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Original Article

Enhancing MANET Battery Life and Performance Using Cluster Node

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Abstract *- One of the commonly used wireless communications is a Mobile Ad hoc Network that can be formed without the need for any access point and is also able to make an instant communication network wherever it is needed. Every node's operation for transmission and receiving the packets is based on the internal battery. To provide the lifetime of the internal battery needs more research to overcome the difficulties. Many research work proposes several methods to improve the battery power in the nodes, but all the works have some limitations and are not able to improve the battery lifetime. This article focuses on improving the nodes' internal battery by using the cluster node, which is chosen by using the cluster node forming methods and assigned the responsibility of the cluster node to overcome the battery wastage. The proposed work is simulated using the Network simulator in Ad Hoc On-demand Vector protocol named CN-AODV to compare the performance, the latest techniques of cluster nodes called CN-AODV, and comparison analysis done with leach cluster named LC-AODV, Clustering Algorithms called CA-AODV with the parameters of power, energy consumption, cluster accuracy, network lifetime, cluster head lifetime, delay, link connectivity and node mobility. The results revealed that proposed work power utilization is 50 % and 25%, less energy consumption is 15% and 25%, the cluster accuracy was 10% and 20%, lifetime is 5% and 10%, network lifetime is 5% and 15%, node mobility time 5% and 15%, connectivity is 5% and 30%, Delay 25% and 30% less time than LC-AODV with CA-AODV respectively.*

Keywords *- MANET, Lifetime, Cluster node, Node mobility, Node connection.*

1. Introduction

Mobile Ad hoc Network (MANET) is a type of wireless communication device which does not need any infrastructure as well as an access point for packet flooding. While making use of the MANET communication, the protocol stack of all the layers is subject to some limitations, such as antenna usage, Hidden and Exposed nodes, routing, and security and power factors. These are supported for better Quality of Service (quality of service) [1] to the MANET nodes. The backbone of proving this quality of service is done with the support of better power management [2]. Most of the time, more power is consumed by the nature of the MANET nodes, like mobility, frequent topological changes, internal battery failure, unwanted packet flooding, and, finally, intruder activities. Several methods and techniques were proposed to eliminate the power utilization of the MANET nodes. Initially, various kinds of MANET protocols [3] were invented to prevent battery power usage, with the support of power-related routing protocols [4]. Later, to improve the battery performance, the gearbox method was introduced [5]. Various power optimization techniques were [6] invented in MANET to support better power management by avoiding overhead.

More number of research papers have been invented to improve the performance of the AODV protocols, such as AOMDV [7], SQR-AODV [8], AODV-BR [9], AODV-RD [10], AODV-BR [11], ATOMDV [12], and AMORLM [13].

Later many modern techniques like Artificial Intelligence neural network-based power optimization were introduced to support the network efficiency and performance [14]. The invention of the Fitness function, along with MANET nodes was named FFAOMDV, has provided the power consumption [15]. EMBOA invented a butterfly optimization approach combined with machine learning to strengthen multipath routing [6].

Geographical positioning monitoring provides an algorithm along with the AODV protocol called PEO-AODV to overcome power difficulties using the hop count parameters [16]. GPS and long-range technologies using the Receiving Signal Strength Indicator-based (RSSI) [17] from the receiver strength were supported for power optimization. LEACH protocol [18] with cluster node selection was supported for node lifespan with energy distribution. Finally, the MANET security and clustering algorithms were supported for battery power issues [19].

MANET supports various power management strategies via a routing protocol, as well as the most recent techniques of machine learning, artificial intelligence, and clustering, to optimize node battery power and lifetime. Still, more study is required to improve the MANET's battery power. This research article focuses on the optimization of power by forming the cluster nodes to support the internal node parameters and making minor changes to the MANET's operating principles. The article is planned to be organized as follows: Section II summarizes the various existing power optimization methods used in MANET, Section III proposes the cluster node forming with the support of algorithm and cluster node responsibility, Results and Discussion given in Section IV, and finally conclusion and Future work in Section V.

2. Research Related Work

2.1. Energy Optimization Based on Cluster Head

Several writers claim that a cluster head-forming-based protocol can extend the life of MANET nodes. The Author [20], uses the ORS methodology of Clustered Head Forming Technique, which produces faster throughput, reduced latency, lower jitter, and lower PDR than other methods. Venkatesh created the HAMBOCHLD method for energy optimization for MANET, and simulation results show that energy waste is reduced to the projected amount.

Goyal [21] presented the HAODV cluster head protocol, which resulted in improvements in PDF, END, and routing overhead. The EECAO clustering model is used by Raj Kumar and Bala [22] for a battery power analysis, but the approach results in a lengthy life lifetime for the MANET nodes. Although two cluster heads are necessary, the researchers in [23] apply the ACO approach, and the cluster heads produce Network Lifespan and Residual Energy. Al-Najjar, A.A.M. [24] uses PDR and NLT methodologies to establish a Uniform Distribution of Energy. Finally, Devika and Sudha [25] developed the C-SEWO innovation design for developing cluster head forms that can enable various unique clustering head-based protocols.

2.2. Energy Optimization Based on Mobility Aware Cluster

Hybrid clustering and mobility-aware approach study could improve the battery power of MANET nodes. To mitigate route failure, the authors Braik et al. [26] use the AGS-ROA mobility aware cluster technique.

Venkatasubramanian [27] use EPO-FGA method for Mobile Node's Lifetime, Hamza and Vigila [28] employ cluster HPSO-GA methodology for node energy improvement, Hamza and Vigila use the EEMST approach [29] for energy optimization, yet the research yielded Sivapriya and Mohandas [30] discovered that the MKMPE technique resulted in increased packet loss rather than optimization.

Saravanan et al. [31] proposed an efficient clustering technique for maximizing MANET node power. The writers Bisen et al. [32] proposed the E-MAVMMF approach for the best performance outcome, while the authors Arulprakash et al. [33] proposed the EBDC method and attained the aim.

According to the study of related work, all of the research work carried out by cornering a specific domain in the MANET, such as routing, mobility, clustering, and hybrid approaches transmission range, also achieved success but other methods created bad results. More research is required to carry out power optimization in MANET. This research study focuses on forming the cluster node and assigning responsibility to the cluster nodes to overcome the unwanted power consumption of the MANET nodes.

3. Cluster Node Architecture

The following factors of internal node parameters and MANET operating principles change are included in the system model established for this research work. Internal node parameters include aspects such as needless packet forwarding, optimal node muting, and beacon signal utilization. MANET operating principles have been modified by including the Sleep and Awake protocols.

3.1. Cluster Node Estimator

The forming of the cluster nodes is based on the internal parameters of the nodes which are in the same region. Based on battery power, mobility, link lifetime, and node mobility, one of the nodes in each region will become the cluster node. A cluster node will have the highest value of node life duration, connectivity, and battery power and the lowest value of node mobility and distance.

3.1.1. Lifetime of the Link

For connecting two nodes and sending packets, the lifetime of each link is required. Because of changes in dynamic topologies, the link in MANET may disconnect; hence, the life duration of the link should be determined in advance before picking the route. This could be calculated using an energy model Equation (1).

$$Nn = \frac{1}{f}\sum_{g=1}^{f} \mathrm{Eg} \qquad (1)$$

Where E_g Energy Dissipation of g^{th} node

3.1.2. Node Mobility

Mobility of the node is an important factor in MANET, which is calculated using Equation (2).

$$Nm = \frac{1}{|ph|}\sum_{g=Ph} \mathrm{Bg} \qquad (2)$$

$|p_h|$ - Set of neighbor nodes, Bg relative mobility

3.1.3. Node Distance

Distance between the nodes used to estimate the link stability, which is evaluated using the formula which is estimated using Equation (3)

$$Rn = \sum_{fg=1} (\mathrm{Ug}, \mathrm{Ph}) \qquad (3)$$

$where\ Ph - \ Set\ of\ neighbour\ nodes$,
$Ug\ Energy\ of\ current\ node$
Where Ph – Set of neighbour nodes,
Ug Energy of current node

3.1.4. Node Power

Node power is an essential parameter in MANET. The highest node power node will be the cluster Head node, which is estimated using the formula in Equation (4)

$$P = \sum_{ng=1} \mathrm{Mmax} * \frac{Mmin}{Mg} \qquad (4)$$

$n - \ total\ nodes\ \ where\ g\ between\ 1 < g < n$
$Mmax\ is\ Maximum\ power\ of\ the\ node$
$Mmin\ represent\ the\ receiving\ power\ of\ the\ node$
$Mg\ \ -\ g\ th\ node\ receiving\ power$

3.1.5. Connectivity

Creating the bidirectional link between two nodes is called connectivity, which is computed using the formula in Equation (5)

$$Ch = \frac{1}{f}\sum_{ng=1}^{n} \frac{Cg}{e} \qquad (5)$$

$where\ Cg\ named\ as\ gth\ connectivity$,
$e\ total\ number\ of\ nodes\ connections.$

3.2. Algorithm Forming Cluster Node

The cluster node forming is based on the cluster node algorithm given in Algorithm I, All the nodes estimate the parameter value called Node Parameter, which is in the format of NP = < lifetime, node power, node mobility, connectivity, node distance >. This NP value is forwarded to other nodes, as shown in Figure 1. Cluster node selection is determined by the Algorithm I.

Algorithm I Steps for Cluster Head Forming

1. Let the MANET have N number of nodes from n1 to Nn
2. All the nodes generate the NP parameters and send them to all other nodes in the same region. There is no flooding of parameter values.
3. Nodes which are in the same region receive the other nodes parameter values.
4. Node compares the other nodes' parameter values; if the node parameter value is higher, than the node becomes a cluster node.
5. Receive the N number of region and Number of Cluster nodes. R1, R2, R3 ...Rn - Regions where each region Ri having a set of N number of nodes, among one node will be a cluster node.
6. For each Region Ri, the Cluster node does follow
   - (I)Collect the route for other clusters
   - (II) Forwarding the data packet to the node
   - (III) Generate beacon signal if needed
   - (IV) Reply to RREQ and RREP messages

4. Simulation Results and Discussion

This proposed work of Cluster node-based energy optimization technique implemented using AODV protocol named CN- AODV, and other methods considered for the comparison analysis are LEACH protocol [18] with cluster nodes selection was named as LC-AODV, clustering algorithms based work [19] was named as CA-AODV.To make the simulation, the network simulator NS2.34 was taken for the simulation study and the simulation parameters are listed in TABLE I.

The simulation dimension was 1500*1500 Sqm, and an Omni directional antenna was selected for the physical layer rather than using the other beam sector antennas. Totally 200 nodes are taken for the simulation; initially, 50 nodes are defined, and slowly, the node count increases by 50 to reach 200 count in every 30ms. The suggested parameters taken for the performance analysis are power, energy consumption, cluster accuracy, network lifetime, cluster head lifetime, delay, link connectivity and node mobility.

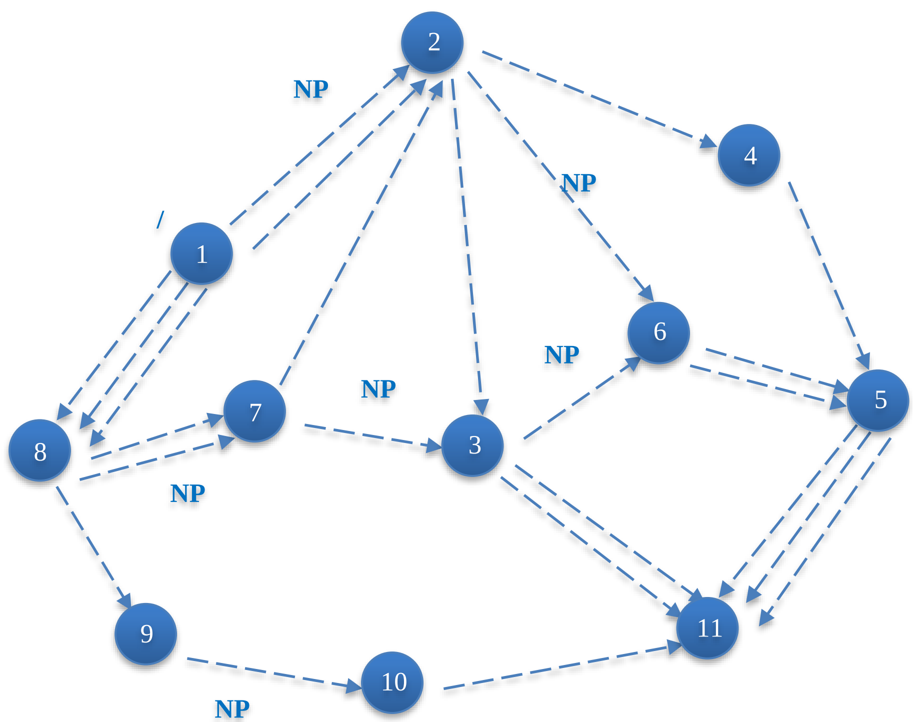

Fig. 1 Cluster node selection

Table 1. Simulation set up

Simulation Parameter	Value set
MANET Network Interface	Wireless Physical Interface
Dimension	1500 * 1500Sq.m
Antenna Defined	Omni Antenna
Number of nodes	50,100,150,200
Link count	20 -50
Source Transmission Type	Constant Bit Rate Transmission
Each Packet size	512 Bytes
Buffer Size	60 Packets
MAC Layer used	802.11b
Simulation Defined Model	Random
Propagation model	2 Way Ground
Maximum node speed	30m/s
Pause Time	30 s
Number of packets sent between the interval	2Packets
Time set for Simulation	50 sec, 100 sec,
Initial node Energy	240 Joule
Each Node transmission power	0.9 J
Each Node receiving power	0.4J
Sleep Power	0.002J
Changeover Time	0.009s

4.1. Power Analysis

The power analysis comparison was done between the proposed CN-AODV with CA-AODV and LC-AODV protocols works, which shows that the proposed CN-AODV consumes less power. Totally 10 data packets and 5 synchronization packets, 2 beacon signals, and 15 RREQ and RREP signals were flooding among the MANET communication; CN-AODV cleverly CN-AODV maintains the constant power even when the node count increases due to the reason of efficient cluster nodes forming, which avoided the one beacon signal forwarding since there is no mobility, cluster nodes answers the RREP signals. The comparison among the three protocols is shown in Figure 2, where the power utilization is 50 % less than the LC-AODV and 25% less than the CA-AODV protocol [34].

4.2. Energy Consumed

The most important parameter related to the research title is energy consumed. From the simulation parameter, there are 200 nodes, and the initial energy assigned to individual nodes is 240 joules, and each transmission receives 0.9 and 0.4 J; when the nodes are in sleep, it consumes 0.002J. Initially, 50 nodes and cluster forming were done, and slowly, the node count was increased to reach 200 and energy consumed for the 10 data packets 1 beacon signal, was estimated. The results found that the proposed CN-AODV consumed less energy because only the data packet was floating among the nodes. The comparison graph shown in Fig 3 which depicts the proposed CN-AODV method with less energy at 15% compared to LC-AODV and 25% compared to CA-AODV.

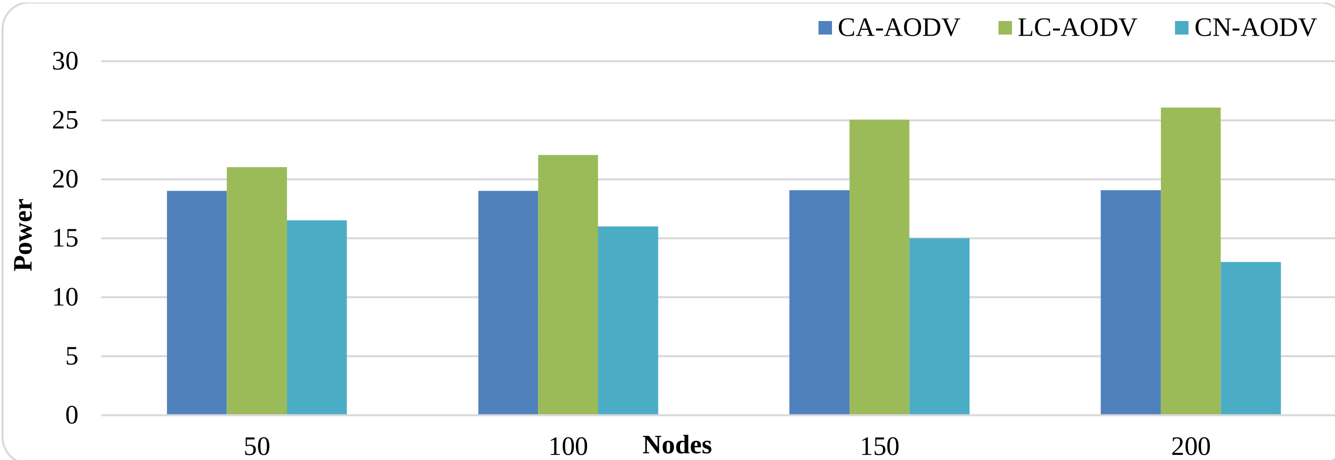

Fig. 2 Power analysis

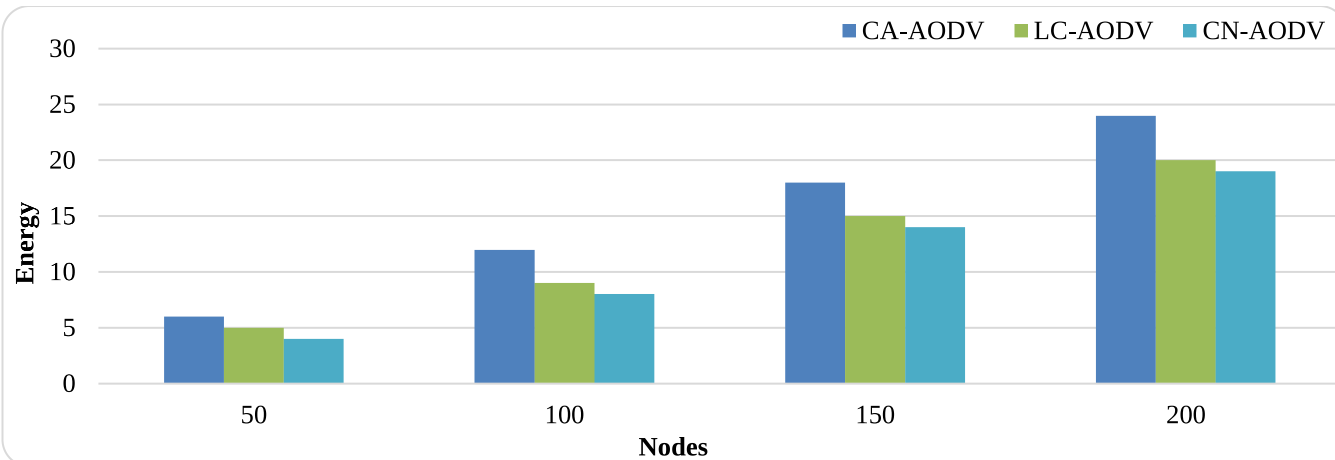

Fig. 3 Energy consumed

4.3. Cluster Accuracy

The cluster node is formed for making all the transactions through the nodes; the accuracy of the cluster node was compared with the other existing methods of CA-AODV and LC-AODV, which is shown in Figure 4; the cluster accuracy of the proposed CN-AODV was 10% highest than LC-AODV and 20% higher than the CA-AODV.

4.4. Cluster Node Lifetime

The cluster node lifetime of the proposed AD-AODV was compared with the LC-AODV and CA-AODV methods, which are shown in Figure 5; the proposed CN-AODV lifetime is 5% higher than the LC-AODV and 10% higher than the CA-AODV due to the proposed cluster nodes responsibility.

4.5. Network Lifetime

The Network lifetime of the proposed AD-AODV was compared with the LC-AODV and CA-AODV methods, which are shown in Figure 6; the proposed CN-AODV network lifetime is 5% higher than the LC-AODV and 15% higher than the CA-AODV.

4.6. Node Mobility

The Network lifetime of the proposed AD-AODV was compared with the LC-AODV and CA-AODV methods, which are shown in Figure 7; the proposed CN-AODV node mobility time takes more time that is 5% higher than the LC-AODV and 15% higher than the CA-AODV.

4.7. Node Connectivity

The number of nodes a cluster node has connected to the proposed AD-AODV was compared with the LC-AODV and CA-AODV methods, which are shown in Figure 8.

The proposed CN-AODV connecting more nodes is 5% higher than the LC-AODV and 30% higher than the CA-AODV.

4.8. Delay

The cluster nodes forming delay of the proposed AD-AODV were compared with the LC-AODV and CA-AODV methods, which are shown in Figure 9. The proposed CN-AODV takes 25% less delay time than the LC-AODV and 30% less time than the CA-AODV.

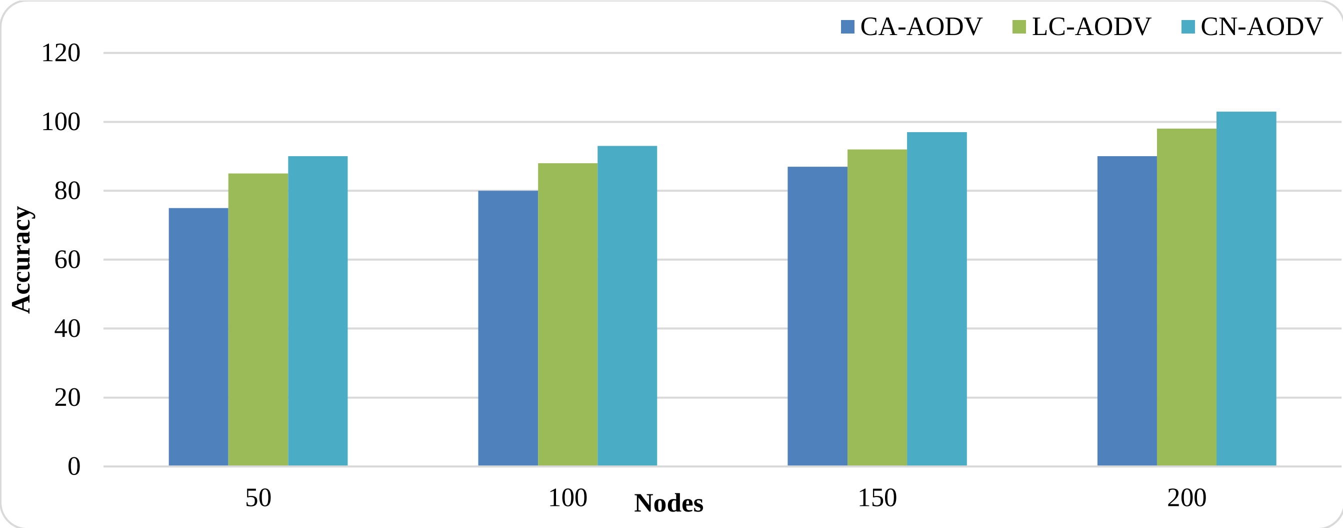

Fig. 4 Cluster accuracy

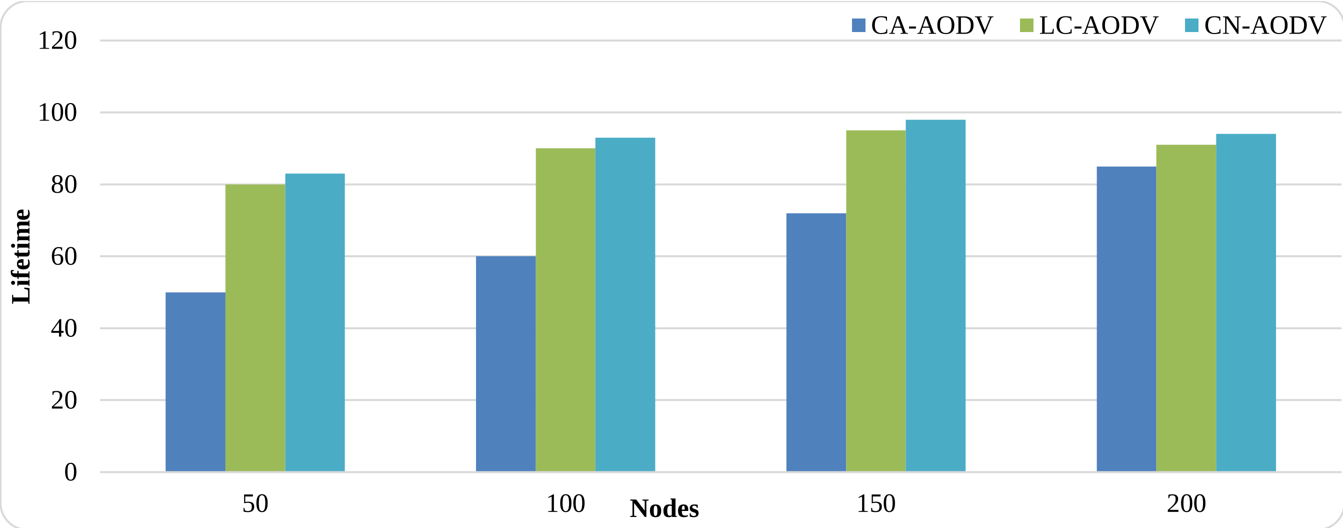

Fig. 5 Cluster node Lifetime

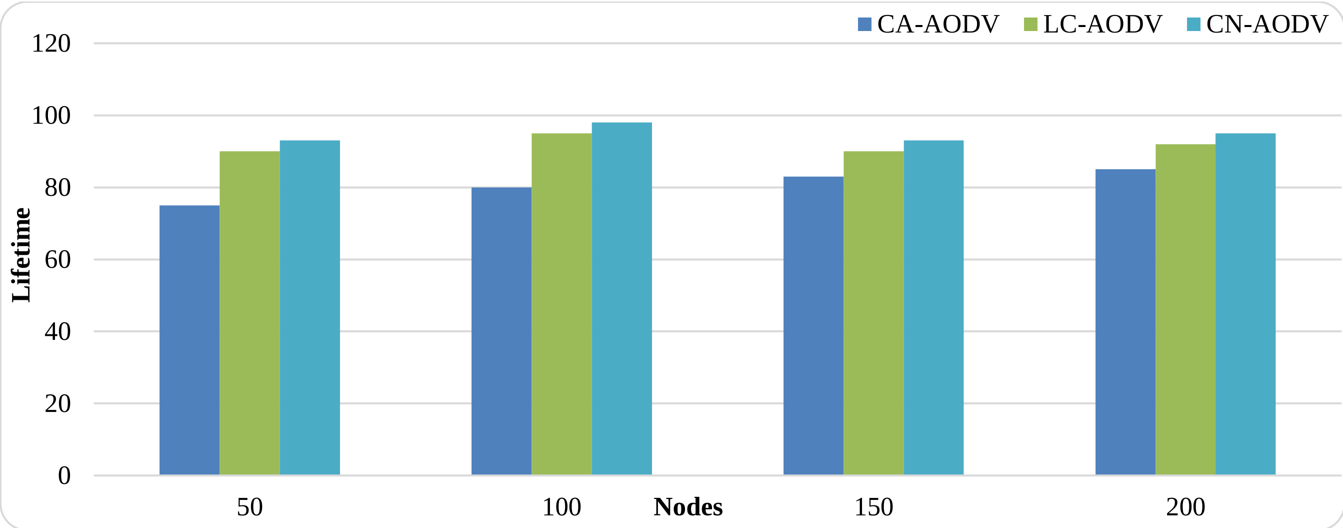

Fig. 6 Network Lifetime

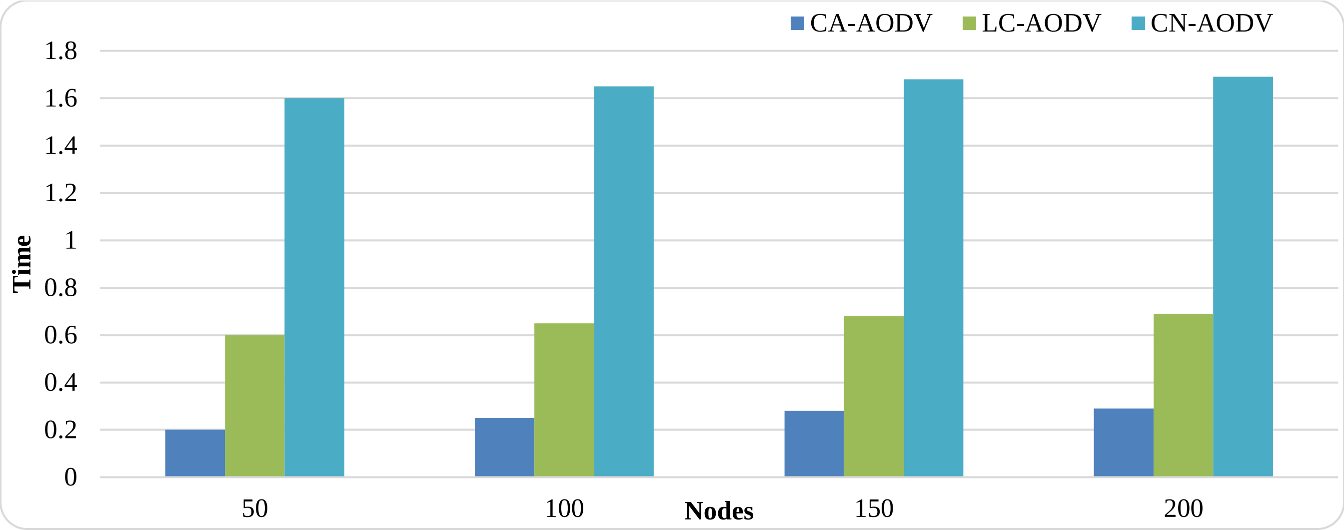

Fig. 7 Node mobility

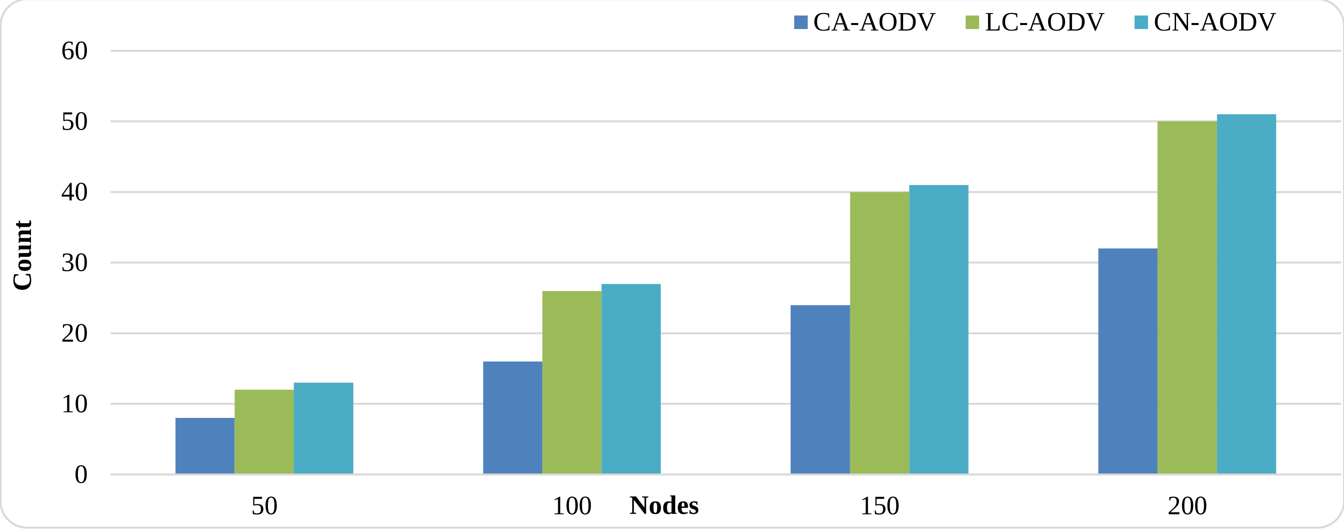

Fig. 8 Connectivity

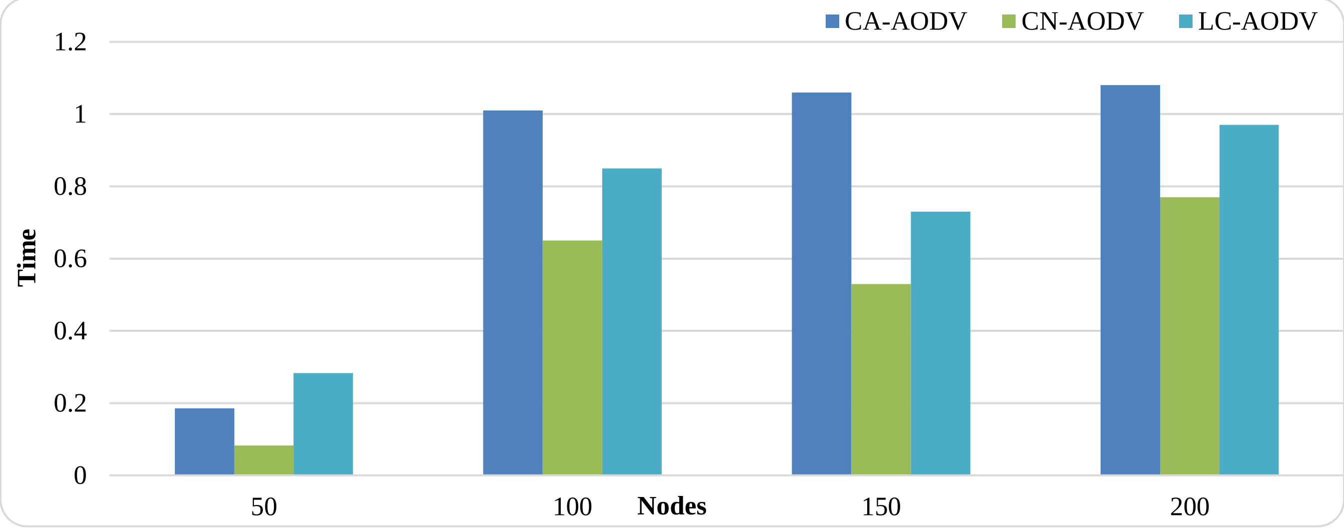

Fig. 9 Delay

5. Conclusion and Future work

This article proposed a novel algorithm to improve the lifetime of the Mobile Ad hoc Network nodes and improve the performance of the nodes. This is achieved by forming the cluster head and assigning the responsibility of the cluster node. The proposed work simulation was done with the support of NS2.34 and called CN-AODV. Comparison analysis done with LC-AODV, CA-AODV with the parameters of power, energy consumption, cluster accuracy, network lifetime, cluster head life time, delay, link connectivity and node mobility. The results revealed that proposed work power utilization is 50 % and 25%, less energy is 15% and 25%, the cluster accuracy was 10% and 20%, lifetime is 5% and 10%, network lifetime is 5% and 15%, node mobility time 5% and 15%, connectivity is 5% and 30%, Delay 25% and 30% less time than LC-AODV with CA-AODV respectively. In future, this work could be enhanced to other protocols.

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