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BEACON SIGNAL AND SLEEP AND AWAKE STRATEGY IN MANET FOR POWER ENHANCEMENT

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ABSTRACT

In Mobile Adhoc Networks (MANETs), efficient battery management is crucial for maintaining device longevity and ensuring stable network communication. A device's battery depletion during active communication can disrupt the entire network and necessitate packet retransmission, causing inefficiencies. Although various strategies, such as optimal routing protocols, optimization techniques, and duplicate packet elimination, have been explored to manage battery power, these approaches still require specialized power-saving mechanisms. This study introduces a novel strategy using beacon signals combined with sleep and awake cycles for network nodes to optimize power consumption and enhance communication reliability. A cluster-based approach is adopted, where a designated Cluster Head (CH) is responsible for managing beacon signals and coordinating sleep and awake schedules across the nodes. This method, termed CHSAB-AODV (Cluster Head Sleep-Awake Beaconing with AODV), was evaluated using Network Simulator 3 (NS3) and compared against traditional AODV implementations. The simulation results indicate that CHSAB-AODV outperforms standard AODV protocols, reducing power consumption by 25% to 50% while maintaining communication efficiency. This significant improvement highlights the effectiveness of beacon-based sleep and awake strategies in addressing power management challenges in MANETs.
Keywords: *MANET , Beacon Signal, Sleep And Awake , Power Management* ,

1. INTRODUCTION

A key factor in maintaining dependable connections in Mobile Adhoc Networks (MANETs)—self-organizing, infrastructure-limited networks used for a variety of applications needing immediate access—is the usage of internal batteries. In situations such as crisis management, where MANET deployment is essential, a dead battery can completely stop communication. Power management techniques must be used effectively in order to prolong battery life. To address the challenges faced by MANETs, such as frequent topological changes, packet forwarding failures due to buffer capacity constraints or internal threats, and collisions resulting from hidden and exposed terminal issues, Numerous routing protocols have been put forth.. These issues all have an impact on the quality of service provided by MANETs.

Reducing gearbox power while simultaneously lowering energy consumption is the first step in traditional tactics for improving MANET battery performance [3]. Packet route selection is a part of power transmission. The topological ordering of MANET nodes dictates routing. A number of novel routing protocol types [4] and several MANET protocols [5] are proposed to address battery power management. Recently, other research articles, such as AOMDV [7], SQR-AODV [8], AODV-BR [9], AODV-RD [10], AODV-BR [11], ATOMDV [12], and AMORLM

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[13], have been published in an effort to improve battery life through the AODV protocol.

In order to improve power management, efforts are concentrated on lowering MANET overhead, which is a critical component of MANET topologies that minimize battery power usage. Numerous optimization techniques aim to achieve this goal. For example, the LEACH protocol's cluster node selection increases longevity by distributing energy [14]. While AI neural network-based MANETs optimize energy utilization, hence supporting network efficiency and overall performance [16], FFAOMDV adds a fitness function to reduce power consumption [15]. Furthermore, extended MANET utilization has been shown by GPS and long-range technologies, which utilize signal strength indicators (RSSI) from receivers [17]. EMBOA [18] efficiently reduces energy consumption to improve multipath routing by fusing butterfly optimization approaches with machine learning methodologies. Clustering techniques address vulnerabilities in MANET security attacks and help to address battery power issues.

Nodes use estimated hop count parameters and geographic position monitoring in the PEO-AODV algorithm [20] for MANETs to deal with power problems. In order to maximize node battery life and power, MANETs use powerful machine learning, artificial intelligence, and clustering techniques in addition to routing protocols. Nevertheless, more investigation is required to improve MANET life. This study focuses on optimizing power using internal node configurations and small modifications to MANET operating principles. Internal settings are used to control beacon signal usage, deactivate idle nodes, and stop unnecessary packet forwarding. A network simulator will be used to mimic this altered operational concept, and the results will be compared to the most recent methods for power optimization.

The core concern of this research is rooted in the critical importance of battery management within Mobile Adhoc Networks (MANETs), where devices operate in a decentralized and dynamic environment. In MANETs, devices function as both endpoints and relay nodes, meaning that unexpected battery depletion can not only disconnect a single device but also disrupt entire communication paths, forcing packet retransmissions and reducing network efficiency. Existing approaches, such as optimized routing protocols and packet reduction techniques, primarily address the effects of power depletion but often lack strategies to directly and efficiently manage power at the node level. Furthermore, devices in MANETs are typically resource-constrained, with limited computational power and energy capacity, making efficient energy utilization essential for sustaining reliable communication. As MANETs continue to be deployed in various critical applications, such as disaster recovery, military communications, and remote monitoring, maintaining battery life while ensuring consistent network performance is a growing necessity. Therefore, this study focuses on developing effective power management strategies to address these core challenges and enhance network longevity and reliability.The arrangement of the article is as follows: Section II provides an overview of the many power optimization techniques that have been employed in MANET up to this point. Section III suggests the ideas behind how MANET operates. Section IV talks about the simulation setup that was used to carry out the research. Section V wraps up and presents the findings.

2. RESEARCH WORK

With an emphasis on different categorization parameters, this section offers a thorough review of the energy optimization methods used in MANET technology since its beginnings. A great deal of research has been done in the field of mobility awareness. Some of the subjects that have been covered in this research include topology management, algorithms, cluster head techniques, mobility aware clusters, and transmission range adjustments.

In order to maximize battery life, a group of authors studied movement awareness in MANET. To do this, their work introduced a number of techniques and adjustments. To optimize battery power utilization, for example, AL-Gabri et al. [21] presented the LEA-AODV approach. Alghamdi [25] modified MANET messages' power management strategies effectively by using the LBMMRE-AOMDV algorithms. In order to lower battery power consumption, Woungang [22] also introduced RREQ modification in MANET REQ messages. Route Energy Comprehensive Index techniques were used by GU and Zhu [23] to optimize energy in route selection strategies. Moreover, Li and Yuan [24] optimized node transmission by using Network Lifetime as a parameter. These various methods and MANET strategy adjustments have successfully controlled power consumption within reasonable bounds.

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An additional research team focuses on how topological management helps MANETs save energy. These authors have created a number of routing protocols using novel techniques and algorithms. An Optimized Power Control method was presented by Rashmi Chaudhry and Shashikala Tapaswi [26], while the innovative M_AODV protocol was developed by Xin Ming Zhang et al. [27]. The POR technique for energy optimization was proposed by Santhi Sri et al. [29], while T. et al. [30] created the Secure Optimized Link State Routing Protocol for energy control. Furthermore, Rao and Singh [32] presented the KF-MAC technique, which was successful in improving Quality of Service (QOS) metrics but had difficulties with delay management. Sridhar et al. [31] also presented the TESAODV protocol. This study avenue makes a substantial contribution to the reduction of power usage.

Several research groups concentrate on applying contemporary methods to accomplish power optimization in MANETs. These authors have created a number of techniques meant to boost MANETs' residual energy. An strategy based on the SNDA method was developed by MUSTHAFA et al. [33]; it produced reliable communication but lacked security features. A Game Theory was used for energy optimization by Vij et al. [34]. Nobahary and colleagues [35] utilized the Credit-Based methodology. The IDSM approach was introduced by Veeraiah et al. [36], and the NCV-AODV protocol for MANET routing was implemented by Abirami et al. [37].

While Jim [38] made use of artificial intelligence technologies, Ponnusamy et al. [39] suggested an energy-efficient approach. The MSD-SNDT methodology was created by the authors [40], and a fuzzy-based approach was provided by the authors in [41]. While Hadi et al. [43] used AODV, Nobahary et al. [42] presented a game theory approach. A methodology based on cluster head generation, according to many experts, can successfully extend the life of MANET nodes.To achieve power optimization, clustering techniques have been used extensively in MANETs recently. The ORS methodology was introduced by Suresh Kumar, R. [44], and the HAMBOCHLD method for MANETs was established by T. Venkatesh [45]. The EECAO clustering model was used by Raj Kumar and Bala [47], whereas Author [46] introduced the HAODV cluster head protocol. To attain a consistent distribution of energy, Al-Najjar [49] used PDR and NLT techniques, while another author [48] applied the ACO methodology. Lastly, the C-SEWO innovation design for clustering in MANETs was created by Devika and Sudha [50].

Related studies indicate that power optimization has been successful for research projects that concentrate on particular MANET areas, like routing, mobility, clustering, and hybrid techniques. It should be mentioned, nevertheless, that alternative techniques have produced even better node optimization outcomes. Notwithstanding these developments, more investigation is still required to examine power optimization in MANET by utilizing more internal factors without taxing the devices' capacity. By concentrating on modifying internal node settings utilizing beacon signals and sleep-awake techniques inside MANET operating principles, this research study seeks to close this gap and achieve efficient power optimization.Considering how often beacon signals are used in MANETs to update node location and status, optimizing device utilization can be achieved using a straightforward but powerful approach. A method that effectively controls the awake and sleep states of nodes can be implemented to greatly enhance power optimization. In order to more efficiently conserve power resources, non-communicating nodes are switched from being continually awake to sleep mode.

The efficient management of battery power in Mobile Adhoc Networks (MANETs) remains a significant challenge due to the inherent limitations of decentralized networks and the resource constraints of mobile devices. Despite advancements in routing protocols and packet optimization techniques, existing solutions often fail to directly address the real-time battery management requirements within nodes, leading to communication disruptions and reduced network longevity. This creates an urgent need for strategies that can dynamically optimize power consumption while maintaining communication reliability and network stability.

3. SYSTEM ARCHITECTURE

From the literature survey reveals that the efficient use of internal parameter could support the power optimization in the MAENT nodes. This research article has focuses on the two parameter named as Beacon signal and Sleep and Awake strategy usage. Both of this proposed concepts is achieved with the support of the cluster head forming, and forming the cluster head is based on the nodes battery, life time, mobility etc.

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Cluster Head forming

This proposed work of the beacon signal and the sleep and awake strategy is done after making the cluster head forming from the group of the nodes. The cluster head forming has a following stage of collecting the data .

Algorithm I Cluster head forming

Step 1 : Collect the total nodes in the MANET, Let us say M= {N1,N2,..Nn}

Step 2; Use nodes location form a group of nodes, Let us take the M is the total node and Group of nodes are G1= {G1N1, G1N2...G1Nn}, G2= {G2N2, G2N2...G2Nn}, ...Gn= {GnN2, GnN2...GnNn}

Step 3: For each group to form the Cluster Head, the entire group share the life time, Residual Energy, mobility to other nodes. Cluster head forming is done with the lower level of energy utilization, To optimization of the energy consumed by each node forwarding the life time and Residual Energy and Mobility to other node based on the life time and residual energy. If the received packet value is more than the current node value then this details will be forwarded otherwise the details of the current node will be forwarded. Such a details float in to the MANET nodes clusters to form the cluster head. This technique optimized the energy spent for unwanted packet forwarding to the next hope. If the node has more residual energy compared to other nodes residual energy, then the node itself nominate to all nodes about the cluster head.

Step 4. Cluster head details send to the other nodes.

From the Figure 1, node 0 send < LT,RE,M> details to the node 1, node 2, node 3, then this node forward the < LT,RE,M> value of the node0 the next hop of node 4, node 5, only the < LT,RE,M> is higher than the node 1 value otherwise node 1 send the its < LT,RE,M> to the next hope. This strategy supports for floating the unwanted packets as well as optimize the energy used for the floating. This technique used by the other nodes to choose the cluster head, finally cluster head node announced by them self's to other nodes.

Role of the Cluster Head

The suggested CHSAB-AODV framework is implemented and assessed with NS3, and the results show that it outperforms the usual AODV protocol. Notably, CHSAB-AODV improves battery power optimization. This breakthrough provides the possibility for its inclusion into other MANET protocols, which will broaden its benefits across the network.When a MANET operates, each node is responsible for forwarding packets to the subsequent hop. This frequently results in an excessive number of identical packets traveling through the network, which consumes a lot of energy. In order to address this problem, the Cluster Head takes on the duty of blocking duplicate packet transfers to cluster head nodes, which lowers the amount of energy that is wasted throughout the network.

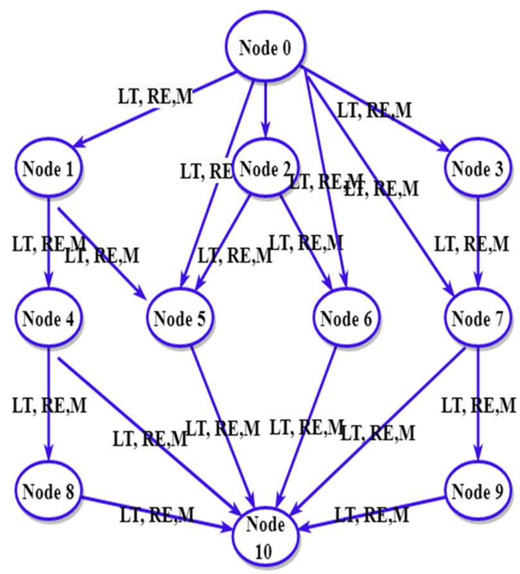

Figure 1.*Cluster Head Forming*

Ideal node mute

on order to efficiently conserve energy, the cluster head sets a node to sleep when it is not on the transmission line. The node awakens in response to a beacon signal, evaluating its state and deciding whether further action is needed. By preventing energy from being lost while nodes are idle, this method maximizes power usage inside the MANET.

Beacon signal usage

The principal aim of employing beacon signals is to bring all nodes in the MANET into synchrony. Beacon signals are sent by cluster head nodes when they are not actively involved in transmission activities. These three tactical steps are sensible suggestions to help MANET nodes lower their power consumption.

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The Beacon Signal is a mathematical equation often used in wireless communication and signal processing, specifically in the context of MANETs. beacon signal equation used in MANETs:
RSSI=Pt −L(d)+Gt+Gr−Ploss --------(1)
Where:

- RSSI is the Received Signal Strength Indicator.
- Pt is the transmitted power.
- L(d) is the path loss at distance d.
- G_t is the gain of the transmitting antenna.
- G_r is the gain of the receiving antenna.
- P_{loss} represents any other power losses in the system.
-

Sleep and awake strategy

Another major role perform by the cluster node is setting the sleep and awake strategy. Cluster node makes the tag nodes between the nodes as shown in the figure .Among the node one node will be sleep state and another node will be in awake state. This will be initiate by the cluster head and making the tag node is done the nodes which are neighbour each other .
In Mobile Ad Hoc Networks (MANETs), energy conservation is crucial due to the limited battery life of mobile nodes. Sleep and awake strategies are used to manage energy consumption efficiently. These strategies involve nodes periodically transitioning between sleep (low-power) and awake (active) states.

1) Basic Concepts

- **Sleep State**: The node powers down most of its components to save energy but cannot send or receive data.
- **Awake State**: The node is fully powered and can send and receive data.

2) Equations and Strategies

a) 1. Duty Cycling

Duty cycling is a common strategy where nodes alternate between sleep and awake states according to a predefined schedule.

Duty Cycle(%)= $\frac{Tawake}{TSleep+Tawakw} * 100 - - - -(2)$

Where:

- T_{awake} is the duration the node stays awake.
- T_{sleep} is the duration the node stays asleep.

2. Energy Consumption Model

The energy consumed by a node can be modeled considering the energy used in both states.

$E_{Total} = E_{awake} * T_{Awake} + E_{sleep} * T_{sleep}$ ---------- (3)

Where:

- E_{total} is the total energy consumption.
- E_{awake} is the energy consumption rate in the awake state.
- E_{sleep} is the energy consumption rate in the sleep state.

b) 3. Sleep Scheduling Algorithms

Various algorithms can be used to determine the sleep and awake times for nodes. Below are a few common strategies:

a. Static Sleep Scheduling
Nodes follow a fixed sleep-awake schedule.
Tcycle=Tawake+Tsleep ------- (4)
b. Adaptive Sleep Scheduling
Nodes dynamically adjust their sleep and awake times based on network conditions, such as traffic load and neighbor activity.
Tawake (t)=f(traffic load,neighbor activity,t) -- (5)
Tsleep(t)=Tcycle−Tawake(t) -------(6)
Where:

- Tawake(t) is the awake duration at time t.
- Tcycle is the total cycle duration.

c) 4. Synchronization

To ensure efficient communication, nodes need to synchronize their sleep-awake schedules with their neighbors.

(1) Synchronous Sleep Scheduling

All nodes in a neighborhood wake up and sleep at the same time.

Sync Time=Common Time Reference+Offset ------ (7)

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(2) Asynchronous Sleep Scheduling

Nodes wake up at different times but ensure that there is overlap in their awake periods with their neighbors.

$$T_{overlap}=T_{awake,i}\cap T_{awake,j} \text{ ------ } (8)$$

Where:

- $T_{overlap}$ is the overlapping awake time between nodes i and j.

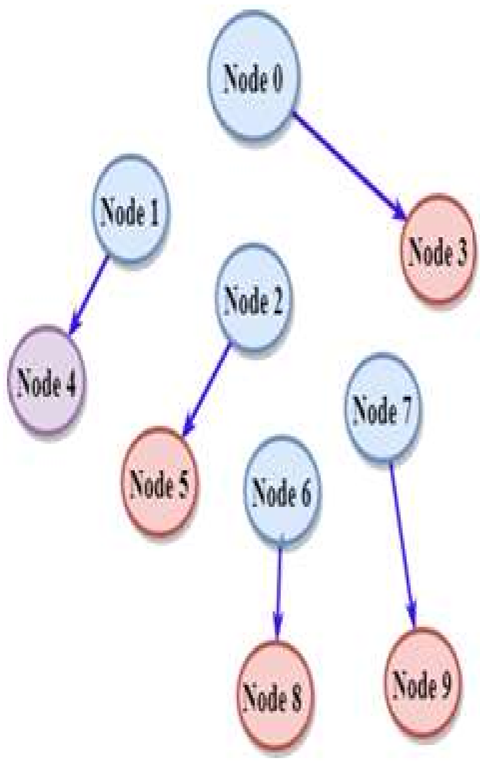

Figure 2. Tag Nodes

4. RESULT AND DISCUSSION

From the literature survey the research article reveals that the need of the power optimization in the MANET nodes could support the nodes life time .The research methods deploys that the beacon signal usages and sleep and awake strategy supports for battery power optimization . The use of beacon signals requires the establishment of cluster nodes, which are tasked with obtaining information from the nodes' implementation. The suggested method was tested using Network Simulator 3 with a high-end PC setup that included an Intel Core CPU, 16 GB of RAM, and Windows 10. The creation of simulation results was made easier by the simulation setup, as shown in Table 4.1 below:

Table 4.1 Simulation Setup

PARAMETER	VALUE
Network	*Wireless Physical Interface*
Area	*1500 * 1500Sq.m*
Antenna	*Omni*
Nodes	*50,100,150,200*
Link	*20 -50*
Transmission	*Constant Bit Rate Transmission*
Each Packet size	*512 Bytes*
Buffer Size	*60 Packets*
MAC	*802.11b*
Model	*Random*
Propagation	*2 Way Ground*
Speed	*30m/s*
Time	*30 s*
Number of packet	*2*
Time set for Simulation	*50 & 100 sec ,*
Energy	*240 Joule*
transmission	*0.6 J*
Receiving	*0.3J*
Sleep	*0.004J*
Changeover	*0.007s*

Comparative evaluation

The AODV protocol was chosen for comparison since one of its capabilities is on-demand routing. AODV protocol and an enhanced version known as Cluster Head Sleep and Awake with Beacon AODV (CHSAB-AODV). The simulation involved Cluster Head construction and support, with the parameters stated in Table 4.1 of NS3. Each parameter was simulated at various node counts: 50, 100, 150, and 200. Figures 3–6 demonstrate the graphical presentation of the collected simulation data for comparison purposes. The comparative research demonstrated that CHSAB-AODV outperformed the regular AODV protocol in all test circumstances.

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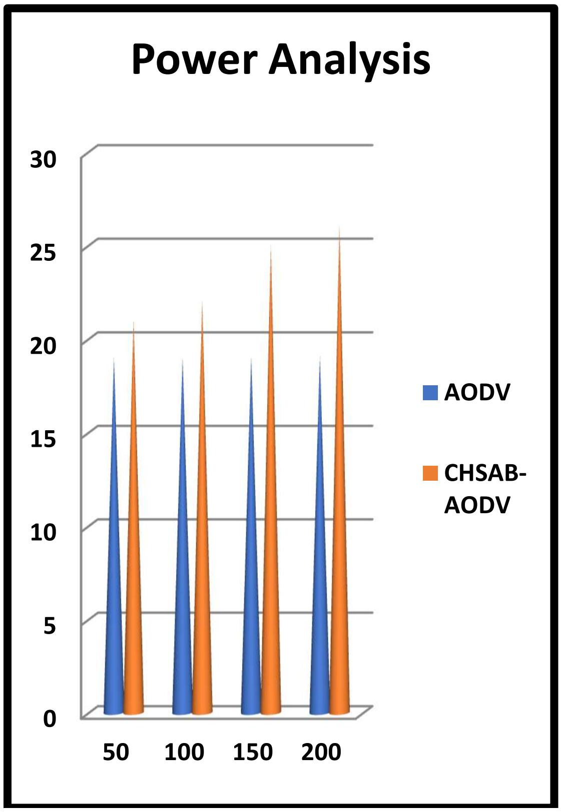

Figure 3 Power Analysis

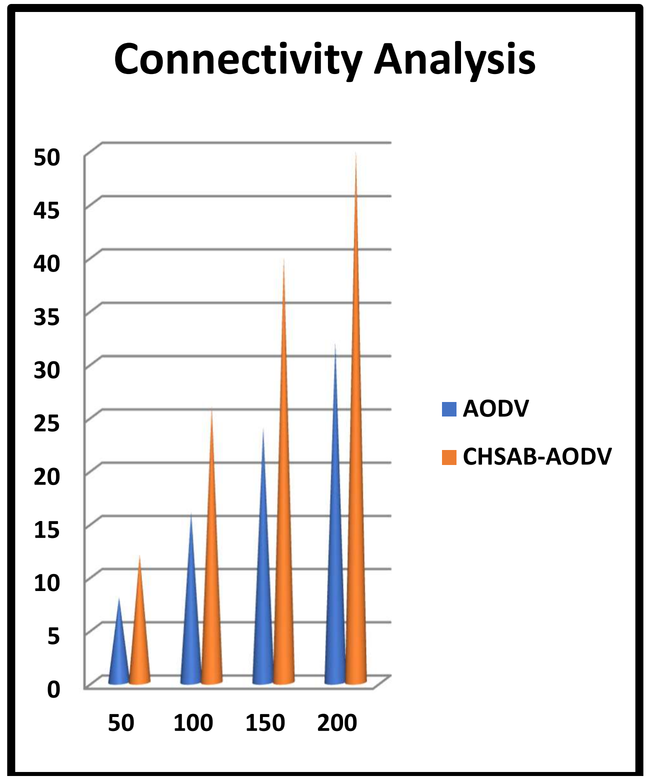

Figure 5 Connectivity Analysis

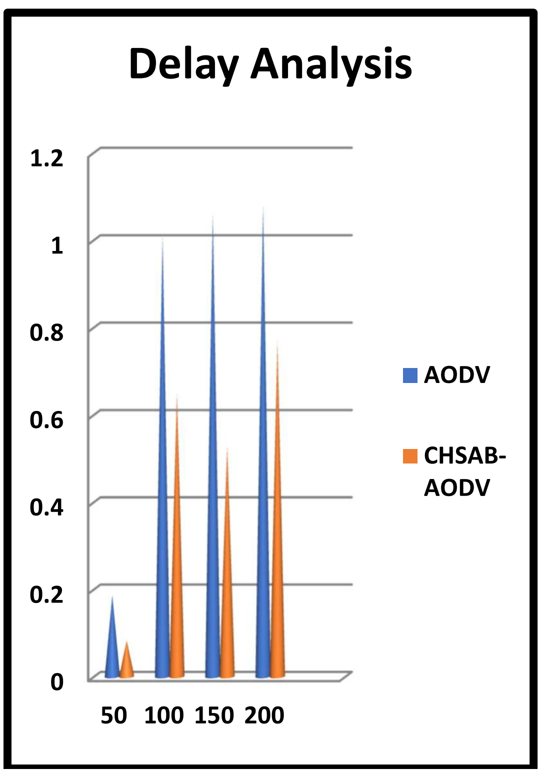

Figure 4 Delay Analysis

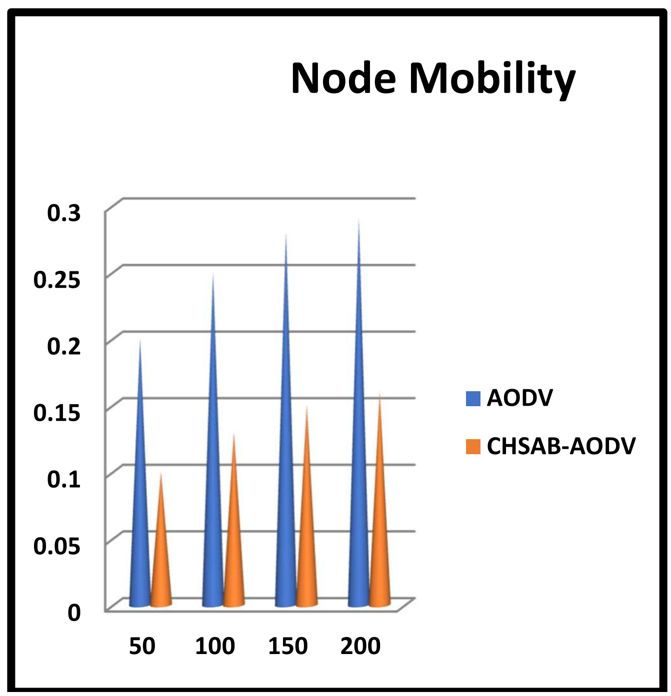

Figure 6. Node Mobility

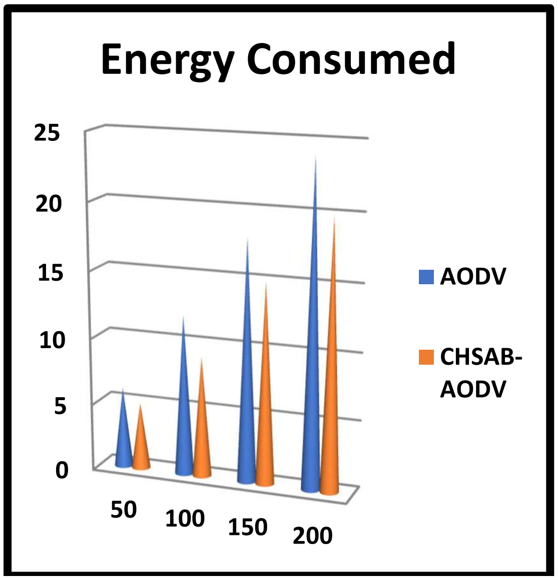

Figure 7 Energy Consumed5.

5. CONCLUSION AND FEATURE WORK

Optimizing battery power and extending the lifespan of Mobile Ad hoc Network (MANET) nodes for efficient packet transmission is a critical and evolving concern. This paper presents a novel energy optimization solution using cluster heads within each network region, accounting for key factors such as node power, mobility, lifespan, link stability, and node distance. In the proposed framework, a cluster node is selected as the cluster head based on its highest values for node longevity, connectivity, and battery power, while ensuring minimal values for mobility and distance. This designated cluster head is responsible for implementing energy optimization using the Sleep and Awake technique, as well as selecting the most efficient routing paths.

The proposed CHSAB-AODV (Cluster Head Sleep-Awake Beaconing with AODV) framework is simulated and evaluated using NS3, and the findings indicate superior performance compared to the traditional AODV protocol. Specifically, CHSAB-AODV demonstrates significant improvements in battery power optimization, which is crucial for extending network longevity and maintaining stable communication. This advancement provides a promising opportunity for integrating the CHSAB-AODV strategy into other MANET protocols, thereby enhancing energy efficiency and network performance across a broader range of applications. The results validate the effectiveness of this approach and highlight its potential for scalable implementation in diverse MANET environments.

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