organized under three phases, which includes initialization, clustering and Gabriel graph construction phases, as described in the below subsection.

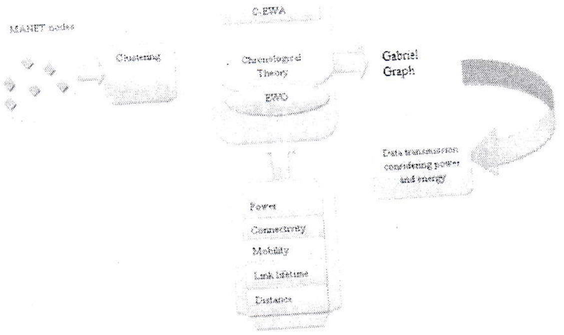

Figure 2 Block diagram of the proposed C-EWA based power optimization technique using topology management

4.1 Initialization

The primary step in the proposed technique is the initialization of the graph, where each node p_h , $1 \leq h \leq r$ is initiated with the value for several parameters that include remaining battery power, connectivity, mobility, squared distance, and link lifetime for selecting the optimal cluster heads at time d. Here, the remaining battery power, connectivity and link lifetime are fixed maximum initially, whereas mobility and squared distance are kept minimum.

4.2 Solution encoding

The solution encoding determines the optimal cluster heads and is explained in figure 3. The representation of solution encoding must take less time for computation, selecting the optimal cluster head. Assume a MANET with total r number of cluster head nodes, among which the proposed C-EWA along with the newly designed fitness function determines m optimal clusters. Hence, the solution can be represented as a vector of dimension m as,

$O=\{p_1, p_2, \ldots, p_n, \ldots, p_m\}; 1 < n \le m$. Here, the optimal cluster head is selected considering large power, increased connectivity, and maximum link lifetime and minimum mobility and less distance.

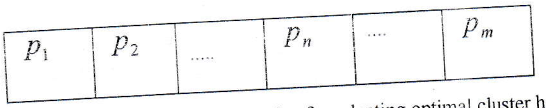

Figure 3. Solution encoding for selecting optimal cluster head

4.3 Formulation of the fitness function

The fitness function is computed for determining the optimal solution from a solution set. The fitness computed for proposed C-EWA uses five factors that involve power, connectivity, link lifetime, squared distance, and mobility. Here, the fitness is considered as a maximization function, and thus, the solution yielding the maximum value of fitness is used for clustering to select the optimal cluster head. The fitness of the proposed C-EWA is given as,

$$S=\sum_{h}^{r}\frac{1}{5}\left[\frac{M_h}{Y_F}+K_h+N_h+\left[1-\frac{B_h}{Y_F}\right]+\left[1-\frac{R_h}{Y_F}\right]\right] \quad (1)$$

where, r represents a total number of cluster heads, M_h indicates power at h^{th} node, Y_F expresses the normalization factor, K_h represents connectivity, N_h represents link lifetime, B_h denotes mobility, and R_h represents the squared distance.

4.3.1 Power

The power [9] is considered as an important parameter for selecting the optimal cluster head. Due to large transmission, the power of nodes is drained out, which degrades the behavior of the node and finally, becomes a dead node. Hence, the node having high power is taken for the clustering. Thus, the minimum power level for transmitting packets from the node h for attaining minimum received power is formulated as,

$$M_h=\left[\sum_{g=1}^{f} M_{\max}\cdot\frac{M_{\min}}{M_g}\right] \quad (2)$$

where, g denotes g^{th} normal node, f represents total normal nodes, $M_{\max}$ indicates maximum power, $M_{\min}$ expresses the minimum received power, and M_g represents the received power at g^{th} normal node.

4.3.2 Connectivity

The connectivity [9] is computed based on the bi-directional links used for linking two nodes and the connectivity is formulated as,

$$K_h=\frac{1}{f}\left[\sum_{g=1}^{f}\frac{K_g}{e}\cdot\right] \quad (3)$$

where, K_g denotes connectivity of g^{th} node, and e represents total connections.

4.3.3 Link Lifetime

The link lifetime [26] is used for connecting two nodes for transmitting the information. The links are used for transmitting the messages in the network. The breakage of links is the major problem that occurs in MANET due to dynamic topologies. Thus, the link lifetime is evaluated in advance to avoid the network failure. The link lifetime is computed using the energy model and is represented as,

$$N_h=\frac{1}{f}\left[\sum_{g=1}^{f}D_g\cdot\right] \quad (4)$$

where, D_g denotes energy dissipation of g^{th} node. When the normal node sends q bytes of data, then the energy dissipation of the normal node is given by,

$$D(u_g)=D_C*q+D_b*q*\|u_g-p_h\|; if \|u_g-p_h\|\ge n_o \quad (5)$$

$$D(u_g)=D_C*q+D_a*q*\|u_g-p_h\|^2; if \|u_g-p_h\|< n_o \quad (6)$$

$$m_{n_o}=\sqrt{\frac{D_a}{D_b}} \quad (7)$$

where, D_C denotes electronic energy, and it is formulated as,

$$D_C=D_W+D_X \quad (8)$$

where, D_W represents transmitter energy and D_X indicates data aggregation energy, D_a is the free space energy, D_b denotes energy parameter related to the power amplifier in the transmitter, and $\|u_g-p_h\|$ denotes the distance between the normal node and the cluster head.

The energy dissipated by the receiver is formulated as,

$$D(p_h)=D_C+q \quad (9)$$

The updated energy after data transmission for the normal node is given by,

$$D_{l+1}(u_g)=D_l(u_g)-D(u_g) \quad (10)$$

where, $D_l(u_g)$ represents energy of current time of normal node and $D(u_g)$ represents the dissipated energy of the normal node.

Similarly, the updated energy after data transmission for cluster head is given by,

$$D_{l+1}(p_h)=D_l(p_h)-D(p_h) \quad (11)$$

where, $D_l(p_h)$ represents energy of current time of cluster head node and $D(p_h)$ represents the dissipated energy of the cluster head node.

4.3.4 Mobility

The mobility [9] of nodes in MANET is discovered individually according to their responsibilities. The node selection process is affected while the movement of the node is fast, whereas it is improved if the movement of the node is slow as it becomes simple for managing nearby nodes. The mobility factor is represented as,

$$B_h=\frac{1}{|p_h|}\sum_{g=P_h}B_g \quad (12)$$

where, $|p_h|$ represents a set of neighbors at node h, B_g indicates relative mobility, and it is given by,

$$B_g^I=\frac{1}{z}\sum_{i=1}^{z}T_g(i) \quad (13)$$

where, z represents the number of times the node received hello packets at time interval I, T_g expresses relative mobility. Here, the relative mobility of a node is described using two factors, mobility speed and movement direction. Consider $t_g(i)$ and $\theta_g(i)$ represent the mobility speed, and movement direction at an instant i is given by,

$$T_g(i)=\sqrt{t_g^2(i)+t_h^2(i)+[2t_g(i)t_h(i)Cos(\theta_g(i)-\theta_h(i)]} \quad (14)$$

where, $t_g(i)$ and $\theta_g(i)$ represent mobility characteristics of the node g.

4.3.5 Distance

The distance is measured using the links, which are used for connecting two nodes, by calculating the distance between g^{th} node and h^{th} cluster head and it is given by,

$$R_h=\sum_{\substack{g=1\\ g\in h}}^{f}(u_g, p_h) \quad (15)$$

4.4 Algorithm of proposed C-EWA for Clustering

The proposed C-EWA is developed by integrating the chronological idea into EWA for the clustering. The proposed C-EWA considers power, connectivity, mobility, link lifetime, distance as the parameters for selecting the optimal cluster head for offering security in transmission. EWA technique can determine the better function values on different benchmark problems and solves the real-world problem effectively. EWA [22] is a meta-heuristic algorithm inspired from the reproduction behavior of earthworms in generating the offspring. EWA is well known for providing a trade-off between exploration and exploitation in metaheuristic algorithms. EWA can execute a global search and local search and is more appropriate for parallel computation and provides a balance between diversification and intensification. The local optima problem is solved by adapting the Cauchy method and to improve the searchability. The Chronological concept is used for updating the solution based on the past events that had occurred. The chronological concept is used for analysis purpose for defining, listing and describing the events occurred with respect to the time. Hence, the incorporation of Chronological concept into EWA is made for finding the cluster head effectively.

The steps involved in C-EWA are elaborated in the given steps,

I) Initialization

Initially, the proposed C-EWA initializes the solution space for determining the optimal solution. The solution space in proposed C-EWA is expressed as,

$$A = \{A_1, A_2, \ldots, A_o\} \tag{16}$$

where, A_o indicates o^{th} population of C-EWA.

II) Calculation of fitness

The fitness is computed for each solution depending on multi-objective fitness parameters, such as power, connectivity, link lifetime, squared distance, and mobility. The fitness of the solution is evaluated based on equation (1).

III) Update positions using the Chronological concept in EWA

Here, the EWA is used to solve the meta-heuristic problems for improving the equations using a solution update of EWA. Thus, the update solution of EWA is formulated using the equation given below,

$$A_{x,y}(i+1) = A_{x,y}(i) + Q_y * L \tag{17}$$

where, $A_{x,y}(i)$ represents current solution, Q_y denotes a weight vector and L indicates a random number generated from Cauchy distribution.

The chronological concept is used to provide the brief description of the algorithm for generating effective solutions. The past events are used for evaluation, and hence, the chronological concept is used in the EWA and the equation obtained is given as,

$$A_{x,y}(i) = A_{x,y}(i-1) + Q_y * L \tag{18}$$

where, $A_{x,y}(i-1)$ represents previous solution.

Substitute equation (18) in equation (17),

$$A_{x,y}(i+1) = A_{x,y}(i-1) + Q_y * L + Q_y * L \tag{19}$$

$$A_{x,y}(i+1) = A_{x,y}(i-1) + 2(Q_y * L) \tag{20}$$

The solution for $(i+1)^{th}$ iteration is given based on the chronological concept as,

$$A_{x,y}(i+1) = \frac{A_{x,y}(i+1) + A_{x,y}(i+1)}{2} \tag*{21)}$$

Thus, the update solution of proposed C-EWA after substituting equation (17) in equation (21) is given by,

$$A_{x,y}(i+1) = \frac{A_{x,y}(i) + Q_y * L + A_{x,y}(i-1) + 2(Q_y * L)}{2} \tag{22}$$

The final update solution is used to update the position of the earthworm, based on which the suitable cluster heads are determined in the network.

$$A_{x,y}(i+1) = \frac{A_{x,y}(i) + A_{x,y}(i-1) + 3(Q_y * L)}{2} \tag{23}$$

where, $$Q_y = \frac{\sum_{x=1}^{o} A_{x,y}}{o} \tag{24}$$

Here, o indicates population size, L represents a random number from a Cauchy distribution with $z = 1$.

IV) Termination

The process is continued until the optimal cluster heads are detected for effective topology management. The algorithm is terminated after reaching the maximum iteration $i_{\max}$ or when no fittest solution is obtained.

The pseudo code of the proposed C-EWA for selecting optimal cluster heads is given below in Table 1.

Table 1 Pseudocode for proposed C-EWA

```
Proposed C-EWA
Input: Solution set $A$
Output: Best Solution
Begin
    Initialize the solution
    while $(i < i_{\max})$
        for each solution
            Update $Q, L$
            Calculate the fitness using equation (1)
            Update the position using equation (23)
            Generate a new set of solutions
            Compute the fitness for all the solutions in the new population
            Choose the solution having maximum fitness as the best solution
            $i = i + 1$
    end while
Return the best solution
Terminate
```

4.5 Gabriel Graph

Gabriel graph [23] is considered as a vertices' set in the plane, in which the edge between two nodes exists if other nodes do not coincide the edges between the two nodes. Each node constructs the Gabriel graph in the cluster for mitigating the transmission power. The Gabriel graph guarantees network connectivity with less transmission of the packetand and thus, the cost of energy is reduced.

The node in each cluster forms a Gabriel graph for mitigating the transmission power to assure the network connectivity with less control packet transmission and thus, the energy is minimized. Here, the links are selected to form a reduced graph. Thus, the graph is formed by considering shorter link in place of larger links for reducing the transmission power of nodes. This process removes multiple links, which result in a disconnected graph and this connectivity is attained by Gabriel graph for each cluster. The graph is considered as t spanner, if t denotes the spanning ratio and it is formulated as,

$$t = \max_{u_g, u_h} \frac{C_{u_g, u_h}}{R_{u_g, u_h}} \tag{25}$$

where, C_{u_g, u_h} indicates the length of the shortest path between two nodes u_g and u_h.and R_{u_g, u_h} indicates Euclidean's distance.

The Gabriel graph is a planar graph, which is computed for each cluster to reduce the transmission power and thus, the energy spanning graph is constructed. Thus, the power computation for each graph is computed and is formulated as follows.

a) Power computation for each path

The power needed to send packets from source to destination depends on the distance between them and the path loss models. For transmitting the packet from source node T to destination node Z at certain distance R, the power is given by,

$$M_{T,Z} = R_{T,Z} . \omega_{T,Z} \tag{26}$$

where, ω denotes channel loss component.

5. Results and Discussion

The results obtained by the proposed C-EWA based topology management are described in this section. The proposed C-EWA is analysed based on the performance using five measures, which include connectivity, power, mobility, throughput and delay.

5.1 Experimental setup

The simulation of the proposed model requires the NS2 simulator and the PC with certain system configurations. The entire simulation of the proposed C-EWA is done in a PC with the 4GB RAM, Windows 10 OS, and the Intel I3 processor. The simulation parameters and their corresponding values are provided in Table 2.

Table 2. Simulation Parameter

Parameters	Value
Simulator	NS2
Simulation Area	1000 × 1000 sq.m
No.of nodes	50, 100
Simulation time	500 sec
Transmission range	100 m
Antenna Type	Omni-directional Antenna
Data Rate	10 Mbps
Battery Model	Linear Model
Velocity	[0-30] m/s

5.2 Evaluation metrics

The evaluation metrics considered for analyzing the performance of existing and proposed methods are described in this section.

a) Throughput

The maximum rate in which a total data packet received per unit time in a communication channel is called throughput.

b) Connectivity

The link between two nodes to send data packets from one node to another is called connectivity.

c) Power

The power is defined as the data transmitted in MANET when the nodes use a limited power.

d) Delay

The delay is computedon the basis ofnumber of nodes. If the number of nodes increases, then the delay is high. Hence, the delay parameter should be less. The delay is computed from the time taken by application request or information to give a response.

e) Mobility

The mobility is computed based on the ability of nodes to move freely in MANET.

5.4 Comparative techniques

The comparative techniques utilized for analyzing the performance of proposed C-EWA are Optimized Power Control (OPC) [9], Local Tree based Reliable Topology (LTRT) [24], and distributed power management (DISPOW) [25].

5.5 Comparative analysis of the proposed C-EWA

The analysis of the proposed C-EWA with existing OPC, LTRT, and DISPOW is carried out using 50 and 100 nodes with different number of rounds. The fitness function is used for evaluating the best Cluster Head for secure routing. The performance analysis is carried out using five metrics, such as connectivity, power, mobility, throughput, and delay by varying the rounds.

5.5. a) Analysis using 50 nodes

The analysis in terms of power, connectivity, throughput, delay and mobility for 50 nodes is illustrated in figure 3. Figure 3.a depicts the analysis based on power by varying rounds from 0 to 50.

For the number of rounds 50, the power attained by existing OPC, LTRT, and DISPOW and proposed C-EWA is 19.137J, 19.998J, 20.049J, and 21.006J. Similarly, for the number of rounds 40, the values of power computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are25.346J, 26.611J, 27.631J, and 27.864J, respectively. When the number of rounds is 120, the comparative methods have the power value of zero.

The analysis in terms of delay using 50 nodes is depicted in figure 3.b. For the number of rounds 30, the delay values computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.158, 0.145, 0.137, and 0.131 respectively.

The analysis in terms of the connectivity parameter is shown in figure 3c. At 10th round, the connectivity values measured by existing OPC, LTRT, and DISPOW and proposed C-EWA are 7.710, 8.099, 7.695, and 8.477 respectively. Similarly, for the number of rounds 50, the connectivity values computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are 3.139, 3.770, 3.314, and 4.447.

The analysis in terms of the mobility parameter is shown in figure 3d. For 10 rounds, the mobility measured by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.243, 0.216, 0.198, and 0.172, respectively. Similarly, for the number of rounds 50, the mobility values computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.784, 0.767, 0.750, and 0.729 respectively.

The analysis in terms of the throughput parameter is shown in figure 3e. For the number of rounds 40, the throughput values computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.673, 0.692, 0.692, and 0.713. Hence, the proposed C-EWA provides superior performance as compared to the existing methods in terms of power, throughput, delay, connectivity and mobility for varying number of rounds.

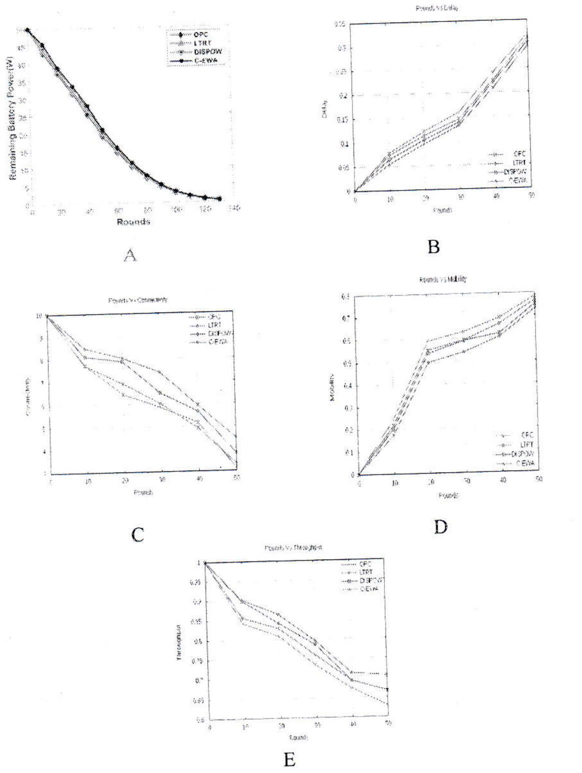

Figure 4 Analysis using 50 nodes in terms of a) Power b) Delay c) Connectivity d) Mobility e) Throughput

5.5 b) Analysis using 100 nodes

Figure 4 presents the analysis in terms of power, connectivity, throughput, delay and mobility for 100 nodes. The analysis in terms of power for a varying number of rounds ranging from 0 to 50 is depicted in figure 4a. For the number of rounds 40, the power values measured by existing OPC, LTRT, and DISPOW and proposed C-EWA is25.943J, 27.390J, 27.398J, 28.677J. The comparative methods have the power value of zero, when the number of rounds is110. The analysis in terms of delay using 100 nodes is depicted in figure 4.b. For the number of rounds 10, the delay values computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.089, 0.0809, 0.074, and 0.065 respectively. Similarly, at 50th round, the delay values measured by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.328, 0.321, 0.315, and 0.305 respectively. The analysis in terms of the connectivity parameter is shown in figure 4c. For the number of rounds 30, the connectivity values computed by existing

OPC, LTRT, and DISPOW and proposed C-EWA are 6.442, 7.399, 7.315, and 7.925. Similarly, at 40th round, the connectivity values measured by existing OPC, LTRT, and DISPOW and proposed C-EWA are 5.397, 6.086, 6.660, and 6.442 respectively. The analysis in terms of the mobility parameter is shown in figure 4d. For the number of rounds 40, the mobility values computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.730, 0.714, 0.662, and 0.636, respectively. The analysis in terms of the throughput parameter is shown in figure 4e. At 30th round, the connectivity values measured by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.740, 0.772, 0.799, and 0.806 respectively. Similarly, for the number of rounds 50, the throughput values computed by existing OPC, LTRT, and DISPOW and proposed C-EWA are 0.653, 0.659, 0.699, and 0.713.

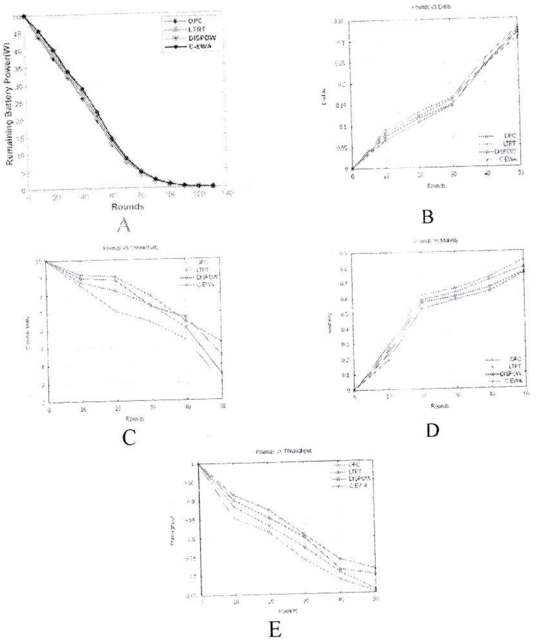

Figure 5 Analysis using 100 nodes in terms of a) Power b) Delay c) Connectivity d) Mobility e) Throughput

5.6 Discussion

The comparative analysis of various techniques in terms of power, mobility, throughput, delay, and connectivity is explained in this section. The maximum performance of the existing techniques, such as OPC, LTRT, and DISPOW and proposed C-EWA is depicted in table 3 by comparing the performance attained for 50 and 100 nodes. The table illustrates that the proposed C-EWA shows superior results than the existing techniques. The proposed C-EWA technique attains a value 21.960J, 0.729, 0.713, 0.295, and 5.256 for power, mobility, throughput, delay, and connectivity. Hence, the proposed C-EWA method has maximum power, connectivity, and throughput, and minimum mobility, delay and can be utilized for data transmission to transmit data from one to another node.

Table 3 Comparative analysis for varying number of nodes

Metrics	**OPC**	**DISPOW**	**WTRT**	**Proposed C-EWA**
Power (J)	19.602	20.357	20.739	**21.960**
Connectivity	3.319	3.452	4.529	**5.256**
Mobility	0.784	0.767	0.750	**0.729**
Delay	0.320	0.313	0.304	**0.295**
Throughput	0.653	0.665	0.699	**0.713**

6. Conclusion

This paper illustrates a technique for power minimized transmission using topology management by proposing an algorithm, named C-EWA. Here, the clustering of graphs is performed and the optimal cluster heads are selected using the proposed C-EWA algorithm for data transmission. Once the optimal cluster heads are selected, then the Gabriel graph is constructed for minimizing the transmission power of the nodes and thereby, maintaining the power and energy in the MANET. The fitness function is computed for finding the optimal cluster heads on the basis of connectivity, mobility, link lifetime, power, and distance. The nodes providing maximum value for connectivity, power, link lifetime and minimum value for mobility and distance, are selected as the cluster heads. Thus, the proposed C-EWA is adapted for transmitting the data effectively from the cluster heads to the destination. The experimentation with the proposed C-EWA is carried out with 50 and 100 nodes. The proposed C-EWA technique attains a value 21.960J, 0.729, 0.713, 0.295, and 5.256 for remaining battery power, mobility, throughput, delay, and connectivity. In future, quality metrices will be utilized for maintaining the connectivity.

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