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Utility-Aware Enhanced Reliable Opportunistic Routing Protocol for Mobile Adhoc Networks

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Abstract*: Usually, the nodes in Mobile Adhoc Networks (MANET) are bounded with the limited power resources to interact with each other nodes without any backbone infrastructures. As a result, an allocation of unbalanced traffic among nodes may increase the power dissipation in the overloaded nodes and path failures that degrade the network lifetime. To tackle this problem, an on-demand Power and Load-Aware (PLA) multipath node-disjoint source routing scheme was proposed based on the Dynamic Source Routing (DSR) protocol that uses a new cost function to determine the multiple node-disjoint power and select the load-aware optimal paths to their destinations. However, this protocol was affected by control overhead and the reliable packet delivery was also not effective. Hence in this article, Power and Load-aware i.e., Utility-Aware Reliable Opportunistic Routing (UAROR) protocol is proposed to enhance the efficiency and reliability of the routing protocol. In this protocol, topology control and link lifetime prediction algorithms are integrated into the PLA algorithm to predict the effect of the node mobility on routing performance. The link prediction algorithm considers both mobility speed and direction for improving the accuracy. As well, an opportunistic topology control algorithm uses packet delivery ratio to maintain the node's stability. Moreover, Utility-Aware Enhanced ROR (UAEROR) protocol is proposed to improve the node's stability and reduce the control overhead by employing the neighbor detection algorithm that uses degree and reachability of nodes. Finally, the simulation results show that the effectiveness of the proposed protocol compared to the existing protocol in terms of throughput, end-to-end delay, packet delivery ratio, network lifetime, energy consumption and control overhead.

Index Terms*: Mobile adhoc network, Power and load-aware routing, Multipath node-disjoint routing, DSR protocol, Neighbor detection

I. INTRODUCTION

One of the types of Wireless Sensor Network (WSN) is MANET which has many mobile nodes for data communication through wireless connections. Those mobile nodes utilize peer-to-peer data communication through multihop paths and functioning based on any wireless backbone infrastructures. Every node can operate as a router by finding and maintaining routes to the other nodes. These types of networks can deploy in different applications like tactical communication, survival, search and rescue management, etc. The data packets are transmitted by using various routing protocols. Different routing protocols have been designed to select the route with the minimum number of hops from the source node to its destination [1].

Such routing protocols have many design principles like scalability, ease of implementation, fault tolerance and dynamic topology control. Generally, each node in the network is connected dynamically in an arbitrary manner and so multipath routing is generated between the source and destination node. When the primary route is failed during packet transmission, a backup route is selected via multiple routes to achieve fault tolerance and route recovery [2]. Additionally, this may provide a load balancing by distributing the traffics among a set of disjoint nodes.

Normally, node-disjoint paths provide the most aggregate resources since neither links nor nodes are shared between the routes. Also, it offers the highest degree of fault tolerance. Likewise, multipath achieves better performance than a unipath. The unbalanced distribution of traffic loads among network's nodes led to a power dissipation of overloaded nodes, the loss of these vital nodes causes link failure which could lead to critical topological changes, affect the network operations and its lifetime. As a result, it may be crucial for using a self-adaptive method to determine the path selection based on the real-time circumstances of the nodes and paths. For this reason, an on-demand Power and Load-Aware (PLA) multi-path node-disjoint source routing scheme was proposed based on DSR protocol [3]. This protocol utilizes a new cost function for finding a multiple node-disjoint power and load aware optimal routes to their destinations that extends the operational life of nodes and maximizes the network lifetime. In addition, over dissipation of nodes in the optimal paths was avoided and the number of path discovery processes was reduced. However, this protocol was affected by control overhead during path discovery process.

Hence in this article, a Utility-Aware Reliable Opportunistic Routing (UAROR) protocol is proposed to enhance the efficiency and reliability of the routing protocol. In this protocol, topology control and link lifetime prediction algorithms are integrated into the PLA algorithm to predict the effect of the node mobility on routing performance. The link prediction algorithm considers both mobility speed and direction for improving the accuracy. As well, an opportunistic topology control algorithm uses packet delivery ratio to maintain the node's stability. Moreover,

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UA Enhanced ROR (UAEROR) protocol is proposed to improve the node's stability and reduce the control overhead by employing the neighbor detection algorithm that uses degree and reachability of nodes. The remaining part of the paper is organized as follows: Section II provides the previous researches related to power and load-aware based multipath routing for MANET. Section III explains the proposed protocol. Section IV illustrates and compares the performance efficiency of proposed protocol with existing protocols. Section IV concludes the research work.

II. LITERATURE SURVEY

A delay-aware data collection network model [4] was proposed with the aim of minimizing the delay during data collection process of WSN. This network model was constructed by designing the two network formation algorithms in both centralized and decentralized approaches. These algorithms were concurrently utilized for maintaining the transmission distance among the nodes at low values to reduce the amount of energy consumed during communication. However, the complexity of this model was high.

An Energy-efficient, Delay-Aware and Lifetime-balancing (EDAL) data collection protocol [5] was proposed with the aim of discovering the minimum cost routes by using Open Vehicle Routing (OVR) for delivering the packets within their deadlines. In this protocol, a centralized meta-heuristic was introduced for reducing the computation complexity and tabu search was employed to find the approximation solutions. Moreover, a distributed heuristic was proposed for large-scale WSN where each source node independently forms the most energy-efficient path for transmitting packets. However, network lifetime of this protocol was less.

Node Disjoint (NDj) multipath routing protocol based on AODV [6] was proposed in MANET. In this technique, multiple node-disjoint paths were discovered towards the destination by AODV routing protocol. Here, a sequence number was used for ensuring freshness of paths and avoiding routing loops. Moreover, the path discovery and maintenance processes of AODV were entirely updated to discover the multiple node-disjoint paths to the destination with the minimum routing overhead and latency. Also, the energy consumption was reduced by selecting an optimum energy expending routes. However, route failure due to energy depletion of nodes and asymmetric links was not efficiently detected.

Energy Aware Load Balancing Multipath (EALBM) routing protocol was proposed [7] based on AODV protocol. In this protocol, three phases were performed namely neighbor discovery, multipath discovery and data transmission. The multipath discovery was initiated by the source node for determining all disjoint multipaths from source to destination. Then, a weight was assigned by each disjoint path according to the energy level of nodes along that path. The path with the maximum energy of nodes was selected for data transmission with reduced delay. However, the packet loss was high.

Lifetime-aware data collection [8] was proposed in WSN. Initially, the problem of lifetime-aware data collection in WSN with only one base station was investigated and a Routing Directed Acyclic Graph (R-DAG) was constructed for data collection. This algorithm makes the utilization of a shortest path DAG and inserts sibling edges for balancing the loads of the base station's children which prolongs the network lifetime. However, latency of data collection was high. Energy Efficient Load-Aware Routing (EELAR) technique [9] was proposed for MANET. The main aim of this technique was to improve both load balancing and energy efficiency in parallel. In this technique, two major processes were performed in parallel such as link estimation was proposed to improve the energy efficiency and learning of network load balancing was performed to improve the QoS performance. However, performance efficiency was less when number of nodes was increased.

Power-aware Node-Disjoint Multipath Source Routing (PNDMSR) protocol [10] was proposed and analyzed in MANET. The major aim of this protocol was to select energy-aware node-disjoint multipath between a source and destination by controlling the overhead. In this protocol, a new power-aware metric such as minimum node cost was used for discovering the optimal routes. In addition, power consumption and bandwidth were also optimized to support reliability in the network. Moreover, network lifetime was maximized by maintaining the minimum energy level to each node. However, overhead and delay were high. Also, many bandwidth and power were exhausted.

III. PROPOSED METHODOLOGY

In this section, the proposed UAEROR protocol is explained in detail. Initially, link prediction and topology control algorithms are integrated with the PLA-DSR, namely UAROR is proposed by considering both mobility speed and moving direction for improving the node's stability and routing performance. Then, this protocol is further enhanced as UAEROR to reduce the control overhead by introducing the neighbor detection algorithm. The detailed information of this protocol is presented in the following sub-sections.

A. Link Lifetime Prediction Algorithm

In this algorithm, only the neighbors whose distances to the destination node are smaller than that of the source node is considered as the candidate neighbor nodes. The link lifetime value is related to the source node S, relaying node R and destination node D. The survival region i.e., the link connection can be guaranteed in that region is changed constantly due to the mobility of the nodes S and D. Also, the communication link may be failed while the node R moves out of the survival region. Thus, the moving direction of the node is also considered with the mobility speed during the link lifetime prediction and the relative velocity of node R corresponding to the nodes S and D is needed to be computed. Consider the mobility speeds of nodes S, R and D are $\overrightarrow{V_S}, \overrightarrow{V_R}$ and $\overrightarrow{V_D}$ with respective moving directions θ_S, θ_R and θ_D. If the node D is selected as the reference frame, then the relative velocity of node S corresponding to D is given as: $\overrightarrow{V_{SD}} = \overrightarrow{V_S} - \overrightarrow{V_D}$.

According to the vector synthesis theory, the relative mobility speed and moving direction of $\overrightarrow{V_{SD}}$ is given as: $V_{SD} = \sqrt{V_{xSD}^2 + V_{ySD}^2}$, $\theta_{SD} = \arctan(V_{xSD}/V_{ySD})$, $V_{xSD} = V_S \cos\theta_S + V_D\, cos\, \theta_D$, $V_{ySD} = V_S \sin\theta_S + V_D\, sin\, \theta_D$; where V_{xSD} and V_{ySD} refers the mobility speed of V_{SD} in x-axis and y-axis, respectively. So, the relative velocity of R relatives to $\overrightarrow{V_{SD}}$ is computed as: $\overrightarrow{V_{SDR}} = \overrightarrow{V_R} - \overrightarrow{V_{SD}}$. Similar to $\overrightarrow{V_{SD}}$, the relative mobility speed and moving direction of $\overrightarrow{V_{SDR}}$ is calculated as: $V_{SDR} = \sqrt{V_{xSDR}^2 + V_{ySDR}^2}$, $\theta_{SDR} = \arctan(V_{xSDR}/V_{ySDR})$, $V_{xSDR} = V_R \cos\theta_R + V_{SD}\, cos\, \theta_{SD}$, $V_{ySDR} = V_R \sin\theta_R + V_{SD}\, sin\, \theta_{SD}$; where V_{xSDR} and V_{ySDR} refers the mobility speed of V_{SDR} in x-axis and y-axis, respectively.

Consider the coordinate of nodes S and D are (x_S, y_S) and (x_D, y_D), respectively. The angle of $\overline{SD}$ relative to the x-axis is obtained from: $\theta_{\overline{SD}x} = \arctan\left(\frac{y_S - y_D}{x_S - x_D}\right)$. According to θ_{SDR} and the triangle geometry theory, the velocity angle of node R relative to $\overline{SD}$ is calculated as: $\theta_{rel} = \theta_{SDR} - \theta_{\overline{SD}x}$. Consequently, if $\theta_{rel} \in \left[0, \frac{\pi}{2}\right] \cup \left[\frac{3\pi}{2}, 2\pi\right]$, then the node R moves nearer to the node D in both x-axis and y-axis. If $\theta_{rel} \in \left[\frac{\pi}{2}, \frac{3\pi}{2}\right]$, the node R moves far away from the node D in both x-axis and y-axis. Based on these two different scenarios, the link lifetime prediction is performed.

1). When $\theta_{rel} \in \left[0, \frac{\pi}{2}\right] \cup \left[\frac{3\pi}{2}, 2\pi\right]$

In this scenario, the distance between nodes R and D is computed as follows:

$$d_{DR}^2 = d_0^2 + d_{DS}^2 - 2d_0 d_{DS} \cos\Phi_3 \tag{1}$$

In (1), d_0 denotes the distance between nodes S and R at time t_0, d_{DS} denotes the distance between nodes S and D. The value of Φ_3 is obtained from (1) since the values of d_{DR}, d_0 and d_{DS} are calculated based on the coordinates of these nodes. Thus, Φ_2 is computed as: $\Phi_2 = \pi - \Phi_3$. If the values of θ_{rel} and Φ_3 are known, then the angle α is computed as: $\alpha = \pi - \Phi_3 - \theta_{rel}$. Also, the transmission range of node S is calculated as:

$$R^2 = d_0^2 + [V_{SDR}(t - t_0)]^2 - 2d_0 V_{SDR}(t - t_0)\cos\alpha \tag{2}$$

By using this equation, the value of t is computed. Therefore, the residual link lifetime is calculated as follows:

$$T_r = t - t_0 \tag{3}$$

1). When $\theta_{rel} \in \left[\frac{\pi}{2}, \frac{3\pi}{2}\right]$

In this scenario, the link lifetime prediction is performed similar to that when $\theta_{rel} \in \left[0, \frac{\pi}{2}\right] \cup \left[\frac{3\pi}{2}, 2\pi\right]$. The distance between nodes D and R at time t_0 is d_{DR}. Moreover, $\measuredangle DR$ is calculated as:

$$\measuredangle DR = \Phi_5 = \pi - (\Phi_2 - \Phi_1) \tag{4}$$

$$\text{Where } \Phi_2 = \pi - \Phi_3$$

$$d_{DS}^2 = d_0^2 + d_{DR}^2 - 2d_0 d_{DR} \cos\Phi_4 \tag{5}$$

$$\Phi_1 = \pi - \Phi_4 \tag{6}$$

As a result, the transmission range of node S is calculated as:

$$R^2 = d_{DR}^2 + [V_{SDR}(t - t_0)]^2 - 2d_{DR} V_{SDR}(t - t_0)\cos\Phi_5 \tag{7}$$

Based on (7), the value of t is computed and so the residual link lifetime of this scenario is computed by using (3).

B. Opportunistic Topology Control Algorithm

The Opportunistic Topology Control (OTC) algorithm is used to adjust the transmission power dynamically and maintaining the stability of the packet delivery ratio. Further, the topology control cost is also reduced by splitting the nodes into different categories. The following definitions are required to explain the OTC algorithm:

- The Neighbor Node Degree (NND) defines the number of neighbors whose distances to the destination node are smaller than that of the source node i.e., the number of neighbor nodes in the survival region.
- The transmission power adjustment ratio defines the fraction of the number of nodes which fine-tune their transmission power to the number of nodes in the entire network.

$$A_{OTC} = \frac{Number\ of\ nodes\ which\ fine-tune\ the\ transmission\ power}{Total\ number\ of\ nodes\ in\ the\ network} \tag{8}$$

The lowest transmission power adjustment ratio indicates that only few amount of nodes need to modify their transmission power with less control cost of the network. In this algorithm, the Packet Delivery Ratio (PDR) between node S and Candidate Neighbor Node (CNN) set is computed as follows:

$$PDR = 1 - (1 - P_i)^n \tag{9}$$

In (9), P_i denotes the PDR between source and one neighbor node and is computed by periodically beacon message exchanging between source and its neighbors, n refers the NND of the CNN. According to (9), the PDR varies significantly. To obtain the stable PDR, the NND must maintain constant in neighbor nodes. To reduce the transmission power adjustment ratio, the nodes are split into different categories in OTC based on their PDR. The decision of whether the transmission ranges need to be adjusted or not is done by which categories that the nodes belong to.

- While the PDR of the node is in the region (E_1, E_2), the node is referred as healthy. Otherwise, the node is unhealthy i.e.,

$$\begin{cases} R_H \quad\ \in (PDR|PDR \in [E_1, E_2]) \\ R_{UH} \in (PDR|PDR \in [0, E_1) \cup (E_2, 1]) \end{cases} \tag{10}$$

In (10), E_1 and E_2 are the boundary values of different categories, R_H and R_{UH} are the healthy and unhealthy region, respectively. To specify the PDR, the required NND of the CNN is determined by (9). Therefore, (10) can be rewritten by NND as follows:

$$\begin{cases} R_H \quad\ \in (n|n \in [n_1, n_2]) \\ R_{UH} \in (n|n \in [0, n_1) \cup (n_2, N]) \end{cases} \tag{11}$$

In (11), N represents the node number in the network. The node S determines the NND in the neighbor node and modifies the transmission power based on the NND value. The transmission power adjustment probabilities may vary in different regions to reduce the transmission power adjustment ratio.

This probability is 0 in healthy region whereas it varies from 0 to 1 in the unhealthy region according to the NND value which can be denoted as follows:

$$\begin{cases} P_H \quad \in (n|n \in [n_1, n_2]) \\ P_{UH} \in (n|n \in [0, n_1) \cup (n_2, N]) \end{cases} \tag{12}$$

In (12), P_H and P_{UH} are the transmission power adjustment probabilities of healthy and unhealthy region, respectively. In unhealthy region, this probability may vary and decide by the variation of the NND. If the NND is far away from the healthy region, the probability will be high to ensure the reliability and PDR, vice versa. Thus, the adjustment probability is computed as:

$$P_i = \begin{cases} \frac{(n_1 - n_i)}{n_1}, & n_i \in [0, n_1) \\ \frac{(n_i - n_2)}{(N - n_2)}, & n_i \in (n_2, N] \end{cases} \tag{13}$$

Here, n_i refers the NND of N_i, P_i refers the transmission power adjustment probability of N_i and $0 \le P_i \le 1$. The probability that the node number is n in the coverage region of the node is Poisson distribution. So, the probability that there are n nodes in the survival region is follows:

$$P(n) = \frac{(\rho\Delta)^n}{n!} e^{-\rho\Delta} \tag{14}$$

Where Δ refers the survival region, ρ denotes the node density of the network. According to (14), the probability that the NND is in the region $[n_1, n_2]$ is computed as follows:

$$P(n_1 \le n \le n_2) = \sum_{n=n_1}^{n_2} \frac{(\rho\Delta)^n}{n!} e^{-\rho\Delta} \tag{15}$$

If $P'(n_1 \le n \le n_2)|_\Delta = 0$, then (15) will obtain the maximum value i.e., the probability that there are n nodes in the survival region Δ is the maximum.

$$P'(n_1 \le n \le n_2)|_\Delta = \sum_{n=n_1}^{n_2} \frac{1}{n!} (\rho\Delta)^{n-1} (n\rho e^{-\rho\Delta} - \rho\Delta\rho e{-}\rho\Delta \tag{16}$$

When $P'(n_1 \le n \le n_2)|_\Delta = 0$, an optimal survival region Δ^* is obtained as:

$$\Delta^* = R^2 \cdot \arccos\left(\frac{R}{2d_{DS}}\right) \tag{17}$$

Where $R^2 \cdot \arccos\left(\frac{R}{2d_{DS}}\right)$ denotes the area of the survival region. Based on (17), an optimal transmission range R^* for the node S is obtained. This transmission range has the maximum probability to ensure that the NND in the NNS is in the region $[n_1, n_2]$. So, the node transmission ranges can be modified to R^* while the node is in the unhealthy region. Consequently, according to (13) and A_{OTC}, the transmission power adjustment ratio of OTC is computed as follows:

$$A_{OTC} = P_{UH} + \frac{1}{N} \sum_{i=1}^{N} P_i \tag{18}$$

According to (14) and (15), the value of P_{UH} is computed as follows:

$$P_{UH} = P[(0 \le n < n_1) \cup (n_2 < n \le N)] \\ = \sum_{n=0}^{n_1 - 1} \frac{(\rho\Delta^*)^n}{n!} e^{-\rho\Delta^*} + \sum_{n=n_2+1}^{N} \frac{(\rho\Delta^*)^n}{n!} e^{-\rho\Delta^*} \tag{19}$$

C. Neighbor Node Detection Algorithm

The enhanced UROR is proposed to select the NNS by considering degree and reachability of nodes. Consider $\mathcal{N}[i]$ and $\mathcal{N}_2[i]$ as all 1-hop and 2-hop neighbors of N_i. Also, the degree and reachability of N_j for $j \in \mathcal{N}[i]$ are denoted as $\mathcal{D}[j]$ and $\mathcal{R}[j]$, respectively. A preset Link Reliability (LR) threshold is denoted as LR_{thr}. If N_k is included in $\mathcal{R}[j]$, then it will also be included in $\mathcal{R}_{rel}[j]$ if and only if $LR_{jk} \ge LR_{thr}$. The metrics LR_{ij} and $\mathcal{R}_{rel}[j]$ are used for constructing the reliable NNS. The value of LR_{ij} $(0 \le LR_{ij} \le 1)$ is computed by inserting the node mobility speed and moving direction into Route Request (RREQ) message. Also, it specifies that the impacting factors of N_j being chosen as a NN from high to low are $LR_{ij}, \mathcal{R}_{rel}[j], \mathcal{R}[j]$ and $\mathcal{D}[j]$.

<u>Algorithm for UEROR</u>

Initialize
Source node broadcasts RREQ to its neighbor nodes;
$if(d(N_i, D) < d(S, D))$
Transmit RREP from N_i to S;
Compute the NND (n) by using OTC algorithm;
$end\ if$
$if((0 \le n < n_1)\ or\ (n_2 < n \le N))$
$P_i = P_i(n);$
$R \xleftarrow{P_i} R^*;$
$else\ if(n_1 \le n \le n_2)$
$P_i = 0;$
$R = R;$
$end\ if$
$\mathcal{G} = \emptyset$; //Empty CNN set for N_i
$for(N_j \in \mathcal{N}[i])$
$if(N_j\ provides\ the\ only\ \mathcal{R}[j]\ to\ specific\ nodes\ in\ \mathcal{N}_2[i])$
Eliminate N_j from $\mathcal{N}[i]$ and include N_j to $\mathcal{G}$;
Eliminate nodes from $\mathcal{N}_2[i]$ enclosed by N_j;
$end\ if$
$end\ for$
$while(\mathcal{N}_2[i] \ne \emptyset)$
$for(N_j \in \mathcal{N}[i])$
Obtain $\mathcal{D}[j], \mathcal{R}[j], \mathcal{R}_{rel}[j]$ by N_i to compute LR_{ij} as:

$$LR_{ij} = P\left(T_{r_{ij}} \ge T_{thr}\right) = 1 - F_{T_{r_{ij}}}(T_{thr}) \tag{20}$$

$//T_{r_{ij}}$: Residual link lifetime of nodes N_i and N_j
$//F_{T_{r_{ij}}}$: Cumulative Distribution Function of residual link lifetime
$end\ for$
Extract N_j with $max[LR_{ij}]$ and $\mathcal{R}[j] \ne 0$;
$if(multiple\ choices\ exist)$
Extract node with $max[\mathcal{R}_{rel}[j]]$ and $max[\mathcal{R}[j]]$;
$max[\mathcal{D}[j]]$ until only one node left;
$if(multiple\ choices\ still\ exist)$
Select N_j randomly from the remaining nodes;
Eliminate N_j from $\mathcal{N}[i]$ and include N_j to $\mathcal{G}$;
$end\ if$
$end\ if$
$end\ while$
Update the CNN set by S;
Transmit data packets to the NN from S through the path selected by PLA algorithm;
Repeat the process till the data packet received by the node D;

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IV. RESULTS AND DISCUSSION

In this section, the performance evaluation of UAEROR protocol is analyzed by using Network Simulator version 2 (NS2.35) and compared with the other protocols such as UAROR and PLA-DSR. The comparison is made in terms of different network metrics such as throughput, end-to-end delay, PDR, network lifetime, energy consumption and control overhead. The simulation parameters are listed in Table 1.

Table 1: Simulation Parameters

Parameters	Value
Simulation area	$1000m^2$
Simulation time	100sec
Number of nodes	200
Routing protocol	DSR, PLA-DSR, UAROR, UAEROR
MAC layer	IEEE 802.11
Propagation model	Two-Ray Ground
Antenna	Omni-directional
Transmitted signal power	0.2818W
Transmission range	250m
Initial energy	100J
Transmitting power	1.4W
Receiving power	1W
Mobility model	Random waypoint
Node's speed	0-10m/s
Pause time	0-100s
Traffic type	Constant Bit Rate (CBR)
Packet size	512bytes
Queue type	Drop tail

A. Throughput

Throughput defines the number of data packets received at the destination nodes within a given time interval.

$$Throughput = \frac{Total\ number\ of\ Packets\ Received\ @\ destination}{Time\ duration} \quad (21)$$

Table 2 shows the comparison of throughput between proposed and existing protocols.

Table 2: Comparison of Throughput

Number of Nodes	PLA-DSR	UAROR	UAEROR
25	0.9	0.91	0.921
50	0.87	0.88	0.893
75	0.84	0.85	0.862
100	0.81	0.82	0.83
125	0.78	0.79	0.804
150	0.75	0.76	0.78

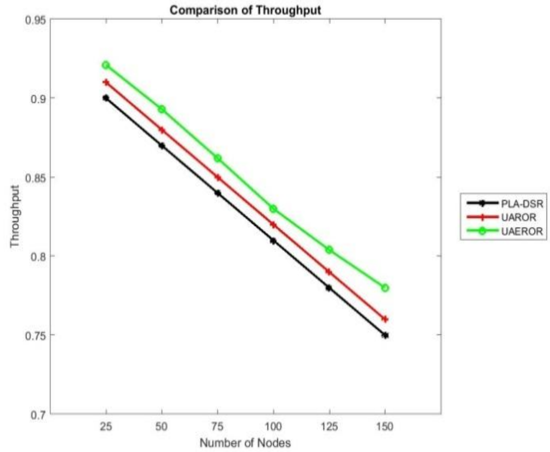

Fig.1: Comparison of Throughput

Fig.1 shows the comparison of proposed and existing protocols in terms of throughput. In the graph, x-axis takes number of nodes and y-axis denotes the throughput. From the analysis, it is concluded that the throughput of the proposed UAEROR protocol is higher than the UAROR and PLA-DSR protocols. For example, when the number of node is 150, the throughput of UAEROR protocol is 2.6% higher than UAROR and 4% higher than PLA-DSR protocol.

B. End-to-end Delay

End-to-end delay refers the elapsed time between transmitting the data packet from the source and receiving it at the destination node.

$$End - to - end\ delay = T_d - T_s \quad (22)$$

Where T_d refers the time when a destination receives the data packet and T_s refers the time when the source transmits that data packet.

Table 3 shows the comparison of end-to-end delay between proposed and existing protocols.

Table 3: Comparison of End-to-end Delay (sec)

Number of Nodes	PLA-DSR	UAROR	UAEROR
25	12	10	7
50	28	20	15
75	52	46	40
100	70	61	54
125	120	110	99
150	150	138	130

In Fig.2, the comparison of proposed and existing protocols is shown in terms of end-to-end delay. In the graph, x-axis takes number of nodes and y-axis denotes the end-to-end delay in seconds. From the analysis, it is observed that the proposed UAEROR protocol has less end-to-end delay compared to the UAROR and PLA-DSR protocols. For example, when the number of node is 150, the end-to-end delay of UAEROR protocol is 5.8% less than UAROR and 13.33% less than PLA-DSR protocol.

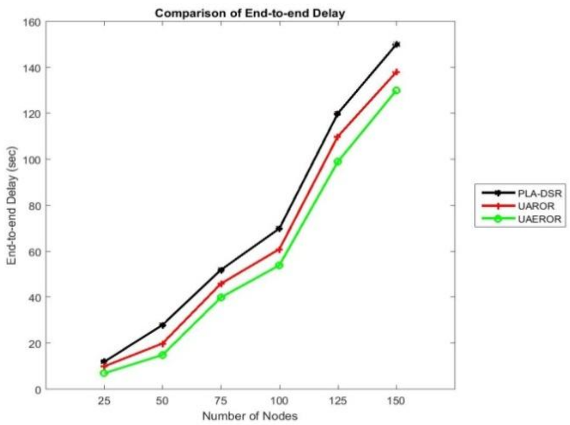

Fig.2: Comparison of End-to-end Delay

C. Packet Delivery Ratio (PDR)

PDR defines the ratio of total amount of data packets delivered at the destination nodes.

$$PDR = \frac{Amount\ of\ data\ packets\ delivered\ @\ destination}{Amount\ of\ data\ packets\ trasnmitted\ from\ source} \quad (23)$$

Table 4 shows the comparison of PDR between proposed and existing protocols.

Table 4: Comparison of PDR (%)

Number of Nodes	PLA-DSR	UAROR	UAEROR
25	88	89.2	90.6
50	86	97.3	89
75	84	95.5	86.4
100	82	93	84.2
125	80	91.2	82.3
150	78	79	80.5

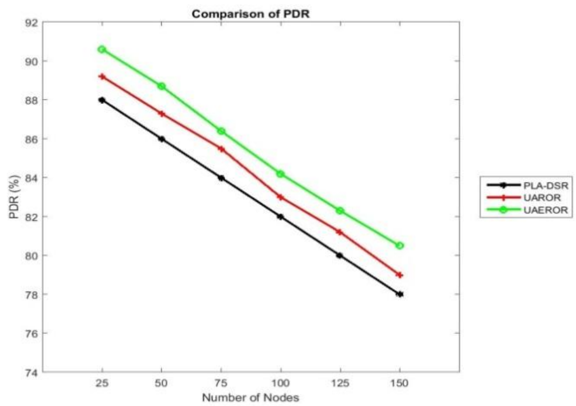

Fig.3: Comparison of PDR

Fig.3 shows the comparison of PDR for both proposed and existing protocols. In the graph, x-axis takes number of nodes and y-axis denotes the PDR in percentage (%). Through this analysis, it is noticed that the proposed UAEROR protocol achieves higher PDR than the UAROR and PLA-DSR protocols. For example, when the number of node is 150, the PDR of UAEROR protocol is 1.9% higher than UAROR and 3.2% higher than PLA-DSR protocol.

D. Energy Consumption

It defines the total amount of energy consumed by the network for data transmission between source and destination within a given time delay.

Table 5 shows the comparison of energy consumption between proposed and existing protocols.

Table 5: Comparison of Energy Consumption (J)

Number of Nodes	PLA-DSR	UAROR	UAEROR
25	42	40.8	38
50	50	49	47
75	57	56.1	54.2
100	65	63.9	61
125	72	71	68.9
150	80	78.9	76.4

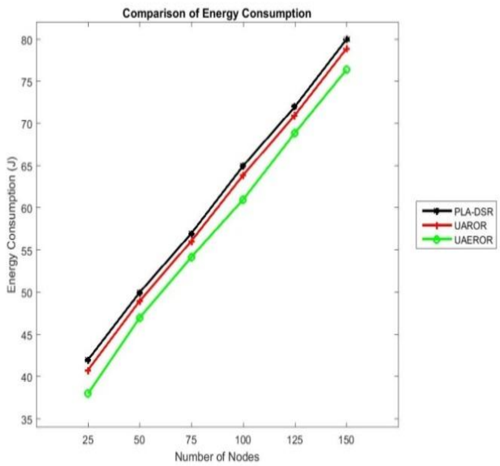

Fig.4: Comparison of Energy Consumption

In Fig.4, the comparison of energy consumption is illustrated for proposed and existing protocols. In the graph, x-axis takes number of nodes and y-axis denotes the energy consumption in Joules (J). From the analysis, it is concluded that the proposed UAEROR protocol has less energy consumption compared to the UAROR and PLA-DSR protocols. For example, when the number of node is 150, the energy consumption of UAEROR protocol is 3.2% less than UAROR and 4.5% less than PLA-DSR protocol.

E. Network Lifetime

It is the maximum amount of time taken by the nodes to transmit the data packets from source to the destination node.

Table 6 shows the comparison of network lifetime between proposed and existing protocols.

Table 6: Comparison of Network Lifetime (sec)

Number of Nodes	PLA-DSR	UAROR	UAEROR
25	81	82.6	85
50	77.3	78.5	80
75	74.8	76	78.1
100	71.5	73	75.3
125	68.1	69.2	71
150	64.8	66.4	68.2

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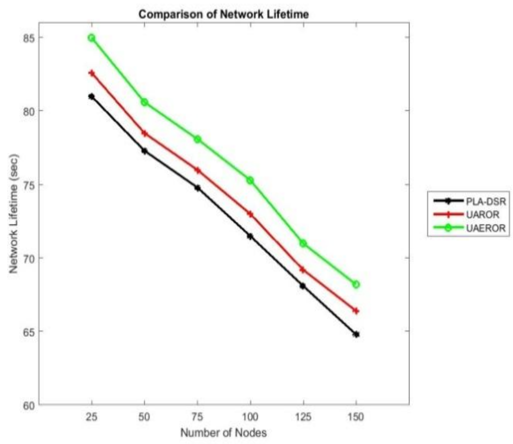

Fig.5: Comparison of Network Lifetime

Fig.5 shows the comparison of network lifetime for the proposed and existing protocols. In the graph, x-axis takes number of nodes and y-axis denotes the network lifetime in seconds. Through this analysis, it is noticed that the proposed UAEROR protocol achieves better network lifetime than the UAROR and PLA-DSR protocols. For example, when the number of node is 150, the network lifetime of UAEROR protocol is 2.7% higher than UAROR and 5.2% higher than PLA-DSR protocol.

F. Control Overhead

It defines the maximum size of data packets transmitted between the source and destination node.

Table 7 shows the comparison of control overhead between proposed and existing protocols.

Table 7: Comparison of Control Overhead (packets)

Number of Nodes	PLA-DSR	UAROR	UAEROR
25	95	93	89
50	104	101	97
75	110	107	103
100	118	115	110
125	126	123	118
150	135	132	127

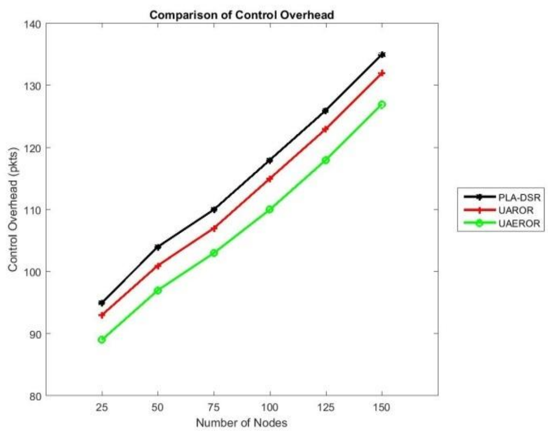

Fig.6: Comparison of Control Overhead

In Fig.6, the comparison of proposed and existing protocols is illustrated in terms control overhead. In the graph, x-axis takes number of nodes and y-axis denotes the control overhead in packets (pkts). From the analysis, it is concluded that the proposed UAEROR protocol reduced control overhead compared to the UAROR and PLA-DSR protocols. For example, when the number of node is 150, the control overhead of UAEROR protocol is 3.8% less than UAROR and 5.9% less than PLA-DSR protocol.

V. CONCLUSION

In this article, a novel protocol named UEROR is proposed to enhance the PLA algorithm efficiently. Initially, UROR protocol is presented that enhances the efficiency and reliability of the routing protocol by combining topology control and link lifetime prediction algorithms with PLA. This protocol predicts the effect of node mobility and maintains the node's stability by considering different parameters such as mobility speed, movement direction and PDR. Further, UEROR is proposed that involves the neighbor detection algorithm by considering degree and reachability of nodes. Finally, the simulation results prove that the effectiveness of the UEROR protocol compared to both UROR and PLA protocols in terms of throughput, end-to-end delay, packet delivery ratio, network lifetime, energy consumption and control overhead.

REFERENCES

1. D. S. Dhenakaran and A. Parvathavarthini, "An overview of routing protocols in mobile ad-hoc network," Int. J. Adv. Res. Comput. Sci. Softw. Eng., vol. 3, no. 2, pp. 251-259, 2013.
2. R. Kaur, R. Mahajan and A. Singh, "A survey on Multipath Routing Protocols for MANETS," Int. J. Emerg. Trends Technol. Comput. Sci., vol. 2, no. 2, pp. 42-45, 2013.
3. H. A. Ali, M. F. Areed and D. I. Elewely, "An on-demand power and load-aware multi-path node-disjoint source routing scheme implementation using NS-2 for mobile ad-hoc networks," Simul. Model. Pract. Theory, vol. 80, pp. 50-65, 2018.
4. C. T. Cheng, K. T. Chi and F. C. Lau, "A delay-aware data collection network structure for wireless sensor networks," IEEE Sens. J., vol. 11, no. 3, pp. 699-710, 2011.
5. Y. Yao, Q. Cao and A. V. Vasilakos, "EDAL: An energy-efficient, delay-aware, and lifetime-balancing data collection protocol for wireless sensor networks," in IEEE 10th Int. Conf. Mob. Ad-hoc Sens. Syst., pp. 182-190, 2013.
6. V. Arya and C. Gandhi, "NDj-AODV: Node disjoint multipath routing in Mobile Ad Hoc Networks based on AODV protocol," in IEEE 7th Int. Conf. Contemp. Comput., pp. 601-606, 2014.
7. S. R. Deshmukh and V. T. Raisinghani, "EALBM: Energy aware load balancing multipath routing protocol for MANETs," in IEEE 11th Int. Conf. Wirel. Opt. Commun. Netw., pp. 1-7, 2014.
8. J. Fei, H. Wu, W. Zheng and Y. Wang, "Lifetime-aware data collection in Wireless Sensor Networks," in IEEE Online Conf. Green Commun., pp. 30-35, 2014.
9. M. A. Salem and R. Yadav, "Efficient load balancing routing technique for mobile ad hoc networks," Int. J. Adv. Comput. Sci. Appl., vol. 7, no. 5, pp. 249-254, 2016.
10. M. Bheemalingaiah, M. M. Naidu, D. S. Rao and P. Vishvapathi, "Performance Analysis of Power-Aware Node-Disjoint Multipath Source Routing in Mobile Ad Hoc Networks," in IEEE 7th Int. Adv. Comput. Conf., pp. 361-371, 2017.

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