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AI BASED CLUSTER HEAD BASED MOBILE ADHOC NETWORK FOR PERFORMANCE IMPROVEMENT

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ABSTRACT

The transmission of packets in Mobile Ad Hoc Networks (MANETs) often experiences delays due to changes in internal parameter values caused by intruders or attackers. Additionally, power consumption in wireless networks remains a challenging issue, as the depletion of a node's internal battery can disrupt the entire communication system. To address these challenges, various methods have been proposed to enhance transmission time and optimize MANET battery management, enabling better evaluation of performance metrics. This article introduces novel Artificial Intelligence (AI)-based techniques for improving transmission time and power efficiency in MANETs using cluster heads. Clustering nodes are dynamically formed within a region based on factors such as high forward time, low delay, residual power, mobility, and node connectivity. These cluster nodes play a pivotal role in selecting optimal transmission paths, thereby enhancing communication efficiency and power optimization. The proposed Forward Parameter-Based Wireless Routing Protocol (FPWP) was integrated into the on-demand AODV routing protocol, resulting in the FPWP-AODV protocol. Comparative simulations with existing AODV protocols demonstrated that FPWP-AODV significantly outperforms its counterparts, achieving superior results in terms of transmission time and power management, making it an effective solution for MANET performance improvement.

Keywords: *MANET, Cluster Head, Transmission Time , Route Management, Life Time, Forward Time, Forwarded Packet*

1. INTRODUCTION

MANET, which operates as an ad hoc network, [1] makes temporary connections between multi-hop routers to transmit data across its network. Its uses are broad, encompassing real-time information transmission, network partitioning, rescue operations, interpersonal communication, and information sharing. MANET automatically adjusts its structure and node configurations to provide accurate and timely data transmission. However, because to the intrinsic mobility of nodes, routing design issues are common. Routing Protocols (RPs) are classified into several categories, including Geographical, Multicast, Power-Aware, Multipath Routing Protocols, Hierarchical, and Location-Aware Protocols, and their attributes are compared across various parameters. Furthermore, MANET networks are exposed to assaults on several levels, demanding an emphasis on safe routing. As a result, this analysis examines several attack types and provides methods to improve MANET's resistance against both active and passive assaults. Protecting against these attacks is critical to keeping malevolent actors from jeopardizing the integrity and efficacy of MANET and wireless designs.

The upgraded fractional authority node of a various hybrid cluster routing method evaluates MANET latency [2]. This study employs a Markov chain model to increase throughput, Packet Delivery Ratio (PDR), and Constant Bit Rate (CBR) traffic performance. A thorough categorization of both machine learning algorithms and traditional machine learning methodologies. It explores a variety of traditional and machine learning approaches tailored for VANETs, while also assessing the effectiveness of K-means clustering algorithms in promoting energy-efficient routing and cluster head selection [3].The use of cluster node selection with the LEACH methodology increases the lifespan span via energy distribution [4]. Furthermore, including a fitness function in FFAOMDV lowers power usage [5]. MANET optimization using AI neural networks attempts to improve energy utilization, hence improving network efficiency and overall performance [6]. Furthermore, the use of signal strength indicator-based (RSSI) data, GPS, and long-range technology demonstrates long-term MANET use [7]. EMBOA [8] improves multipath routing by combining butterfly optimization and low-energy machine learning methods. Support for clustering approaches is critical in addressing MANET security difficulties and battery power constraints [9]. Moreover, within the MANET PEO-AODV algorithm [10], nodes employ geographic location tracking and establish hop count parameters to adhere to power constraints.

According to the review on relevant clustering techniques, several research projects have been carried out utilizing various techniques, such as genetic algorithms in conjunction with power [11], connection, link lifetime, squared distance, and mobility. The 3Dimensional Improvise Clustering Algorithm[12], KMORP algorithm[13], Fuzzy C-Means[14] utilizing Distance and Residual Power, cutting-edge cluster-based methodology[15], EO-CN works[16], Beetle Colony Optimization Algorithm-based Clustering Scheme[17] , Multi-Node Charging Strategy[18] , Geographic Algorithm and Sub cluster Algorithm[19], the combination of a rank-based cluster [20] routing technique with position-based, Ultimately, while various strategies and advantages are used in the formation of cluster nodes, the methods fail to address the drawbacks. The formation of the cluster nodes using the forward time and other factors is the main topic of this article. Better transmission time is achieved by the nodes forward time in MANET nodes. The article is organized as follows: Section II presents an overview of various clustering approaches aimed at enhancing MANET performance. The third section proposes a parameter-based model for cluster formation. Section IV outlines the simulation setup used in the investigation. Finally, Section V summarizes and emphasizes the results.

2. RESEARCH WORK RELATED TO THE PROBLEM STATEMENT

The authors of this paper, Agrawal & Rathi [11], In Mobile Ad hoc Networks (MANETs), clustering turns into a challenging optimization problem, especially when the network is big. One method uses evolutionary approaches, including genetic algorithms (GAs), which are renowned for their propensity to converge prematurely, to divide the MANET into clusters. This paper introduces a unique clustering technique based on the Improved Rabbit Optimization Algorithm (IROA) to overcome this constraint. In order to guarantee that the Cluster Heads (CHs) selected are appropriate, this method focuses on choosing CHs through the application of multi-objective functions. These chosen CHs are then the basis for the formation of clusters. When selecting the optimal Cluster Heads (CHs), the IROA algorithm considers multiple variables, including power, connectivity, link lifetime, squared distance, and mobility. After CH selection, each CH notifies nearby nodes of its weight value via a HELLO message, enabling mobile nodes to join the CH and create clusters according to the weight of the CH. A cluster maintenance phase is also implemented to handle changes in topology brought about by node mobility. According to simulation data, the proposed system outperforms existing clustering schemes based on ROA, PSO, and GA in terms of both throughput and energy efficiency..

A variant of FM known as Fuzzy C-Means utilizing Distance and Residual Power introduced by Amit Choksi and Mehul Shah [12], leverages residual power and distance to

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identify CHs for improved data .Gupta and Seth [13] Introducing 3Dimensional Improvise Clustering Algorithm (3DICA), a unique cluster routing protocol created expressly to solve the node uncertainty issue during head selection. After cluster formation, the author assesses energy usage taking into account the transmission operations of both cluster chiefs and members. The effectiveness of this strategy is demonstrated by simulation findings, which indicate that it can effectively transmit more data while dramatically cutting down on the amount of time needed for cluster building in three-dimensional environments.

In the suggested system proposed by Aifullah et al. [14], inter-cluster forwarding nodes facilitate message transmission among dissimilar clusters. These findings underscore how KMORP surpasses current methods in terms of throughput, PDR, and E2E delay. Godwin Asaamoning and Paulo Mendes [15] aim to simplify traffic engineering across multiple wireless clusters through their research. Their solution combines a rank-based intra-cluster routing technique with position-based inter-cluster routing, enabling even distribution of traffic loads among several cluster heads.

Luo et al. [16] utilize the Geographic They then take into account the aircraft's communication retention time in detail in order to update clusters. This helps to improve network structure and cluster robustness by preventing isolated communication nodes by means of affiliated cluster members and preserving cluster communication continuity through gateway nodes. After analyzing the algorithm's theoretical performance, real route data is simulated. The findings of the experiment and analysis point to no expenses associated with clustering or cluster upkeep. Furthermore, in contrast to conventional methods, this method effectively increases overall cluster stability while minimizing turnover among cluster members, minimizing the frequency of cluster head replacements, minimizing cluster head control loss over members, and maintaining an acceptable number of clusters.

The authors of this study, Gupta & Sharma [17], provide a brand-new framework designed to improve network security using a cutting-edge cluster-based methodology. It proposes a fuzzy approach that uses parameter weighting to solve vulnerabilities and dynamically evaluates the trustworthiness of both individual nodes and clusters. Furthermore, a system for trust reconfiguration is suggested so that nodes that are unable to demonstrate their trust can be given another opportunity based on the overall trust from earlier assessments. With the help of a clustering nodular framework known as EO-CN, this research by Niaz Ahamed & Sivaraman [18] presents an effective optimization strategy for vehicular ad hoc networks (VANETs). Concerns about network overhead are successfully addressed by the suggested approach, especially in cases where node concentrations fluctuate.

In order to create optimized clusters that would enable trustworthy data distribution, Gopinath et al. [19] introduce a unique clustering scheme called beetle colony optimization algorithm-based clustering scheme. Swarm intelligence and beetle antenna search are two essential tactics that the bcoacs algorithm combines to enable both intra- and inter-cluster communications. In their paper, fang ET al. [20] introduces a novel method for mobile sensor networks (msn) called multi-node charging strategy (mmcs), which utilizes fuzzy clustering.

Table I Summary of Literature survey

S.No	Authors	Technique	Merits	Demerits
1	Agrawal & Rathi [11]	genetic algorithms along with power, connection, link lifetime, squared distance, and mobility	throughput and energy efficiency	maintenance phase is needed for the cluster maintenance
2	Mehul Shah [12]	Fuzzy C-Means utilizing Distance and Residual Power	END by 20%, throughput by 5%, and energy usage by 68%.	Dynamic Clustering Algorithm is needed
3	Gupta & Seth [13]	3Dimensional Improvise Clustering Algorithm	effectively transmit more data	building only in three-dimensional environments and amount of time needed for cluster building
4	Aifullah	KMORP algorithm	38% improvement in Packet Delivery	comprehensive simulations

	et al. [14]		Ratio (PDR)	required
5	Asaamoning and Paulo Mendes [15]	Rank-based cluster	consumption of 72.5 J of power	Not feasible in the entire scenario.
6	Luo et al.[16]	Geographic Cluster	Method effectively increases overall cluster stability while minimizing turnover among cluster members, minimizing the frequency of cluster head replacements, minimizing cluster head control loss over members, and maintaining an acceptable number of clusters.	Maintaining an acceptable number of clusters but extra clustering for emergency not possible.
7	Gupta & Sharma [17],	cutting-edge cluster-based methodology	decrease in latency and drop ratio of 41.46% and 36.37%,	An only notable improvement was achieved in performance indicators.
8	Niaz Ahamed & Sivaraman [18]	EO-CN works	size, network , density, and distance	experimental process only possible
9	Gopinath et al. [19]	Beetle Colony	Achieving a maximal throughput	The lifetime of the clusters is needed.
10	fang et al. [20]	Multi-Node Charging Strategy	the best charging places for every cluster	Addresses energy constraints only in large-scale MSNs and greatly improves network performance while lowering energy expenses.

From the Literature survey about the related clustering techniques shown in the TABLE I , the different research work was done using different Technique like genetic algorithms along with power, connection, link lifetime, squared distance, and mobility, C-Means use Distance and Power, 3Dimensional Improvise Clustering Algorithm, KMORP algorithm , combining a rank-based routing technique with position-based inter-cluster routing, Geographic Cluster Partitioning and Sub cluster Algorithm, cutting-edge methodology , EO-CN works , Beetle Colony Optimization Algorithm-based Clustering Scheme , Multi-Node Charging Strategy. Finally all the methods uses some techniques and given certain merits in forming the cluster nodes but fails on solving the demerits. This article focuses on forming the cluster nodes using the forward time along with AI and the other parameters. The nodes forward time achieves the better transmission time in the MANET nodes.

3. SYSTEM ARCHITECTURE

From the literature survey the cluster nodes forming for improving the MANET performance used many latest techniques to prove the proposed work. This article proposes the improvement in transmission time with the support of cluster node forming based on the forward time and other internal parameters. Construct the MANET graph G = $\{m_1, m_2......m_m,......m_n\}$. The variable "m" represents the total number of MANET nodes, where $1 < m \leq n$ denotes the entire number of nodes in the network, with "n" being the upper limit .The formation of the cluster nodes uses the nodes parameters.

Forward time:

The forward time detection technique is employed to monitor the activity of each node in terms of forwarded time. This estimated forwarded time is specifically designed to support intermediate node route selection. The forwarded time for every node is calculated using Equation 1.

$$\text{Forward Time } Ft = \sum tt\ Pi \quad (1)$$

Where $1 \leq i \leq n$

Where "tt" represents the transmission time of all packets in the MANET, denoted by Pi, for each node.

Energy

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An energy model could be used to calculate using the Eq (2).

$$Nn = \frac{1}{f}\sum_{g=1}^{f} \text{Eg} \qquad (2)$$

Where "Eg" represents the energy dissipation of the g^th node.

The mobility of a node, distance, power and connectivity are computed using the Eq (3), 4, 5 and 6 respectively.

$$Nm = \frac{1}{|ph|}\sum_{g=Ph} \text{Bg} \qquad (3)$$

$|p_h|$ - The set of neighbor nodes is denoted as "Bg", and it represents the relative mobility among them.

$$Rn = \sum_{fg=1} (\text{Ug, Ph}) \qquad (4)$$

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

$$P = \sum_{ng=1} \text{Mmax} * \frac{Mmin}{Mg} \qquad (5)$$

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

$$Ch = \frac{1}{f}\sum_{ng=1}^{n} \frac{Cg}{e} \qquad (6)$$

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

Algorithm I Forming AI -Cluster Node

Steps for AI -Cluster Head forming

1. Gather every node in the MANET and create a region. Let M be the MANET Set,

And the regions are formed as {R1, R2, R3 ...Rn}.

One node will be chosen to serve as a cluster node for each region Ri that has a set of N nodes.

2. Do the following for each Region Ri:

for (i=1; i<= n; i++)
{
Compile the forward time, life duration, mobility, distance, power, and connectivity of every node.

A cluster node will have the lowest node mobility and distance values and the maximum node forward time life time, connectivity, and battery power values. Algorithm I is used to form the cluster head after gathering MANET nodes with mobility, life, distance, power, and connectivity. The output of the set of nodes plus the cluster node is then obtained as a clustering node processing output, as illustrated in Fig 1.

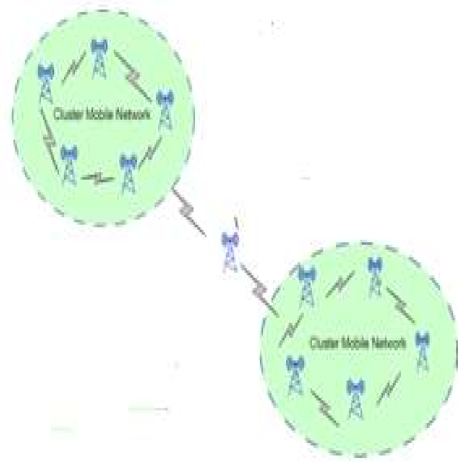

Figure 1 Cluster Node

4. RESULT AND DISCUSSION

The proposed work of improving transmission time in the MANET nodes using the cluster node forming with respect to the internal parameters of forward time, mobility, speed, link was simulated using the Network Simulator 2.34 with the node setting parameters as shown in the Table II. The proposed work was implemented in AODV protocol and named as Forward Parameter based Wireless routing protocol (FPWP-AODV) and comparison was done with the normal AODV protocol with cluster nodes forming with the support of other than forward time parameters named as AODV. Initially 50 nodes are defined in the simulation and slowly increased to 100, 150 and 200 nodes with every 10ns. The simulation results compare the parameters are Throughput, packet delivery ratio, End to end delay, packet drop, energy consumption, Residual energy, clustering accuracy.

Table II Simulation Parameter

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PARAMETER	VALUE
MANET Network Interface	*Wireless Physical Interface*
Dimension	*1500 * 1500Sq.m*
Antenna Defined	*Omni*
Nodes	*50,100,150,200*
Link	*20 -50*
Transmission Type	*Constant Bit Rate Transmission*
Each Packet size	*512 Bytes*
Buffer Size	*70*
MAC Layer	*802.11b*
Simulation Model	*Random*
Propagation	*2 Way Ground*
Node speed	*20m/s*
Pause	*25 s*
Number of packet send	*5Packets*
Time set	*50 sec, 100 sec ,150sec*
Node Energy	*500 Joule*
transmission power	*0.1 J*
receiving power	*0.5J*
Sleep Power	*0.003J*
Changeover Time	*0.008s*

Throughput Analysis

Throughput is defined as the maximum number of packets received from the sender and can be calculated using equations 7 and 8.

$$Throughput = \frac{Packet\ Size}{Transmission\ time} \quad (7)$$

$$Transmission\ time = \frac{File\ size}{Bandwidth} \quad (8)$$

Initially the node counts was 50 nodes and packet start transmitting from the sender node to the receiver nodes and slowly the nodes count was increased from 100,150, and 200 .Throughputs comparison from the simulation results shown that the proposed FPWP-AODV throughput are 224,269,322,365 Kbps where as the existing AODV throughput 180,220,222,250 and 224,269,322,365 Kbps, respectively which is shown in the Figure 2 and the results proved that the proposed FPWP-AODV performs double times better than the existing because the cluster nodes chosen based on the better transmission time nodes .

. End of End to Delay

Each node's operation allots time for packet processing, transmission, and reception from one node to another using the Equation (9).

$$EED = Packet\ transmission + packet\ processing + packet\ delivery \quad (9)$$

Initially the node counts was 50 nodes and packet start transmitting from the sender node to the receiver nodes and slowly the nodes count was increased from 100,150, and 200 .Delay comparison from the simulation results shown that the proposed FPWP-AODV delay was 20,33,37,50Ms where as the existing AODV delay was 40,50,60,80 respectively which is shown in the Figure 3 and the results proved that the proposed FPWP-AODV performs less f forwarding of the packets.

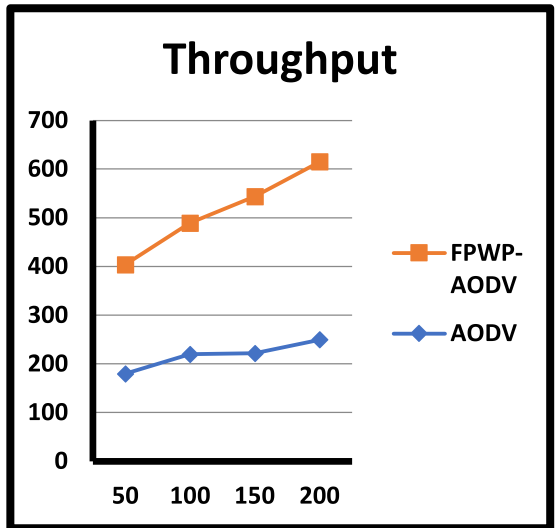

Figure 2 Throughput

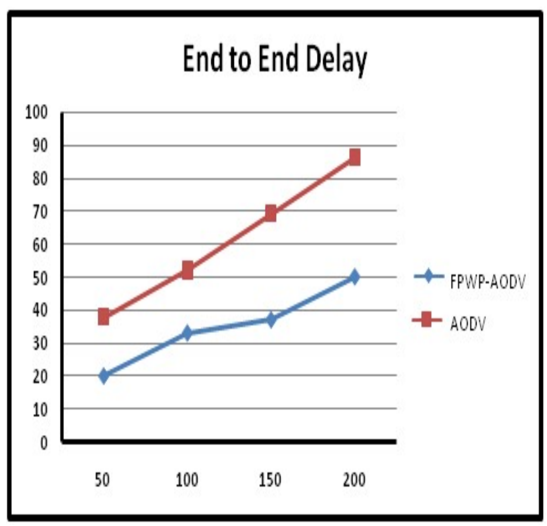

Figure 3 End to End Delay

Packet Delivery Ratio

Based on the data in the trace file, the packet delivery ratio is computed using Equation

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(9), which considers the number of packets sent by the sender and the number of packets received by the receiver.

$$PDR = \frac{Received\ packet}{Send\ packet} * 100 \qquad (9)$$

Initially the node counts was 50 nodes and packet start transmitting from the sender node to the receiver nodes and slowly the nodes count was increased from 100,150, and 200 .Packet delivery ration comparison from the simulation results shown that the proposed FPWP-AODV work was 160,180,195,199 where as the existing AODV PDR was 80, 85, 89, 95% respectively which is shown in the Figure 4 and the results proved that the proposed FPWP-AODV performs better packet delivery ration more than 50 %.

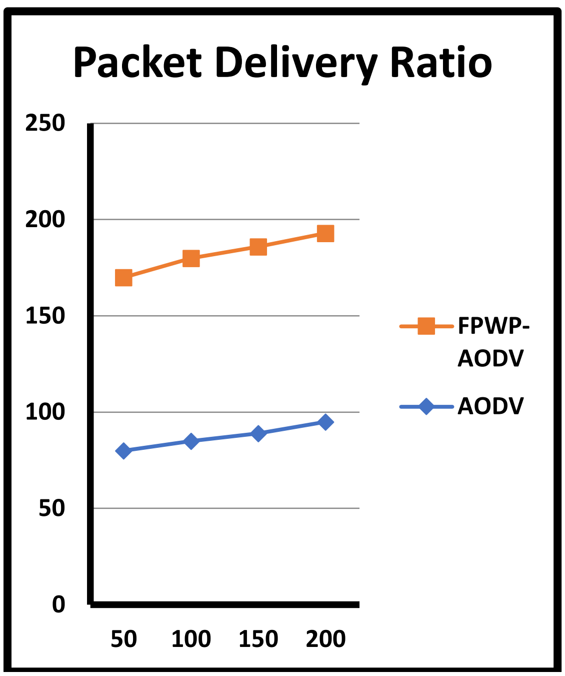

Figure 4 Packet Delivery Ratio

Energy consumed

The transmission Energy E_{Tra} and receiving Energy E_{Rec} summing is used to estimate node Energy Consumption.

$$E_{con} = E_{Tra} + E_{Rec} \quad (10)$$

The total energy required by a single route connection for transmitting and receiving packets is compared to the AODV protocol utilising nodes numbered 50,100,150, and 200, with values in Figure 5 that the proposed FPWP-AODV consumed 5,9,15,20 J spent more energy than the traditional AODV 10,20,34,44 J which is double time more than the proposed work .

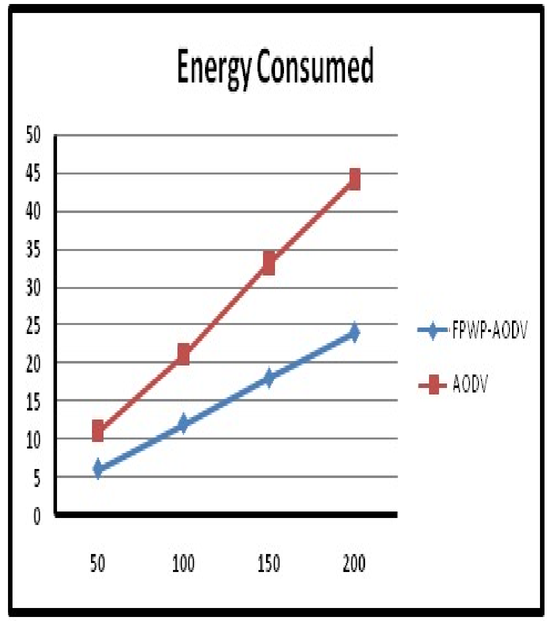

Figure 5 Energy Consumned

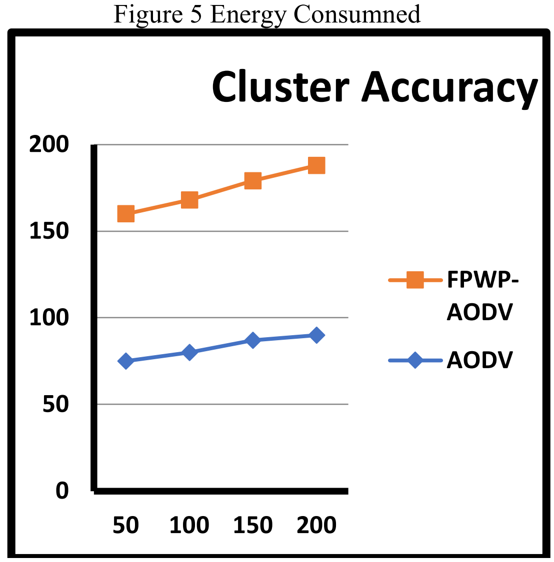

Figure 6 Cluster Accuracy

Cluster Accuracy

Clustering Accuracy = Total $Overlaps/Total\ Nodes$ (14)

By altering the nodes to 50,100,150, and 200, the simulation is validated.The current AODV protocol achieves 75%, 80%, 87%, and 90%, whereas the proposed FPWP-AODV protocol achieves 155,166,189,199 %.In comparison, as shown in Figure 6 the

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recommended work done highest cluster Accuracy.

5. CONCLUSION

This article proposes a novel method to enhance the transmission time of MANETs by introducing an AI -cluster node formation approach based on forward time and other internal node parameters, simplifying the process compared to existing literature. The proposed method, named FPWP-AODV, is implemented within the AODV protocol. A comparison is conducted with the conventional AODV protocol, where cluster nodes are formed using parameters other than forward time, termed as AODV. Simulation results compare various parameters including throughput, PDR, END, packet drop, energy consumption, residual energy, and clustering accuracy. The results proved that proposed FPWP-AODV throughput 224,269,322,365 Kbps , delay was 20,33,37,50Ms PDR was 160,180,195,199, consumed 5,9,15,20 J cluster accuracy 75%, 80%, 87%, and 90%, where as the existing AODV values were 180,220,222,250 and 224,269,322,365 Kbps, 40,50,60,80 , 80,85,89,95% , 10,20,34,44 J , 155,166,189,199 %.respectively results proved that the proposed FPWP-AODV performs double times better than the existing because the cluster nodes chosen based on the better transmission time nodes .

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