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EABRT-TOPSIS: An Enhanced AODV Routing Protocol with TOPSIS-based Backup Routing Table for Energy-Efficient Communication in CA-MANET

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Abstract: The Cloud-Assisted Mobile Ad hoc Network encounters various challenges because of the unpredictable movement of nodes, leading to frequent link failures. This instability leads to degraded network performance due to high energy consumption during route discovery when communication loss occurs between the Indirect and the Super Peer, disrupting the Super Peer's ability to serve the request of Indirect Peer. To reduce the high energy consumption, we propose EABRT-TOPSIS, an enhanced AODV routing protocol that integrates TOPSIS, a multi-criteria decision-making method to maintain a backup routing table with alternate optimal routes for the Indirect Peer. This algorithm considers hop count, residual energy, and bandwidth as decision criteria for evaluating and ranking the alternate routes. Our proposed work optimizes the energy usage, by selecting an optimal route with highest rank among all the available alternate optimal routes in the backup routing table to connect Indirect Peer and the Main Peer during link failure. This improves the network performance and reduces the energy consumption caused by communication loss. We evaluate our proposed algorithm using the NS-2.35 simulator. Our results demonstrate significant improvements in key performance metrics like throughput, end-to-end delay, overhead, and energy usage compared to the traditional AODV and AOMDV routing protocol which highlights the proposed approach that mitigates the impact of link failures and energy depletion, resulting in an energy-efficient communication.

Keywords: *AODV, AOMDV, Available bandwidth, Cloud-Assisted MANET, Hop Count, Residual Energy, TOPSIS*

1. Introduction

Mobile Ad hoc networks (MANETs) refer to a category of distributed wireless network in which devices communicate without any centralized infrastructure [1]. The topology is dynamic and each individual node within the network functions as a transceiver. In order to enhance the MANET's functionality, the Cloud network is integrated with MANET resulting in an architecture called Cloud-Assisted Mobile Ad-hoc Network (CA-MANET) [2]. In this architecture, the cloud server acts as a central point of control where the mobile nodes are considered as Peers that can communicate with the SP-Super Peer, via the MP-Main Peer within the MANET thereby enabling the Peers to access the cloud resources.

1.1. Advantages of CA-MANET

The integration of a cloud server with a MANET can offer several advantages, which are outlined as follows:

• The scalability and reliability of the system were enhanced through the utilization of cloud server resources.

• Enhanced security is achieved by implementing centralized security mechanisms.

• Enhanced mobile device storage, together with remote network management and monitoring.

CA-MANET architectures are particularly useful in scenarios where a large number of mobile devices need to be connected and managed, such as in IoT networks, emergency response, and military operations. Fig. 1 depicts the CA-MANET scenario, in which the Cloud network and MANET forms an Overlay [3]. When the cloud server is linked directly to the Internet, it functions as a data centre (DC), while the DCs within the overlay function as SP's. In a MANET, MP's are those that link directly to the SP, while IP-Indirect Peer connects to the SP via a MP.

1.2. Challenges in CA-MANET

The Unpredictable node movement in a Cloud-Assisted MANET can cause frequent link failures, which can have an effect on both network connectivity and cloud resource utilization [4]. This is particularly problematic in situations where communication fails between the SP and the service requested IP. Some consequences of a link failure in a CA-MANET are as follows:

1. Route Challenges: When the SP is unable to fulfil the service request, then the network's performance will decline.

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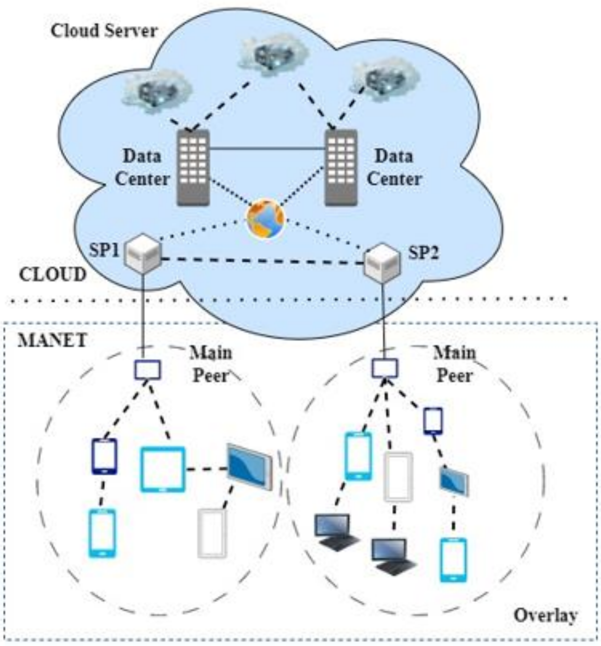

Fig. 1. Cloud-Assisted MANET's Overlay Architecture

2. Energy Consumption: The battery life of mobile devices is negatively impacted since more power is used trying to make new connections or re-route data packets.

3. Resource Management: The MP may be unable to efficiently manage the mobile device resources, leading to inadequate network performance and higher energy usage.

4. Reliability: The reliability of the network decreases as data packets are lost and connections are dropped. For applications like emergency response and military operations, which rely heavily on a stable network connection, this can have serious consequences.

These challenges highlight the importance of developing an energy efficient routing protocol in MANET, that facilitates optimal route selection by managing the residual energy resources in case of a communication loss between SP and IP [5]. The existing standard

routing protocols for performing routing operations in MANET are AODV [6] and AOMDV [7]. Despite being the most popular protocol in MANET, AODV uses the shortest path while selecting the route between the nodes for communication. However, due to the dynamic topology of a MANET, the shortest paths are not always the best, and links can be intermittent [8]. Additionally, AOMDV is more complex than AODV because it involves the maintenance of multiple routes between nodes and requires more time to set up multiple routes. This results in an increase in overhead, delay, network latency, and computational requirements of the protocol [9]. Furthermore, conventional routing protocols are unable to identify a failing link in the midst of an active data transmission, and existing energy-efficient routing protocols tend to prioritize alternate routes over the optimal routes for communication between the nodes. This leads to incorrect route selection, which in turn leads to frequent connection failures, that drains the network energy resources and reduces the network's lifetime.

In order to address these limitations and challenges, it is imperative to improve the AODV protocol considering the energy-related constraints [10],[11] and maintaining a backup routing table [12] with alternate routes, so that the route selected can be reliable and optimal to ensure successful data delivery. To address this challenge, we propose EABRT-TOPSIS, an enhanced AODV routing protocol based on TOPSIS technique [13] for the Cloud-Assisted MANET network which helps in maintaining a backup routing table by evaluating and ranking the possible alternative routes for the IP by considering a set of decision-criteria like Hop count, Residual energy, and Available bandwidth. This helps the IP to select an optimal route among the available alternate routes when a communication loss occurs with the SP [4].

Following this outline is the rest of the paper: In Section 2, the Literature Survey on the existing routing protocols are reviewed. Section 3 presents the Problem description followed by Proposed mechanism for the considered scenario in Section 4. Simulation results are demonstrated in Section 5 with performance evaluation Section 6. Section 7 presents the Conclusion and Future work.

2. Literature Survey

CA-MANETs have recently garnered a lot of research attention due to their adaptability in integrating MANETs with cloud computing infrastructure [14]. The dynamic topology of MANETs, however, causes link failure, disrupting communications between nodes. In the event of a link failure, this has a profound effect on the amount of energy required for route discovery [5]. Therefore, to ensure the complete performance of the network, it is important to consider the energy depletion factor in case of link failure [11]. The existing research works that focus on the link failure, energy consumption and backup routing table maintenance for route selection based on multi-Criteria Decision-making techniques in the event of link failure in the Cloud-Assisted MANET are discussed here.

B. H. Khudayer et al. [15] proposed a LFPM (Link Failure Prediction Mechanism) in MANETs. This protocol uses the Received Signal Strength (RSS) to compute the link stability metric that predicts the link failure between the nodes. D. S. Jayalakshmi et al. [16] proposed an EER (Energy Efficient Routing) protocol that aims in detecting the best route by considering the channel and connection strength, energy level of the path to reduce the route failure.

P. Jayalakshmi et al. [17] presented an ACO (Ant Colony Optimization) based enhanced energy-efficient intelligent routing protocol to addresses the problem of link failure. Considering the pheromone deposition quantity, the RSS's power level and nodes distance are estimated to select the best intermediate hops. C. N. Kumar et al. [18] proposed energy efficient disjoint multipath routing protocol for routing optimization. The link failures situations are addressed by ensuring successful transmission of data to the intended destination using simulated annealing technique.

A. Ishizaka et al. [19] presented Multi-Criteria Decision Making (MCDM) techniques, such as TOPSIS in maintaining a backup routing table, to select new routes quickly and efficiently when a communication loss occurs, thereby preventing the network's energy depletion. B.S. Kim et al. [20] summarized recent research on applying the Multi Attribute Decision Making (MADM) algorithm in wireless ad hoc networks to construct stable pathways between source and destination. G. Singla et al. [21] suggested the TOPSIS algorithm in which the route selection based on hop count, battery life, mobility and latency are all discussed by. This method uses AHP to establish attribute weights and TOPSIS to find the optimum solution.

B. Zhou et al. [22] proposed a mCloud for heterogenous MCC that focus on improving the performance and availability of Mobile Cloud Computing services using the TOPSIS in which the energy cost, congestion level, link quality link speed is considered as criteria in making the offloading decision of MCC services. E. Amiri et al. [23] proposed AODV routing using TOPSIS algorithm by incorporating nodes relative speed, strength of received signal, average delay and congestion as factors within the RREQ packet and Hello messages, such that each node has the information of its neighbor's links.

V. T. Lokare et al. [24] suggested a Fuzzy TOPSIS based approach for optimal route selection among multiple available routes depending on the reliability, jitter, Bandwidth and delay between the source and destination nodes. N. Iqbal et al. [25] presented a HNERP method that makes routing decisions by considering hop-count and node energy. Though it follows multi-metric criteria for route selection, this algorithm mainly concentrates on eliminating energy depletion node than concentrating on link quality. V. Tilwari et al. [26] suggested MCLMR approach that uses TOPSIS technique with decision factors like node movement, contention window size, and the quality of link where Expected Number of Transmissions are considered to reduce the impact of control message flood.

Applying the Fitness Function technique to the AOMDV routing protocol, A. Taha et al. [27] proposed an FF-AOMDV algorithm for optimizing energy consumption in MANET which was evaluated considering the performance metrics including energy consumption, throughput, and packet delivery ratio. S. Tabatabaeibe et al. [28] proposed a new routing protocol that uses the TOPSIS multi-criteria algorithm to select relay groups and the Cuckoo Optimization Algorithm to find the shortest route between relay groups by considering variables like remaining energy, bandwidth, node speed, and hop count.

Although the above-mentioned existing research works concentrate on energy depletion challenge and employing the MADM techniques, to utilize a backup routing table in the event of a link failure, there remains a gap in addressing the scenario in which link failure occurs between the SP and IP of CA-MANET, when the service requested IP moves out of range resulting in communication loss. This motivates our work to propose EABRT-TOPSIS routing protocol for maintaining the backup routing table to identify the most energy efficient alternative routes by considering the hop-count, node energy availability, and path available bandwidth as decision-factors.

3. Problem Description

The proposed algorithm is inspired by the NMABHM - Node Monitoring Agent Based Handover Mechanism problem scenario [4]. When the IP leaves the communication range of MP during ongoing communication, the connection between the two will be severed and the SP and IP will be unable to exchange data as shown in Fig. 2. However, completing the task of providing the requested

service to the Peer is essential.

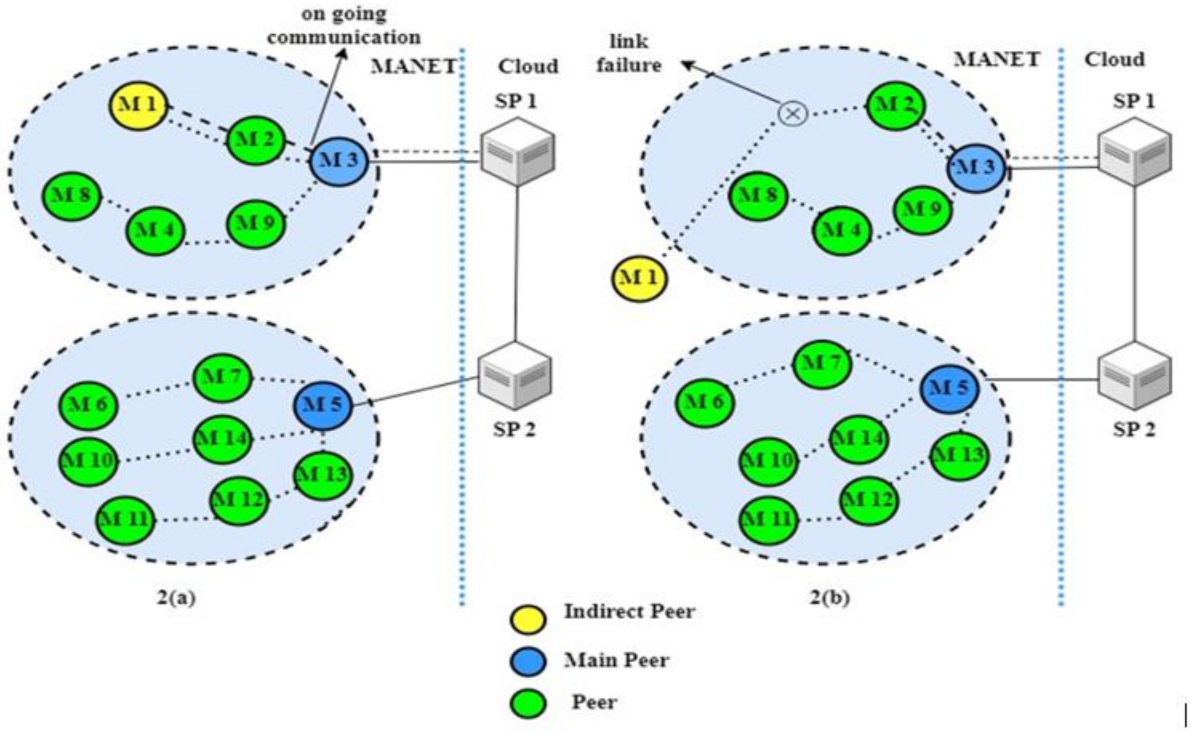

Fig. 2. Scenario of disrupted communication in the network: 2(a) On-going Communication and 2(b) link failure

3.1. Problem Scenario

Fig. 2 (a) indicates a CA-MANET with 14 nodes in the MANET i.e., M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13 and M14. M3 and M5 acts as MP, whereas M1 is IP. These mobile nodes are clustered into two distinct zones using a modified K-means method to ensure secure and efficient data transfer between them [12]. The nodes M1, M2, M3, M4, M8 and M9 are within a communication range of M3 with M1-M2-M3, M8-M4-M9-M3 as paths. Similarly, the nodes M5, M6, M7, M10, M11, M12, M13, and M14 are within a communication range of M5 that have M6-M7-M5, M10-M14-M5, M11-M12-M13-M5 as paths. M3 is directly connected to SP1 (Super Peer) and M5 is directly connected to SP2 (Super Peer). A two-way communication is possible between any two neighbouring mobile nodes within range of each other. If not, the message will be sent through a series of relays before reaching its final destination.

Let us consider a scenario in which IP M1 sends a service request to SP1 via MP M3. SP1 can respond to M1's request for a service if SP1 has already cached that service. Imagine SP1 has the requested service in its cache and initiates a communication with M1 via M3. Due to MANET's dynamic topology, when M1 moves out of the communication range of M3, the link between M1 and M3 fails and communication loss occurs between M1 and SP1 as shown in Fig. 2(b). To facilitate the service requested by the IP, an optimal route needs to be selected between the IP and the nearest MP. To address this issue, we utilize the benefits of TOPSIS technique in AODV routing protocol to maintain a backup routing table for energy-efficient communication in CA-MANET.

3.2. Approach

The following network scenario is considered to provide appropriate route selection between the IP (source) and the MP (destination) in case of link failure:

1. The link failure situation is considered at the MANET side in the CA-MANET and the mobile nodes act as Peer.

2. The network considered is a cluster-based Hybrid-MANET with Cluster Head (CH) functions as MP.

3. The SPs in the overlay share information related to service during the communication [29].

4. MP in each group is aware of the IP node movement from a Node Monitoring Agent [4].

4. Proposed Mechanism

When communication loss occurs between SP and IP due to link breakage with the MP, the proposed method as shown in Fig. 3 will be employed in the network layer by modifying the AODV routing protocol based on TOPSIS technique for maintaining a backup routing table.

4.1. Proposed Scheme Design

The proposed model of EABRT-TOPSIS technique involves two stages. Stage 1 is the normal network condition i.e., during the ongoing communication between SP and the service requested IP, there is no link failure and the communication is successful. Stage 2 involves two processes namely Route discovery, Route establishment and Maintenance that gets initiated in case of a link failure between the SP and IP.

1. In Route Discovery phase RREQ packets are broadcasted to the neighbouring nodes in order to establish route with the nearest MP.

2. Within the Route establishment and Maintenance phase the route is established based on the optimal route selected, and in case of link failure, the Route Maintenance process selects the next best alternate optimal route from the backup routing table.

These two phases contribute in selecting optimal route by maintaining a backup routing table in which only those paths are considered with nodes that ensures efficient energy levels, minimum hop count and effective bandwidth utilization thereby avoiding the process of re-route discovery during link failure.

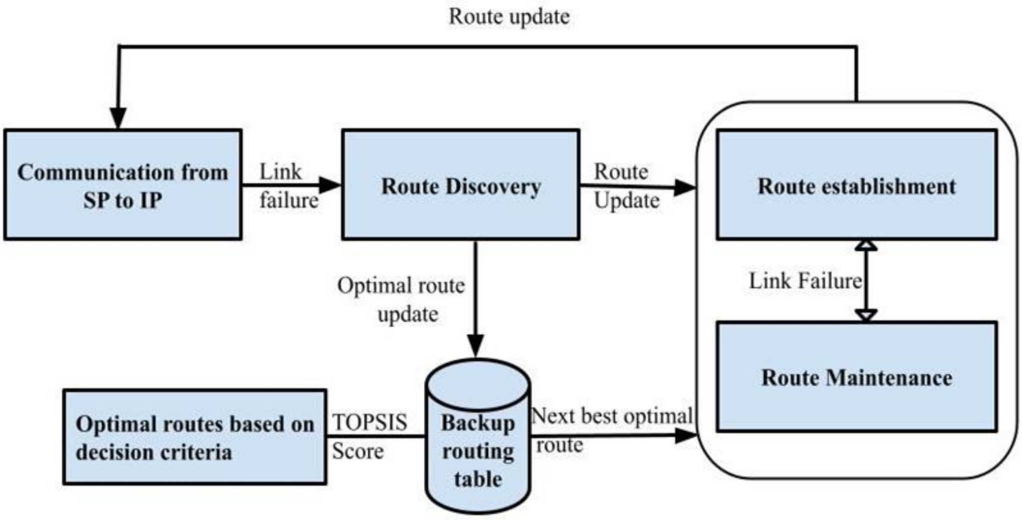

Fig. 3. Proposed Model of EABRT-TOPSIS technique

4.1.1. Route Discovery

As shown in Fig. 4(a), IP broadcasts control packets such RREQ in order to determine the best path to the nearest MP by considering hop count, residual energy, and available bandwidth.

The Route Discovery follows the steps listed below:

1. The IP (M1) sends a Route Request (RREQ) packet to its neighbouring nodes, including the MP (M5) within the communication range.

2. The RREQ packet is then forwarded by the neighbouring nodes, and the process continues until it reaches the MP (M5).

4.1.2. Route Establishment and Maintenance

The following steps are involved in this phase:

- The RREQ packet is processed by the Main Peer (M5), which then utilizes the backup routing table to determine the most efficient path for the IP to take in order to reach the MP. Hop count, Residual energy, and available bandwidth are the factors that the TOPSIS algorithm takes into account while deciding on the optimal path.
- The MP (M5) sends a RREP to the IP, providing the details of the selected route.
- The IP (M1) establishes the route by sending RREP packets through the selected route.
- The network continuously monitors the established route to detect any further link failures or changes in the network topology.
- If the connection between the IP and chosen route fails, then the IP will use the CA-MANET's backup routing table where precomputed optimal routes to the destination node are stored in the backup routing table.

The available route information with associated metrics is maintained in the routing table and it is updated whenever a new route is discovered or an existing route is changed.

4.2. Maintaining a Backup Routing Table using TOPSIS

To implement a backup routing table in the proposed CA-MANET scenario, the AODV routing protocol is modified to include the TOPSIS technique [30] a multi-criteria decision-making approach used to evaluate and rank alternatives based on their similarity to the "ideal" solution. This will likely involve adding new function variables to the AODV to represent the various criteria and alternatives being considered. For every node, a backup routing table that stores the information regarding the available optimal routes to each destination along with their respective attributes such as hop count, residual energy and available bandwidth is maintained. When a link failure occurs, as mentioned in the Route

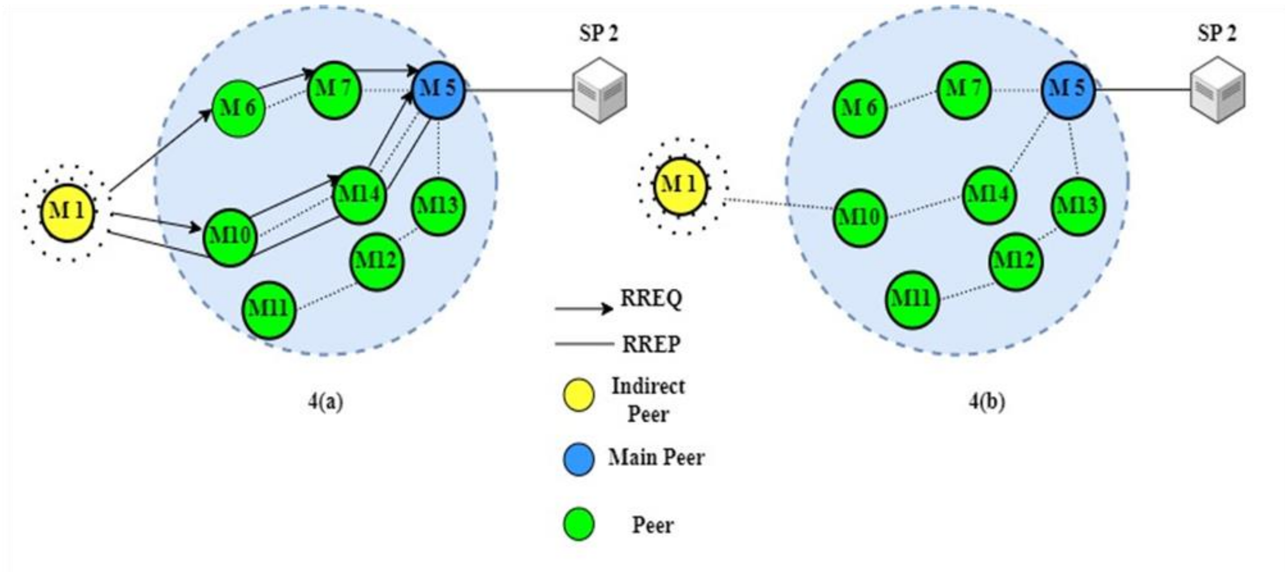

Fig. 4. Phases in the Proposed Scheme 4(a) Routing discovery 4(b) Route establishment and Maintenance

discovery, Route establishment and Maintenance phases, a backup routing table is formed by following TOPSIS technique based on the decision criteria like hop count, Residual energy and available bandwidth.

The formula to calculate the decision criteria is:

1. Hop Count (HC): The number of intermediate devices amidst the source and destination nodes is termed as hop count [31].

$$HC = Number\ of\ intermediate\ nodes + 1 \quad (1)$$

2. Residual Energy (RE): This refers to the remaining energy that is available to a node after accounting for energy consumption.

$$RE = Initial\ Energy - Energy\ Consumption \quad (2)$$

where Initial energy is the node's primary energy source at the beginning of network operation, and Energy consumption is the node's energy used for operations like transmitting, receiving data, processing data, and maintaining network connections.

3. Available Bandwidth (ABW): In AODV, the available bandwidth [32] is one of the metrics used to determine the best path to destination node and the calculation of the available bandwidth for each path is typically done by each node by collecting information from its neighbour's. The formula for calculating the available bandwidth in a MANET is:

$$ABW = \frac{Total\ Bandwidth}{Number\ of\ Active\ nodes} \quad (3)$$

where Total Bandwidth refers to the highest possible level of data transmission over the network within a specified time period, and Number of Active Nodes is the number of nodes that are currently transmitting or receiving data over the network.

Considering the above-mentioned criteria, the TOPSIS algorithm is implemented as below:

1. Define the Decision Matrix (DM) that includes the available routes and their attributes.

$$\begin{matrix} & C_1 & C_2 & \dots & C_3 \end{matrix}$$

$$DM=\begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{bmatrix} \begin{bmatrix} x_{11} & x_{12} & \dots x_{1n} \\ x_{21} & x_{22} & \dots x_{2n} \\ \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & x_{mn} \end{bmatrix} \quad (4)$$

where m alternatives are represented with A_1 to A_m, whereas n criteria are mentioned using C_1 to C_n. x_{ij} is the numerical value of i^{th} alternative of jth criteria.

2. Evaluate the Normalized Decision Matrix that reflects the relative performance of each alternative. To normalize the values in the decision criteria, we apply vector normalization to bring all the criteria to the same scale.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (5)$$

3. Calculate the Weight Decision Matrix by using AHP to measure each criteria's relative importance. The normalized weighted value is evaluated by

$$v_{ij} = w_j n_{ij} \quad (6)$$

where i considers values from 1 to m, j from 1 to n and w_j is the weight assigned to j_{th} criteria.

4. Select the Ideal Solution (A+) and Negative Solution (A-) based on the Weight Decision Matrix.

The positive solution $A^+ = (v_1^+, v_2^+, \dots, v_n^+) = \left[\left[max v_{ij} \mid j\epsilon I\right], \left[min v_{ij} \mid j\epsilon J\right]\right] \quad (7)$

where I and J are the benefit and non-benefit criteria.

The negative solution $A^- = (v_1^-, v_2^-, ..., v_n^-) = [[minv_{ij} \mid j\epsilon I], [maxv_{ij} \mid j\epsilon J]]$ (8)

5. Calculate the Distances from the Ideal and the Negative Solutions for each competitive alternative.

$$d_i^+ = [\sum_{j=1}^{n}(v_{ij} - v_j^+)^p]^{1/p} \quad (9)$$

$$d_i^- = [\sum_{j=1}^{n}(v_{ij} - v_j^-)^p]^{1/p} \quad (10)$$

for i=1, 2, ..., m.

6. Compute the relative closeness for each competitive alternative.

$$R_i = \frac{d_i^-}{d_i^- + d_i^+} \quad (11)$$

for i=1, 2..., m with $0 \leq R_i \leq 1$

7. Compute the TOPSIS score i.e., Rank the order for preference based on the relative closeness in descending order. The best optimal route is with highest R_i value.

Once the optimal route is selected, the node updates its backup routing table with the selected route. The backup routing table needs to be updated periodically based on the NMA's disseminated data on node migration [12] and the update occurs when a node loses communication with its group. Table 1 shows the TOPSIS score obtained for each alternative path of M1 when the communication loss occurs with SP1. The optimal routes are selected depending on the highest TOPSIS score i.e., highest TOPSIS score path is given rank1, similarly for the other available paths ranks are allocated.

The description of the table is given as follows:

Table 1. Relative Closeness values for the decision criteria

Path	*Hop Count*	*Residual energy (J)*	*Bandwidth (Mbps)*	*Normalized Hop Count*	*Normalized Residual energy*	*Normalized Bandwidth*	*Weighted Normalized Hop Count*	*Weighted Normalized Residual energy*	*Weighted Normalized Bandwidth*	*TOPSIS Score*
M6-M7-M5	2	80	6	0.58	0.58	0.75	0.23	0.17	0.23	0.53
M10-M14-M5	2	70	7.5	0.58	0.40	0.94	0.23	0.12	0.28	0.65
M11-M12-M13-M5	3	75	4	0.87	0.48	0.37	0.25	0.14	0.11	0.55

1. Field 1 specifies the available paths of the destination (MP) from source (IP).

2. Field 2,3, & 4 indicates the decision criteria for our proposed work. Based on the considered numerical values the Hop count is calculated using (1), Residual energy and the Bandwidth are calculated using (2) and (3).

3. The next 3 fields indicates Normalized values of the decision criteria computed using (5).

4. Depending on the weights assigned i.e., Weight for Hop Count as 0.4, Weight for Available Energy as 0.3 and Weight for Bandwidth as 0.3, the Weighted Normalized values are computed using (6).

5. Equation (7), (8), (9) and (10) are all evaluated to find the ideal Solution for the considered DM and finally the TOPSIS score i.e., the relative closeness value for the optimal alternate paths is calculated using (11).

In this case, M10-M14-M5 has the highest TOPSIS Score, which indicates that it is the optimal route for M1 to reach M5 after the link failure.

Based on the TOPSIS Scores, the optimal route for M1 to reach M5 after the link failure would be M10-M14-M5, as it has the highest TOPSIS Score of 0.65 compared to M11-M12-M13-M5 with 0.55 and M6-M7-M5 with a TOPSIS Score of 0.53. Therefore, the backup routing table contains these alternate optimal routes based on their TOPSIS score in descending order. Hence, with our proposed approach the route establishment is between the indirect Peer M1 using the M10-M14-M5 to communicate with M5 in case of link failure as shown in Fig. 4(b).

5. Simulation Results

The Network Simulator 2.35 [33] is a discrete event network simulator that is widely used for research and is designed to simulate various types of communication networks, including mobile ad-hoc networks (MANETs). Using the NS-2.35 simulator, we evaluated the EABRT-TOPSIS technique to establish a backup routing table in the instance of communication loss. To implement. TOPSIS in the AODV routing protocol in NS-2, the existing AODV code is modified to incorporate the TOPSIS decision-making method based on criteria like hop count, Residual energy and bandwidth, that helps in modifying the routing decision process to use the TOPSIS method to evaluate and rank the alternatives. TCL is used to enhance the AODV protocol and process the TOPSIS technique in decision making for choosing a route when a link failure across the IP and the MP. In our work, the simulation is conducted in a 1000*500 area with 40 nodes by implementing the Energy model within a Flat Grid topology for 400s.

5.1. Simulation Parameters

5.2. Performance Metrics

The performance metrics considered for the evaluation are listed below:

1. Throughput: The highest data rate transmitted via a network in a given period of time, which is often measured in bits per second (bps) or packets per second (pps).

2. End-to-End delay: Including all processing and transmission delays, the total time it takes a packet to transit from the source node to the destination node is known as the "end-to-end delay."

Table 1. Parameters considered for the Simulation

Simulation Parameter	Value
Simulation time	400 s
Simulation range	1000*500
Traffic model	CBR
Number of nodes	40
Length of Queue	50
Protocol	EABRT-TOPSIS
Model	Energy Model

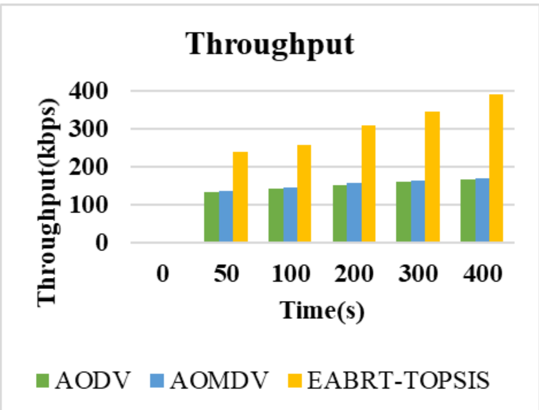

Fig. 5(a) Throughput

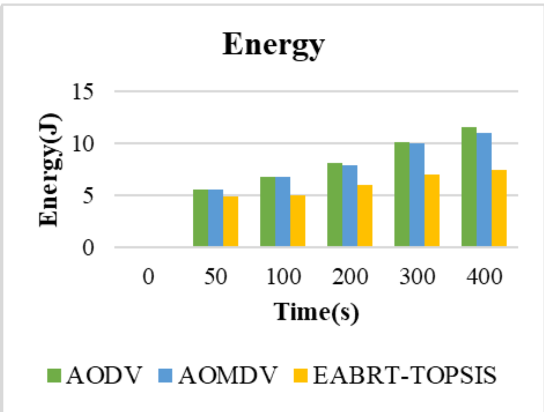

Fig. 5(b) Average Energy Consumption

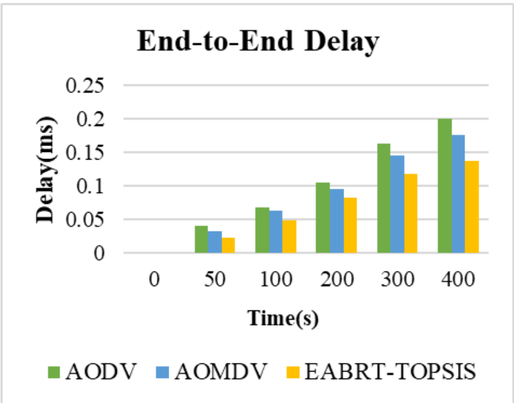

Fig. 5(c) End-to-End-delay

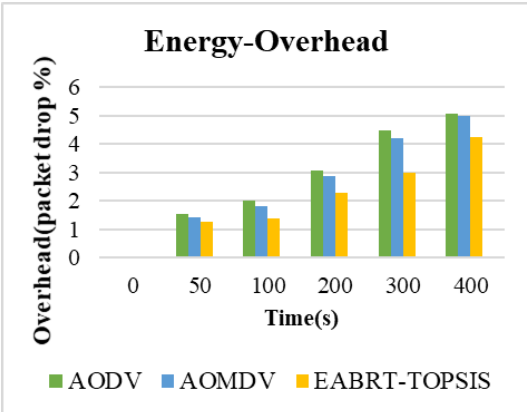

Fig. 5(d) Energy Overhead

Fig. 5. Graphical representation of Performance Metric Vs Simulation Time

3. Average energy Consumption: This metric refers to the average amount of energy consumed by each node in the per unit time.

4. Routing Overhead: It refers to the amount of additional data that is required to support the routing of packets between nodes in the

network.

6. Results and Analysis

The graphs are evaluated based on the Performance metric vs Simulation time, and a comparison is made between AODV, AOMDV, and the proposed EABRT-TOPSIS routing protocol as shown in Fig. 5. The graph in Fig. 5(a) illustrates a comparison of throughput values between our proposed EABRT-TOPSIS algorithm and the existing AODV and AOMDV routing protocols. EABRT-TOPSIS algorithm showed an approximately 11% higher throughput at the start of the experiment as compared to AODV and around 7% higher throughput than AOMDV. As time progressed, the percentage difference between the algorithms increased. By the time 400s had elapsed, the EABRT-TOPSIS algorithm demonstrated a superior performance with a 30% higher throughput compared to AODV and 20% higher throughput compared to AOMDV. On average, the overall percentage of throughput improvement of the EABRT-TOPSIS algorithm compared to AODV and AOMDV was 43.6%, which is indicative of the efficacy of our proposed algorithm in enhancing data delivery, relative to AODV and AOMDV routing protocols.

The graphical representation of the energy consumption of proposed EABRT-TOPSIS algorithm at each time interval compared to AODV and AOMDV routing protocols is shown in Fig. 5(b). In the initial state, EABRT-TOPSIS consumed 18% less energy compared to AODV and 11% less compared to AOMDV. After 100s, the energy consumption of EABRT-TOPSIS algorithm is 19% and 15% less compared to AODV and AOMDV. As time varies and at the 400s of simulation, the EABRT-TOPSIS algorithm achieves 35% less energy consumption than AODV and 33% less compared to AOMDV. This represents the effectiveness of the proposed EABRT-TOPSIS algorithm reducing energy utilization and enhancing the network's overall energy efficiency. Fig.5(c) illustrates the graph that corresponds to the end-to-end delay metric comparison between the EABRT-TOPSIS, AODV and AOMDV routing protocols. At the beginning, EABRT-TOPSIS achieves a significant reduction of 40% and 35% end-to-end delay in contrast to AODV and AOMDV respectively. As time progresses, and finally at the 400s of the simulation, the end-to-end delay of EABRT-TOPSIS is significantly 38% less compared to AODV and 29% less compared to AOMDV. On average, our EABRT-TOPSIS algorithm achieves 60% lower end-to-end delay compared network

to the AODV and AOMDV routing protocols at different time intervals.

In Fig.5(d), the graph depicts the energy overhead values of EABRT-TOPSIS compared with AODV and AOMDV. Our algorithm achieves 18.2 % less energy overhead compared to AODV, and 11.3% less when compared with AOMDV in the beginning state. As time progresses, the EABRT-TOPSIS algorithm shows considerable energy overhead and at the final 400s of simulation time, the EABRT-TOPSIS exhibits 16.4 % and 15.6% less overhead when compared to AODV and AOMDV. On average, EABRT-TOPSIS achieves 44.12 % less overhead than combined AODV AOMDV at different time intervals. This depicts our protocol exhibits low packet loss, whereas AODV and AOMDV protocols have significantly higher packet loss.

The simulation results demonstrate that our suggested method achieves a 35% reduction in energy consumption and nearly 44% higher throughput, 60% less overhead and 44% less delay than the AODV and AOMDV routing protocols. This illustrates that our proposed method is energy efficient and exhibits the optimal resource allocation in selecting the most optimal route that connect the MP and the IP thereby resulting in improved network performance.

7. Conclusion and Future work

To select an optimal route across the IP and the MP in the event of a link failure, we proposed an EABRT-TOPSIS algorithm i.e., Enhanced AODV Routing Protocol that uses the TOPSIS, a multi-criteria decision-making technique to maintain a backup routing table. In comparison to the AODV and AOMDV routing protocols, this technique selects the optimal route from the available alternative routes based on decision-making criteria such as hop count, residual energy, and available bandwidth, thereby efficiently utilising the energy in the network. Our research contributes to the field by providing a comprehensive solution to address frequent link failures, energy depletion, and communication loss in Cloud-Assisted MANETs, with potential applications in various mobile and wireless communication scenarios. Simulation is performed for 40 nodes over a duration of 400 s, assuming that the MP serves as the Cluster Head and that SP's share relevant information. This work can be expanded by considering a greater number of nodes, simulating for a longer period of time in view of the nodes' dynamic nature and including additional decision-making factors in the TOPSIS technique.

Author contributions

For this research work all authors' have equally contributed in Conceptualization, methodology, validation, resources,

original draft preparation, review and editing.

Conflicts of interest

The authors declare no conflict of interest.

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