ISSN No:-2456-2165

An Efficient Caching Mechanism with Optimized Economic Utility-Aware Enhanced Reliable Opportunistic Routing Protocol for Enhancement on Storage Space Utilization in MANETs

U. Sridevi,
Research Scholar, Department of Computer Science,
SSM College of Arts and Science,
Komarapalayam, Namakkal, Tamilnadu, India

Dr. K. Kamaraj,
Principal,
SSM College of Arts and Science,
Komarapalayam, Namakkal, Tamilnadu, India

Abstract:- For Mobile Adhoc Networks (MANETs), different routing protocols have been developed to improve the network lifespan by reducing the Energy Consumption (EC) of nodes. Since each node within the network has limited energy resources for multi-path data transmission. To solve this constraint, an Optimized Economic Utility-Aware Enhanced Reliable Opportunistic Routing (OEUAEROR) protocol has been proposed which provides an optimal resource algorithm for increasing the efficiency of large-scale networks. Conversely, the network traffic was not reduced since this protocol constrains the cache or memory space of each node in the network. As a result, an Optimized Cache space enhanced EUAEROR (OCEUAEROR) protocol is proposed in this article to minimize the traffic over the network and improve the cache space usage effectively. To do this, a combined version of OEUAEROR protocol and Storage Efficient Caching (SEC) scheme is proposed. This protocol can be performed on the basis that a data packet at any node consists of the data packets of that node and the lost data packets from its nearby nodes. Besides, a Generalized Dominating Set (GDS) method is applied by using the entire cached packets to choose the most suitable nodes as the caching locations for data packet replicas and prevent the packet loss due to the network traffic. At last, the simulation outcomes analyze that the effectiveness of the proposed OCEUAEROR protocol compared to the OEUAEROR protocol in terms of throughput (TP), End-to-End Delay (E2D), Packet Delivery Ratio (PDR), Network Lifetime (NetLife), EC and Control Overhead (CO).

Keywords:- *MANET, Multipath Routing, OEUAEROR Protocol, Caching, Memory Utilization, Generalized Dominating Set.*

I. INTRODUCTION

MANET is a branch of wireless networks consisting of several thousand mobile nodes which transfer the data packets through wireless links between the origin node and the destination. Such wireless nodes use the multihop routes to relay peer-to-peer traffic and to enable them on the basis of wireless backbone systems. Each node may act as a router through the detection and control of routes to another node. In specific, such networks are used in security, disaster management, health monitoring, etc. Usually, most protocols for routing have been used in the data transmission to determine the shortest path from origin to destination [1]. Such protocols are mostly based on various ethical principles, including connectivity, ease of use, fault reduction and complex topology management.

In general, nodes in the MANET are randomly connected to each other, and thus multipath routing between the origin and destination nodes is established. An alternative route is established for recovery of the network across multiple paths, while a primary route failure occurs in data transmission [2]. This can also manage the load over the network by sending traffic to a variety of disjoint nodes. Node-disjoint routes typically provide the most available resources as there are no connections or nodes between the routes. It also gives the highest degree of tolerance for fault. Multipath can also achieve better performance than unipath. On the other hand, the unequal distribution of traffic loads between nodes tends to an overloaded network by increasing the energy usage. This can lead to critical changes in topology, network characteristics and life span.

For this purpose, a self-adaptive method is necessary to choose the routing path as per the real-time circumstances of node and path. For this, a multipath node-disjoint routing framework based on the Dynamic Source Routing (DSR) protocol has been built for on-demand Power and Load-Aware (PLA). A new cost value was used in this protocol to find a multi-node-disjoint PLA optimal route between the source and destination for optimizing network longevity [3]. In fact, node's EC and the amount of path selection functions have been reduced on optimized routes. Conversely, during the discovery of the path, the CO was high. Consequently, a Utility-Aware Reliable Opportunistic Routing (UAROR) protocol was suggested for enhancing routing protocol's efficiency and reliability [4]. The impact of node mobility on routing has been predicted in the UAROR protocol by combining the topology control and link lifespan prediction algorithms with PLA. In addition, it was suggested for the use of a neighbor detective algorithm, namely UA Enhanced ROR (UAEROR) protocol to increase the stability of the node and decrease the CO. Nonetheless, this protocol was not appropriate for wireless networks of future generations because it was unable to achieve the multi-objective goal orientation. An asymmetric strategy was also important to use various transmit power at origin and relay nodes to effectively enhance network lifespan. As a result, a multi-objective Cooperative Medium Access Control (CMAC) protocol was suggested by the Economic UAEROR (EUAEROR) protocol [5] to integrate an energy-efficient relay selection process in order to increase network life, energy efficiency and TP. However, the performance was decreased while network density becomes larger because each node must assign additional resources to transmit data packets to other nodes. Therefore, the EUAEROR protocol has been further developed as the Optimized EUAEROR (OEUAEROR) protocol using the optimal resource allocation algorithm for determining the appropriate resource distribution settings and optimizing the TP of high-scale MANETs. But, this protocol limits the use of cache or storage space of each node which increases the network traffic.

Hence in this article, Optimized Cache space enhanced EUAEROR (OCEUAEROR) protocol is proposed to decrease the network traffic and increase the storage ability of each node. To enhance the efficiency of cache or storage space utilization, Storage Efficient Caching (SEC) scheme is integrated with the OEUAEROR protocol. This protocol considers the characteristic that the data packets at a node have the data packets of the node itself and the missing data packets from its adjacent nodes. The appropriate nodes are chosen as the caching locations for data replicas by the Generalized Dominating Set (GDS) method that uses the complete cached packets so that the packet loss can be minimized. Based on this protocol, the cache or storage space efficiency is increased effectively.

The remainder of this article is planned as follows: Section 2 includes the previous research on multipath routing for PLA cooperation in MANET/WSN. The proposed OCEUAEROR protocol is discussed in Section III. The simulation details of the OCEUAEROR protocol compared to OEUAEROR protocols can be seen in Section IV. The work is summarized in Section IV.

II. LITERATURE SURVEY

A new technique [6] was introduced on the basis of the Association Rules for cache replacement in the adhoc network. The similarity between data entities is measured and then used as the main heuristic during cache replacement by FP-Growth association rule mining. Nevertheless, the algorithm of FP-Tree mining was not automated and its storage requirements were high. In order to identify multiple node-disjoint routes between source and destination using the AODV protocol, a Node-Disjoint multipath routing protocol (NDJ) [7] was proposed. To order to achieve this, AODV's path identification and security systems have been fully modified with minimal routing overhead and latency. Optimal energy was also chosen using paths to reduce consumption of energy. Nevertheless, path loss was not effectively detected owing to node EC and asymmetric links.

The Energy-Aware Load Balancing Multipath (EALBM) protocol was suggested [8] to enable the multipath detection and data transmission to mitigate energy costs and delays. But, the packet failure of this protocol was not reduced. The Efficient Power-Aware Routing with Network coding (EPARN) for MANET has been suggested [9] through the use of Cooperative Communication (CC) and the network coding to link disconnected networks with lower node transmission capacity and improved network connectivity. In contrast this algorithm's performance was not effective. The Energy Efficient Load-Aware Routing Protocol (EELAR) [10] was suggested in order to enhance load-balancing and energy efficiency by means of link analysis and network load balancing modeling in parallel. But, the performance of this protocol was poor while the number of nodes increased.

In order to enhance efficiency by coordination between the physical, MAC and network layers, the Adaptive Multi-QoS Cross-layer Cooperative Routing (AMCCR) protocol [11] was suggested. An approach to the study of the channel state variations on the physical layer was originally designed. The communication strategy was then selected strategically to use the mutual MAC framework by taking advantage of spatial heterogeneity. Afterwards, the network layer selected the best relay candidates to choose an optimal route from origin to destination based on several QoS metrics. In fact, this protocol was generalized to allow dual-hop half-duplex connectivity by using the coding technique via the chosen relay. Nevertheless, the protocol was not effective in its performance.

A collaborative cache management scheme [12] was proposed for MANETs based on the Service Cache Providers (SCPs) called Cooperative Caching based on Service Providers (CCSPs). The proposed system enabled the choice of mobile nodes from certain SCPs which are equipped with the cache summaries of neighboring nodes. Nodes within the same location can thus easily locate the stored data from that region. This strategy utilizes the election process regularly to ensure balancing of loads. Still, the network load size and average latency time were high.

ISSN No:-2456-2165

III. PROPOSED METHODOLOGY

In this section, the OCEUAEROR protocol is explained in detail. For a given undirected connected graph $\mathcal{G} = (\mathcal{V}, E)$ where $\mathcal{V}$ and E are group of nodes and links, respectively. For a given parameter p consider a group of node $\hat{\mathcal{S}} \subset \mathcal{V}, \forall v \in \mathcal{V} - \hat{\mathcal{S}}, \exists v \in \hat{\mathcal{S}}$ such that $v \in \widehat{\mathcal{N}}_p(u)$ which indicates the set of nodes whose shortest distance to node u is not more than p hops, then $\hat{\mathcal{S}}$ is defined as the p-GDS of $\mathcal{G}$.

Actually, the value p is represented as the criterion to find the p-GDS which manages the dimension of a dominate set. In accordance with the GDS definition, each dominating node covers more number of normal nodes. Since $\mathcal{G}$ is linked, this method can be converged after all the nodes are noticeable. Also, the nodes in $\mathcal{V} - \hat{\mathcal{S}}$ should be within p hops away from the minimum one node in $\hat{\mathcal{S}}$. For example, consider $p = 2$, the schematic diagram of GDS method is shown in Figure 1.

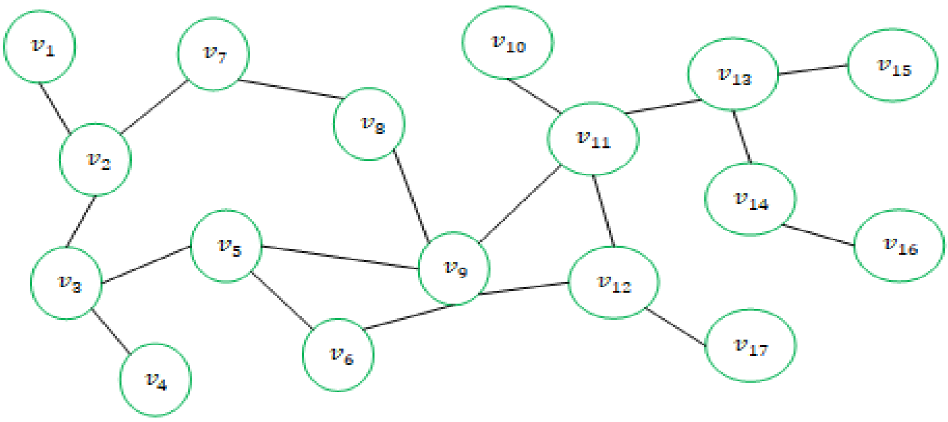

Fig 1(a). Network Topology

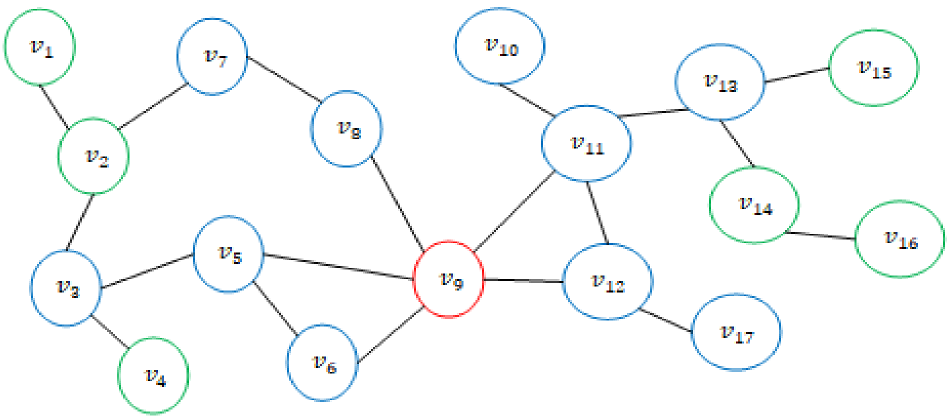

Fig 1(b). Phase II of *Algorithm for p*-GDS Choice

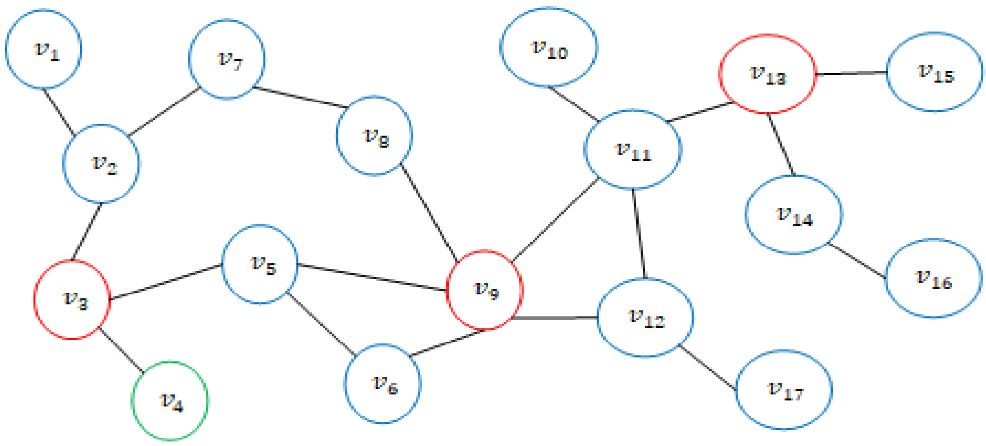

Fig 1(c). Example of GDS Choice ($p = 2$)

Figure 1(a) portrays the network topology whereas Figure 1(b) illustrates the Phase II of p-GDS choice algorithm in which node v_9 with the maximum degree is labeled in red and its adjacent nodes in 2 hops are labeled in blue. The final stage is illustrated in Figure 1(c) where nodes v_3, v_9 and v_{13} are chosen as the generalized dominating nodes.

➢ *Algorithm for* p-GDS Choice:

Initialize

Fix a parameter p in a given undirected connected graph $\mathcal{G} = (\mathcal{V}, E)$;

Label all nodes $\mathcal{V}$ in green and calculate the degree of each node in $\mathcal{G}$;

Represent $\widehat{\mathcal{N}}_p(u)$ as the group of nodes whose shortest path to node u is not higher than p;

Represent $\hat{d}(v)$ as the number of green node in $\widehat{\mathcal{N}}_p(v)$;

//Phase I

Choose the node v with the maximum degree and label it in red;

Label the green nodes in $\widehat{\mathcal{N}}_p(v)$ in blue;

//Phase II

$\boldsymbol{while}(all\ the\ nodes\ in\ v\ are\ labeled\ in\ red\ or\ blue)$

Determine $\hat{d}(v)$ of the blue node v;
Label the node v with the maximum $\hat{d}(v)$ in red;
Label the green node in $\widehat{\mathcal{N}}_p(v)$ in blue;

$\boldsymbol{end\ while}$

Obtain the dominating nodes which are labeled in red represented by $c_1, c_2, \dots, c_n$;

Obtain normal nodes which are labeled in blue;
End

Based on this p-GDS in MANET, a SEC scheme is proposed in which the data packets replicas are stored in $\hat{\mathcal{S}}$. For a node v_i in $\hat{\mathcal{S}}$, the caching probability is 1; or else, the caching probability of the node v_i is set to be 0. Based on the p-GDS definition, it can ensure that the packets can be retrieved within p hops.

Caching probability $\mathcal{P}_i^c$ of a node v_i can be represented as the likelihood of the node to cache the data replicas carried by transmitting the data packets. The algorithm for SEC scheme is given in below.

➢ *Algorithm for SEC Scheme*

Initialize

Choose p value by the network manager;

//Caching position

$\boldsymbol{for}(each\ RREQ)$ the network manger do

//Phase I

Obtain the GDS $\hat{\mathcal{S}}$ by taking the data server as the initiating node according to *Algorithm for* p*-GDS Choice*;

//Phase II

Configure the caching probability $\mathcal{P}_i^c$ of node v_i based on

$$\mathcal{P}_i^c = \begin{cases} 1, & v_i \in \hat{\mathcal{S}} \\ 0, & v_i \notin \hat{\mathcal{S}} \end{cases} \quad (1)$$

//Phase III

If $\mathcal{P}_i^c$ of v_i is 1, when v_i receives a data packet, it transmits the data packet and caches a data replica;

If $\mathcal{P}_i^c$ of □ is 0, when □ receives a data packet, it transmits the data packet only;

□□□ □□□

End

IV. SIMULATION RESULTS

In this section, performance of OCEUAEROR protocol is analyzed by simulating these protocols using Network Simulator (NS2.35) and evaluated with the OEUAEROR protocol in terms of TP, E2D, PDR, NetLife, EC and CO. The simulation parameters are given in Table 1.

Parameters	Value
Simulation area	1000×1000m^2
Simulation time	100sec
Number of nodes	200
Routing protocol	OEUAEROR and OCEUAEROR
MAC layer	IEEE 802.11
MAC header	34bytes
RTS/CTS	44/34bytes
HRF/ACK	38/38bytes
PHY header	24bytes
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
Noise power	-90dBm
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

Table 1:- Simulation Parameters

4.1 Throughput

It is the amount of packets received by the destination within given time.

$$Throughput = \frac{\text{Total number of received packets at the destination}}{\text{time}}$$

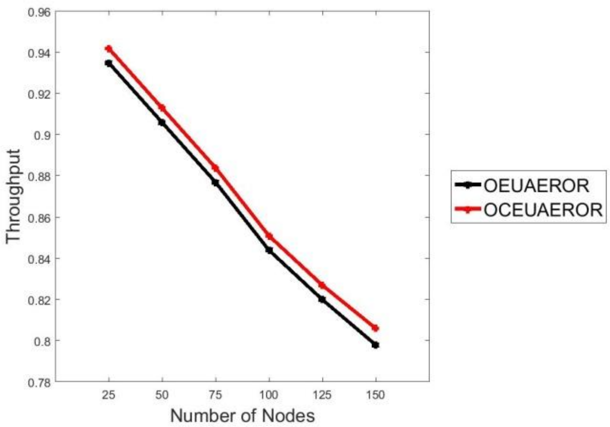

Fig 2:- Throughput vs. Number of Nodes

In Figure 2, evaluation of Throughput values for OCEUAEROR and OEUAEROR is shown. In this graph, x-axis and y-axis are the number of nodes and their respective Throughput values. From this analysis, it is observed that the OCEUAEROR protocol has high Throughput than the OEUAEROR protocol. While considering 150 nodes in the network, the Throughput of OCEUAEROR is 1% greater than OEUAEROR protocol.

4.2 E2D

It is the time considered to transmit the packets between the source and destination.

$$E2D = T_D - T_S$$

Where T_D denotes the time at the destination while it receives the packet and T_S denotes the time at the source when it transmits that packet.

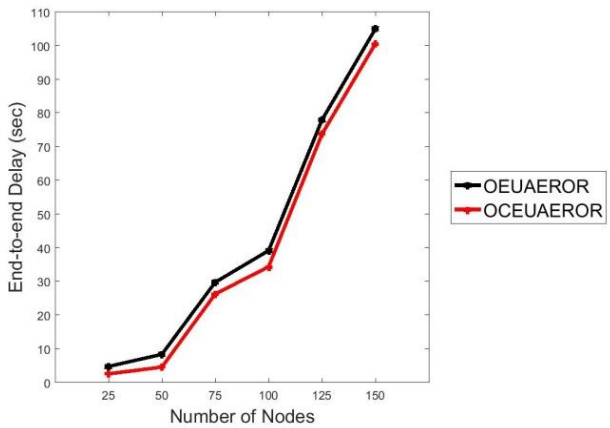

Fig 3:- E2D vs. Number of Nodes

In Figure 3, evaluation of E2D values for OCEUAEROR and OEUAEROR is shown. In this graph, x-axis and y-axis denote the number of nodes and their corresponding E2D values (in seconds). Through this analysis, it is observed that the OCEUAEROR protocol has minimized E2D than the OEUAEROR protocol. For 150 nodes, the E2D of OCEUAEROR is 4.2% minimized than OEUAEROR protocol.

4.3 PDR

It is the amount of the number of packets that are sent from the source to the sum of packets.

$$PDR = \frac{\text{Total number of received packets at destination}}{\text{Total number of packets sent from source}}$$

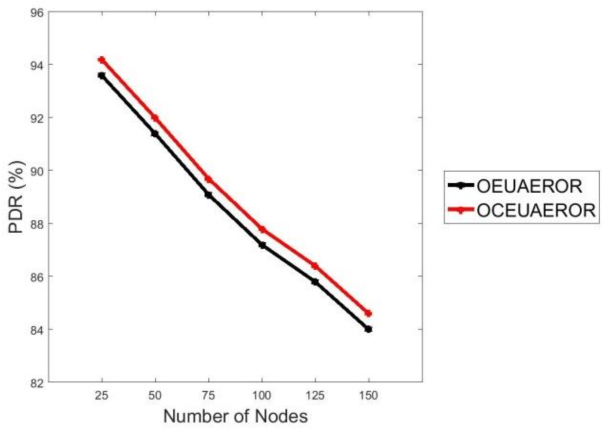

Fig 4:- PDR vs. Number of Nodes

Figure 4 shows the evaluation of PDR values for OCEUAEROR and OEUAEROR protocols. In this graph, x-axis and y-axis are the number of nodes and their respective PDR in %. Based on this analysis, it is observed that the OCEUAEROR protocol has increased PDR than the OEUAEROR protocol. For 150 nodes in the network, the PDR of OCEUAEROR is 0.71% increased than OEUAEROR protocol.

4.4 EC

It is the total energy used by the network during communication.

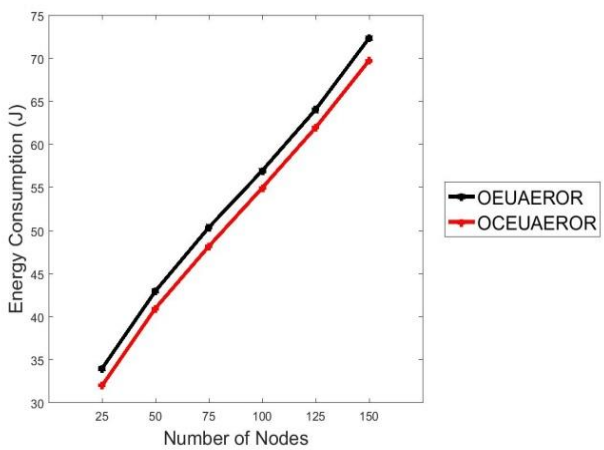

Fig 5:- EC vs. Number of Nodes

In Figure 5, evaluation of EC values for OCEUAEROR and OEUAEROR is illustrated. In this graph, x-axis and y-axis stand for the number of nodes and their respective EC in Joules (J). From this analysis, it is noticed that the OCEUAEROR protocol has decreased EC than the OEUAEROR protocol. When 150 nodes are considered in the network, the EC of OCEUAEROR is 3.6% less than OEUAEROR protocol.

4.5 NetLife

It is the maximum time taken by the nodes for communication.

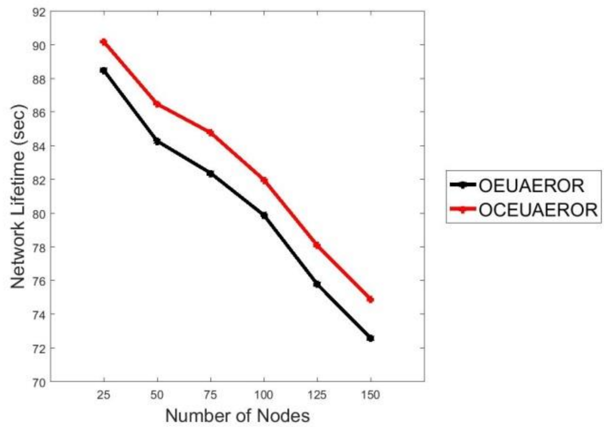

Fig 6:- NetLife vs. Number of Nodes

In Figure 6, evaluation of NetLife values for OCEUAEROR and OEUAEROR is shown. In this graph, x-axis and y-axis indicate the number of nodes and their corresponding NetLife in seconds. From this analysis, it is observed that the OCEUAEROR protocol has higher NetLife than the OEUAEROR protocol. If 150 nodes are taken, then the NetLife of OCEUAEROR is 3.2% higher than OEUAEROR protocol.

4.6 Control Overhead

It is the maximum size of packets sent from the source to the destination node.

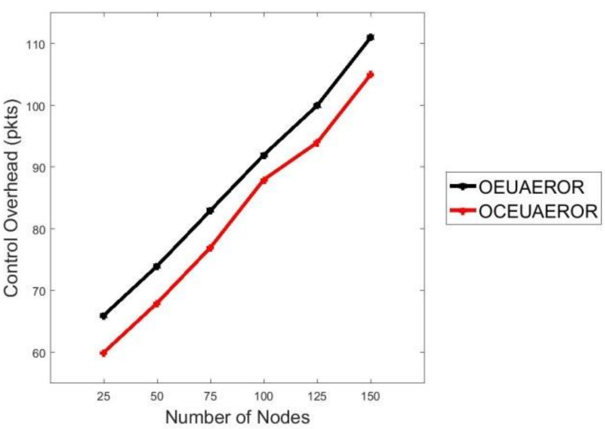

Fig 7:- CO vs. Number of Nodes

Figure 7 shows the evaluation of CO values for OCEUAEROR and OEUAEROR protocols. In this graph, x-axis and y-axis indicate the number of nodes and their corresponding CO in packets (pkts). From this analysis, it is observed that the OCEUAEROR protocol has minimum CO than the OEUAEROR protocol. For 150 nodes in the network, the CO of OCEUAEROR is 5.4% less than OEUAEROR protocol.

V. CONCLUSION

In this paper, an OCEUAEROR protocol is proposed by combining OEUAEROR protocol with SEC scheme for reducing the network traffic and improving the caching efficiency in MANETs. This protocol is executed based on the fact that the data packet at any node will have the data packets of that node and the missed data packets from its neighboring nodes. Also, the most appropriate caching positions for data packet replicas are chosen by using the GDS method. By using this protocol, the packet loss due to the network traffic is prevented with a high caching efficiency. Finally, the simulation outcomes proved that the OCEUAEROR protocol has an improved efficiency than the OEUAEROR protocol in terms of TP, E2D, PDR, NetLife, EC and CO.

REFERENCES

[1]. Dhenakaran, D. S., & Parvathavarthini, A. (2013). An overview of routing protocols in mobile ad-hoc network. *International Journal of Advanced Research in Computer Science and Software Engineering*, *3*(2), 251-259.

[2]. Kaur, R., Mahajan, R., & Singh, A. (2013). A survey on Multipath Routing Protocols for MANETS. *International Journal of Emerging Treands and Technology in Computer Science*, *2*(2), 42-45.

[3]. Ali, H. A., Areed, M. F., & Elewely, D. I. (2018). An on-demand power and load-aware multi-path node-disjoint source routing scheme implementation using NS-2 for mobile ad-hoc networks. *Simulation Modelling Practice and Theory*, *80*, 50-65.

[4]. Sridevi, U., & Kamaraj, K. (2019). Utility-aware enhanced reliable opportunistic routing protocol for mobile adhoc networks. *International Journal of Recent Technology and Engineering*, *8*(2), 4187-4194.

[5]. Sridevi, U., & Kamaraj, K. (2019). An optimization on economic utility-aware enhanced reliable opportunistic routing protocol for MANET. *Sylwan Journal, 163*(12).

[6]. Islam, N., & Shaikh, Z. A. (2010). Exploiting correlation among data items for cache replacement in Ad-hoc Networks. In *IEEE Second International Conference on Information Management and Engineering*, pp. 614-617.

[7]. Arya, V., & Gandhi, C. (2014). NDj-AODV: Node disjoint multipath routing in Mobile Ad Hoc Networks based on AODV protocol. In *IEEE Seventh International Conference on Contemporary Computing*, pp. 601-606.

[8]. Deshmukh, S. R., & Raisinghani, V. T. (2014). EALBM: Energy aware load balancing multipath routing protocol for MANETs. In *IEEE Eleventh International Conference on Wireless and Optical Communications Networks*, pp. 1-7.
[9]. Femila, L., & Vijayarangan, V. (2014). Transmission power control in mobile ad hoc network using network coding and Co-Operative Communication. In *IEEE International Conference on Communication and Network Technologies*, pp. 129-133.
[10]. Salem, M. A., & Yadav, R. (2016). Efficient load balancing routing technique for mobile ad hoc networks. *International Journal of Advanced Computer Science and Applications*, *7*(5), 249-254.
[11]. Gawas, M. A., Gudino, L. J., & Anupama, K. R. (2017). AMCCR: Adaptive Multi-QoS Cross-Layer Cooperative Routing in Ad Hoc Networks. *Journal of Computer Networks and Communications*, *2017*.
[12]. Larbi, A., Bouallouche-Medjkoune, L., & Aissani, D. (2018). Improving cache effectiveness based on cooperative cache management in MANETs. *Wireless Personal Communications*, *98*(3), 2497-2519.