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Fitness Function for Enhanced Node Mobility Calculation

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1. INTRODUCTION

MANETs (Mobile Ad-hoc Networks) are built up of MNs (mobile nodes) that build transitory networks and do not require infrastructures or centralized managements. One of the biggest limitations of MANETs are in the area of energy as MNs lack permanent power supplies and rely on batteries resulting in limited network lifetimes as batteries quickly drain their resources when MNs move or change positions quickly MANETs.

To improve the related MNs, they are selected for routing by employing discovery algorithm, the proposed Enhanced Protocol using NMCs (Node Mobility Calculations), the NMCs AOMDV is proposed. It is created and utilized to locate MNs with comparable properties for communication and energy-saving power efficiency. It connects the source and destination MNs in the most energy-efficient way possible. It increases the lifetime of a network while cutting energy usage. An Enhanced NMCs AOMDV performs better in terms of power savings. When compared to previous MANET algorithms, efficiency extends network lifetime and reduces energy usage.

The proposed procedure centered on selecting an energy-efficient Fitness Function (FF) via the proposed NMCs AOMDV. The simulation tool is used to evaluate the proposed work. The results acquired for the Energy Efficient Power (EEP) achieve improvement in energy dissipation, the ratio of residual energy of the MN and hope counts as a new metric to pick the route path in NMCs AOMDV Fitness Function.

2. FF_AOMDVs (FITNESS FUNCTIONS AD-HOC MULTIPATH DISTANCE VECTORS)

Existing protocols based on FF_AOMDVsare routing systems that use multipoint relaying as link-state packet forwarding mechanisms. Fitness Functions work in two ways: they cut down control packets that are sent and links that send link-state messages. The sizes of link state packets are minimized by declaring only portions of links in link state’s updates. Multipoint relays are subsets of links or neighbours that get allocated to link-state changes and are responsible for packet forwards. Periodic link-state changes are more efficient when multipoint relays are used. When links fail or are added, link state update methods do not generate control packets during these operations.

MPR sets are collection of MNs that serve as multipoint relays. The network's MNs choose an MPR set to process and forward link status packets created by them. Neighbor MNs that aren't part of the MPR don't forward MN P's link state packets. Similarly, MNs have subset of neighbours called MPR selectors, which are neighbors who select MNs as multipoint relays. MNs in their MPR Selector configurations forwards packets received from other MNs. Both MPR sets and Selectors have members who change over a period of time. Members of MN's MPR sets are selected in such a way that MNs are similar in MPR sets. MNs are related to two-hop neighbor hoods.

MNs that make up MPR sets have substantial influences on performances since MNs calculate routes to all destinations through members of their MPR sets (FF_AOMDVs). MNs transmit their MPR Selector sets to MNs within their local

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vicinity on a regular basis. MNs deliver Hello messages with a list of neighbours where MNs have bidirectional connections and list of neighbours whose transmissions were received lately but with whom bidirectional ties have not yet been confirmed for MN memberships in MPRs. MNs modify their two hop topology tables on receiving Hello packets which indicate multipoint relays as an option.

A data structure called a neighbour table stores the list of neighbours, two-hop neighbours, and the state of neighbouring MNs. Connection statuses of neighbouring MNs might be unidirectional, bidirectional, or multipoint relays. The items use carry timeout number and when reached, remove stale items from neighbour tables. Similarly, MPR sets are associated with sequence numbers, which are incremented with new MPR sets.

The MPR set does not need to be optimum, and it might be the same as the neighbour set when the network is first started. The fewer the MNs in the MPR set, the more efficient the protocol is in comparison to link-state routing. TCs (Topology controls) packets are sent out by MNs and contain topology information that are used to update routing tables. MPR Selector sets of MNscary packets of TCs which are flooded over the network using multipoint relays. MNs in the network get a number of TCs from other MNs, and topology tables re built using data contained in TCs. MNs may launch TCs early than normal periods if the MPR Selectors are modified after previous transmissions and minimum amount of time has passed. The MPR Selectors are the destination MNs of topology table entries, and originators of TCs are last-hop MNs to destinations. As a result, routing databases maintain track of all MNs' paths in the network.

Algorithmic MPR Selections

MPR set computations with minimum sizes are NP-complete problems. Standard MPR selections by algorithms use protocols based on FF_AOMDVs whose implementations are as follows.

Let N(x) be the MN x's neighbourhood. The set of MNs in the range of x that have a bidirectional relationship with x is known as N(x).have a bidirectional relationship with x is known as N(x). The two-neighborhood of x is denoted by N2(x), for example, the set of MNs that are neighbours of at least one MN in N(x) but do not belong to N(x) (Figure 6.2).

The traditional algorithm for MPR selection is detailed below based on the notations above:

Step 1:$U \leftarrow N^{2(x)}$
Step 2:$MPRs(x) \leftarrow \emptyset$
Step 3: $\text{while} \ \exists \ v: v \in U \wedge \exists \ ! \ w \in N(x): v \in N(w) \text{do}$
Step 4: $U \leftarrow U - N(w)$
Step 5: $MPR(x) \leftarrow MPR(x) \cup \{w\}$
Step 6:$\text{while}(\cup = \phi)\text{do}$

$$\text{choose } w \in N(x) \text{such as:} \ CRITERIA(w) =$$
$$|N(w) \cap U = \max(w'nU|: w' \in N(x))$$
$$U \leftarrow U - N(w)$$
$$MPR(x) \leftarrow MPRs(x) \cup \{w\}$$

Step 7:$\text{return } MPRs(x)$

a) Mobility Degrees of MNs

MNs in MANETs can be found in one of four states with its neighbours: MNs move while their neighbours stay static, MNs are static while their neighbours move, both MNs and their neighbours move, and both MNs and their neighbours stay static. Due to these stages, MN's connection statuses with neighbours vary over a period of time as MNs in MANETs move.

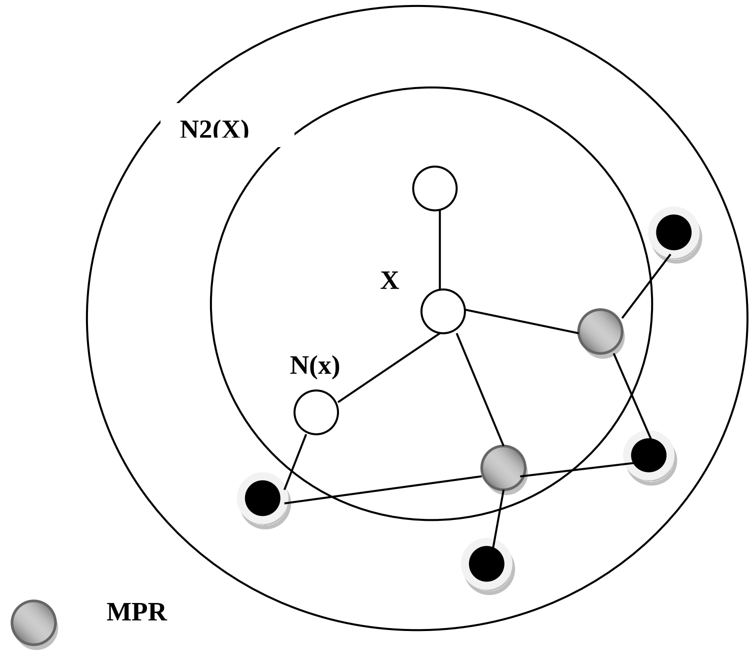

Figure 1: Computation of the MPR

Based on this discovery, create a mobility metric that represents the degree of network MN movement. This mobility metrics have no units and are unaffected in simulationsby model'svariables or patterns of movements. Furthermore, they are evaluated in discrete time periods. MN's mobility degree $M\frac{\lambda}{i}$ during time t is depicted below:

$$M\frac{\lambda}{i} = \lambda\frac{NodesOut(t)}{Nodes\ (t-\Delta t)} + (1-\lambda)\frac{NodesIn(t)}{Nodes(t)}$$

Where

$NodesIn(t)$: Counts of MNs joining communication rangesin intervals$[t-\Delta t, t]$
$NodesOut(t)$: Counts of MNs leavingcommunication ranges in intervals$[t-\Delta t, t]$
$Nodes(t)$: Counts of MNs in communication rangesduring time t.

λ:Mobility coefficients in the interval [0,1]

Mobility degrees of MNs are determined locally, regardless of their network locations. The neighbours of MNs alter local and relative quantifications. Changes in MN's neighbours compared to the preceding (states) at time $t-\Delta t$ can be defined as MN's mobility degree in MANETs at a given time t. As a result, MNs that join and leave affect the assessment of mobility degrees. They also specify mobility coefficients between 0 and 1 to keep MNs mobility degrees in the range of 0 to 1.

As an example, assuming MNi is in the condition indicated in (Figure 2 (a)) with ten neighbours where neighbours state changes are depicted in (Figure 2 (b)): blue MNs (four) disappearfrom communication ranges while red MNs (two) join the ranges during the interval. MN's conditionscan be depicted as Figure 2 (c) with six alterations (at time t). When time periods end MNscan assess changes in their neighbours as indicated by relative mobilities and comparable to to 13/40=32.5 percent (withλ=1/2).

MANET's MNs may evaluate their mobility independently and autonomously at regular intervals or periodically by exchanging the Hello messages. Ther mobility of MNs are computed and re-computed.

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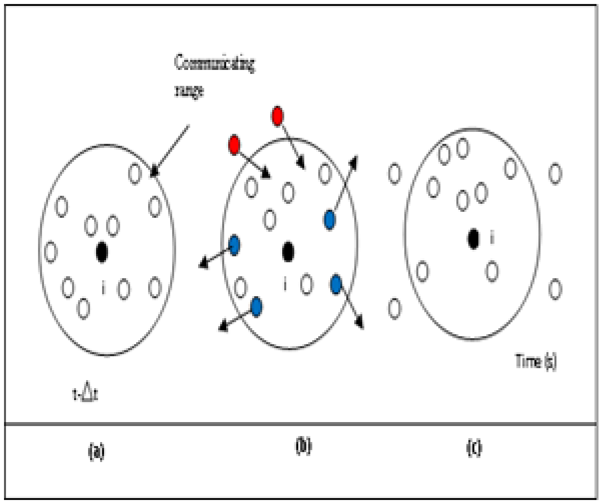

Figure 2: Node Mobility Degree Changes in Its Neighbours Compared to the Previous (State)

3.AN ENHANCED NMCs IN MANETs

The difficulty with the existing protocols is that they fail to assess energy levels and transmission rates of MNs, making it impossible to measure behaviours of MNs effectively. There are no evaluations of each MN's residual energy, and communication speed, data packets are delivered and received faster than in the prior technique with success ratio. The related MNs are not chosen for routing in the existing protocol by employing the related MN discovery algorithm. As a result, NMCs is presented as a solution to these problems. NMCs is developed and utilized to discover MNs with similar communication and energy properties. Failures override MN transmission rate and energy consumption. NMCs strives for energy-efficient MN power usage in each search if the MN residual energy is high and the MN maintains stable energy.

4. PROCESS OF ENHANCED NMCs

The energy-efficient routing method must distinguish between MNs with similar and MNs with dissimilar features in the network. Only MNs with similar features are chosen for packet transmission. Furthermore, the network requires an efficient method of improving energy efficiency as well as avoiding wasteful energy use. Because most of the MNs in mobile networks have already failed, and their energies are utilized in packet transmission, energies are squandered. Connections or entire packet transmission assemblies fail if MNs in connections fail or are unavailable or in inactive states.

This work's suggested NMCs employ related MN discovery approaches to find related MNs selected only for routing, and are built and used to recognize MNs with comparable properties for communications while saving energies. They provide most energy-efficient routing paths between sources and destinations in MANETs. They also enhance network life spans while lowering energy consumptions buy their use of the proposed NMCs AOMDV..

Node Mobility Calculation

Novel EEP-OHRAs (Energy Efficient Multipath Optimized Hierarchical Routing Algorithms) have been suggested in this work and are based on Fitness Functions and NMCs AOMDV protocol. When source MNs transmitRREQs, several pathways to destinations are discovered. Data packets are transmitted across these routes regardless of the quality of the routes. Route selections will be different when the suggested approach is utilized in same scenarios. Source MNs have three (3) pieces of information when RREQsare transmitted and received to determine the shortest and most energy-efficient route. The data comprises the following:

- Network energy level information for each MN
- Route distance
- The amount of energy expended throughout the route discovery procedure.

The path that uses the least amount of energy could be

(a) the shortest distance;

(b) the path using the most energy;

(c) both.

The data packets sent by source MNs through routes with highest energy levels and consumptions are calculated. When all routes to the destination fail, this protocol, like other multipath routing protocols, will launch a fresh route discovery process. If the chosen route fails, the source MNs will choose alternate routes from routing tables that are the fastest and use the least amounts of energy. The optimal path will spend less energy because it is shorter to the destination, and it may be determined as follows:

$$\text{Optimum route} = \frac{\sum v(n) \in r\, ene(v(n))}{\sum v \in V ene\ (v)} \qquad \text{(equ.1)}$$

V represents all of the network's vertices, while v stands for vertices (MNs) in optimal routes r. They assess the energy levels of all possible routes before selecting the ones that use the least amount of energies. The alternate route's length will be decided. The shortest path is maintained by the FF AOMDVs. (NMCs AOMDV) follows the same methods after selecting the route with the greatest energy level; the routing table keeps track of the route with the shortest distance. The following formula is used to find the shortest path:

$$\text{Optimuim route 2} = \frac{\sum\ e(n) \in r dist\ (e(n))}{\sum e \in E} \qquad \text{(equ.2)}$$

Where *e*implies optimal routelinks (edges).r and E stand for edges of the network. It compares the distances of the optimal route's links to the distances of all the network's links. The following is the pseudo-code for determining **Node mobility:**

Algorithm: 1
Step 1: Determine the source and destination of your data.
Step 2: Locate a source Start the route discovery process.
Step 3: Distribute packets to MNs for routing.
Step 4: In Source Route Tables, update routing information.
Step 5: Initialize Beacon's Sources.
Step 6: Distribute packets to MNs for routing.
Step 7: Update energies and locations for all MNs in the whole network in the Step Source Energy Table.
Step 8: double-check
If(*ene*>DHigh&&*dist*<DLow&&*hop Count*<DLow)
. . . (Eq. 1 & 2)
Choose communication routes.
Else if (*ene*>D High &&*dist*>D high &&*hop Count* <D
Low) . . . (Eq. 1)
Choose communication routes.
Else if (*ene*<D Low&&*dist*<D Low &&*hop Count* <D Low t) . . . (Eq. 2)
Choose communication paths.
Step 9: Send discovered routes on a regular basis.
Step 10: Send the beacon message on a regular basis.

2 Procedures for Calculating Energy Values Algorithm:

Step 1: Initialize the settings to initialenergy = 100, maxenergy=0, MNs=50, and Nodeid=0 (unique id for each MN)
Step 2: Determine Intermedenergy based on an event and time (event = "r" || event= "d")
|| event="s"|| event="f")
Step 3: Calculate the consumed energy for each MN using the formula: consumenergy[i]=initialenergy-Intermedenergy[i] for I in Intermedenergy).
+=consumenergy[i] = totalenergy
if(maxenergy<consumenergy[i])
MNid=i MNid=i MNid=i MNid=i MNid=i MNid=i MNid=i MNi
Step 4: Calculate average energy, which is equal to total energy divided by MNs.

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Algorithm: Node Discovery Algorithm
Step 1: Calculate transmission rates and energy consumptions for MNs.
Step 2: Find MNs that are energyefficient in searches.
Step 3: If Node Residual Energies==high, continue to next steps.
Step 4: MNs maintain consistent energy levels.
Step 5: They help in attaining energyefficient paths.
Step 6: else,
If Residual Energies of MNs ==low, proceed to step 7.
Step 8: Questionable MNs are traced and eliminated from routing paths.
Step 9: Endif.
Step 10: Extend the life of the network while lowering energy use.
Step 11: End For.
Simulations are used to execute the programme (EEP-OHRA). The network parameters and topology in this simulation were specified using an OTcl script, which included traffic sources, counts of MNs, queue sizes, speeds of MNs, used routing protocols along with many other features. During simulations, two files were created: a trace file for processing and network animator, NAM (visualization tool) for viewing simulations. Figure 6.4 shows route selections of (EEP-OHRAs) based on essential parameters for better comprehension on fitness functions of NMCs AOMDV.

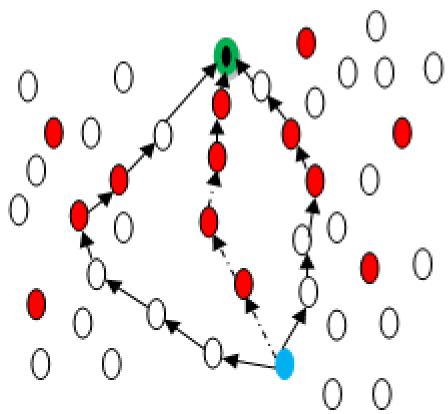

Figure 3: Selections of Optimum Routes in NMCs _AOMDV

As shown in figure 3, the NMCs AOMDV first broadcasts an RREQ to get information about the possible routes to the destination, where the fitness function searches the network for MNs with a higher energy level (red MNs). Source points receive RREPs with information on various routes to destination along with their energy levels. MN's mobility functions analyze results after computing route energy levels to determine paths having highest energy levels. The route's lengths are explored for highest energy levels and shortest distances. As observed on the path with the broken arrow, the energy level is prioritized (Figure 6.4). Routes with most energies but are not the shortest, may be chosen, albeit with lower priorities. If intermediate MNs between sources and destinations have lower energy levels than the rest of the network, fitness functions choose the shortest possible paths based on these features. Fitness functions always choose routes that use least amount of energies and have longest network life spans.

5. PERFORMANCE METRICS

The following are the performance measures utilized in the simulation experiments:

1) PDRs (Packet Delivery Ratios) are proportions of data packets delivered to destination MNs compared to data packets generated by sources.These metrics assesses quality of routing protocol's data packet deliveries between sources and destinations. Higher PDRs imply greater performances of routing protocols. The following formula is used to compute PDRs:

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$$\text{PDRs} = \frac{\text{number of packets received}}{\text{number of packets sent}} * 100 \quad \text{(equ.3)}$$

2) The counts of bits successfully received by destinations are referred to as throughputs where the units of measurements are kilobits per second (Kbps). Throughputs are measurements of routing efficiencies of mechanisms when destinations receive data packets. Throughputs can be computed using:
1000 kbps TP=(number of bytes received*simulation time)*(number of bytes received*simulation time) (equ.6.4)

3) End to End Delays or latencies: They indicate average time taken by data packets to correctly convey messages between sources and destinations across networks.
Interface queue queues, propagations and periods of transfers, delays in MAC retransmissions, and buffering in route discovery latencies are all examples of delays. Below is the formula for computing the

$$\text{E2E delay} = \frac{\sum_{i=1}^{n}(Ri-Si)}{n} \quad \text{(equ.4)}$$

4) Energy Consumptions: Energy consumptions refer to energies utilized by MNs in simulations and determined by computing all MNs energy levels during termination of simulations after accounting their initial energies. These computations are depicted mathematically as Equations (6.6):

$$\text{Energy Consumption} = \sum_{i=1}^{n}(\text{ini (i)} - \text{ene(i)})\text{(equ.5)}$$

5) Network Lifespans:Life spans are time taken by n MNs to drain their batteries and computed using:

$$\text{Network Lifetime} = \sum_{i=1}^{n}(\text{ ene (i)} = 0)) \quad \text{(equ.6)}$$

6) Routing Overhead Ratios: They are computed by dividing total routing packets by total delivered data packets. The average counts of routing packets required to convey single data packets were examined in this study. These ratios compute required bandwidth consumptions for transmitting data. Routing overheads influence network's dependability in terms of bandwidth utilizations and battery power usages of MNs.The following formula is used to determine routing overheads:

Routing costs include overhead (%)

$$\frac{\text{No of routing packets}}{\text{No of routing packets+No of data packets sent}} * 100 \text{ (7)}$$

6. RESULTS AND DISCUSSION

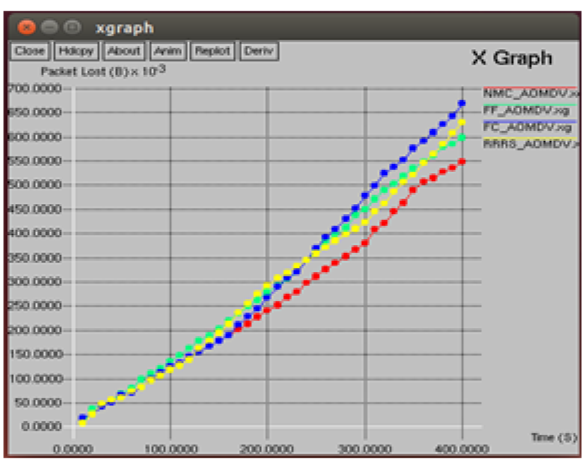

Figure 4: End to End among NMCs _AOMDV for 200 Nodes

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Table 1: End-to-End Delays for 100 and 200 Nodes

Time (Seconds)	(FF_OMDV)	(RRRS_AOMDV)	(FC_AOMDV)	Proposed
10	1.05	1.08	1.14	0.82
25	1.11	1.12	1.18	0.90
50	1.18	1.20	1.22	0.90
75	1.43	1.40	1.39	0.99
100	1.32	1.21	1.14	0.97
10	1.04	1.07	1.13	0.81
25	1.10	1.11	1.17	0.89
50	1.17	1.16	1.21	0.88
75	1.45	1.41	1.38	0.91
00	1.31	1.20	1.12	0.96

Figures 5 and 4 show the end-to-end comparison results of EN AMODV, TRUST AOMDV, and NMCs AOMDV after 400 rounds.

The total number of end-to-end suggested EN AMODV, TRUST AOMDV, and NMCs AOMDV MNs is taken for 100 and 200 MNs, respectively.

Finally, this proposed protocol among EN AMODV, TRUST AOMDV, and NMCs AOMDV receives 16% more energy in 100 MNs and 17% more energy in 200 MNs than the existing EE AOMDV, TS AOMDV, and protocols based on FF_AOMDVs, which receives the maximum no energy among the nine existing protocols.

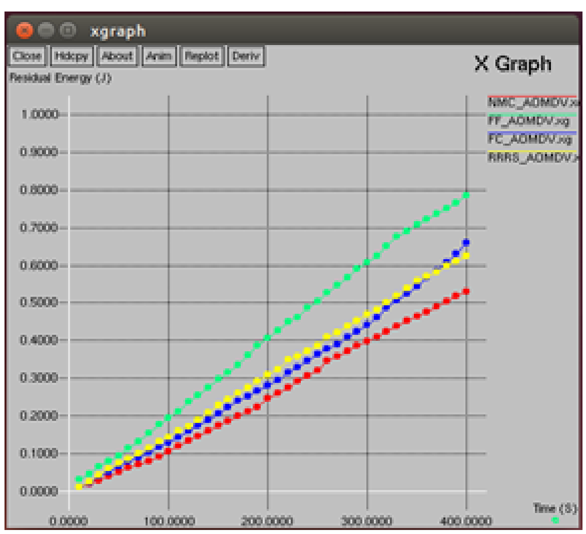

Figure 5: Total Numbers of Packets Loss for NMCs _AOMDV Protocol for 200 Nodes

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Table 2: Total number of Packet Lost for 100 and 200 Nodes

Time (Seconds)	Existing (FF_OMDV)	Existing (RRRS_AOMDV)	Existing (FC_AOMDV)	Proposed (NMCs _AOMDV)
Total number of Packet Lost for 100 Nodes				
10	17	16	15	9
25	38	34	33	27
50	81	74	73	61
75	91	86	82	74
100	103	101	98	91
Total number of Packet Lost for 200 Nodes				
10	16	15	14	9
25	38	33	32	26
50	80	73	72	55
75	90	83	71	42
100	91	65	42	24

The total number of packet losses for the planned EN AMODV, TRUST AOMDV, and NMCs AOMDV protocols, as well as the existing EE AOMDV, TS AOMDV, and protocols based on FF_AOMDVss, is taken for 100 MNs.

Finally, the proposed EN AMODV, TRUST AOMDV, and NMCs AOMDV protocols have a packet loss of 79 % in 100 MNs and 11 % in 200 MNs of less messages than the existing PAAOMDV, TS AOMDV, and protocols based on FF_AOMDVss, which have the lowest packet loss of the nine existing protocols.

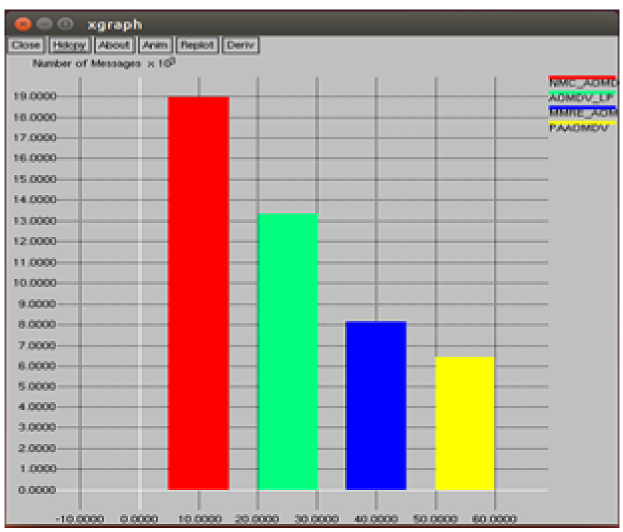

Figure6: Total Counts of Packet Delivered for NMCs _AOMDV Protocol for 200 Nodes

Figures 7 and 6 compare the total amount of packets sent by EN AOMDV and TRUST AOMDV after 400 rounds of NMCs AOMDV with the previous protocols FF_AOMDVs.

For 100 and 200 MNs, NMCs AOMDV receives 11820 messages, while FF_AOMDVs receives 10781 messages.

Finally, this suggested protocol NMCs AOMDV receives 57 percent of higher messages taken in 100 MNs and 44 % in 200 MNs. The current protocols based on FF_AOMDVs, which receives the most no messages of any extant protocol.

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, TS AOMDV, and FF_AOMDVs once 400 rounds are completed.

TRUST AOMDV has received 11820 messages, while EN AMODV has received 11792 messages. NMCs AOMDV, on the other hand, receives 11829 messages. For 100 and 200 MNs, AOMDV is used.

Finally, the proposed protocol EN AMODV, TRUST AOMDV, and NMCs AOMDV receives 59 percent more messages in 100 MNs and 72 percent more messages in 200 MNs than the existing PAAMODV, TS AOMDV, and protocols based on FF_AOMDVs, which receivemost messages amongst nine existing protocols.

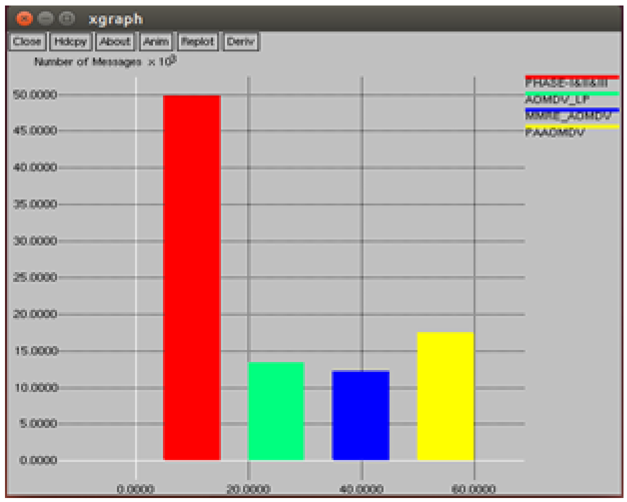

Figure 7: Total Number of Packet Delivered for EN_AMODV, TRUST_AOMDVand NMCs _AOMDV Protocol for 200 Nodes

Table 3: Packet Delivery Ratiofor 100 and 200 Nodes

Time (Seconds)	**(EE_OMDV)**	**(TS_AOMDV)**	**(LQ_AOMDV)**	**Proposed**
Packet Delivery Ratio for 100 Nodes				
10	30	33	36	42
25	40	46	50	62
50	42	53	72	83
75	56	60	65	74
100	51	56	66	79
Packet Delivery Ratio for 200 Nodes				
10	31	34	37	43
25	41	47	51	63
50	43	52	73	84
75	51	59	65	75
100	52	57	67	78

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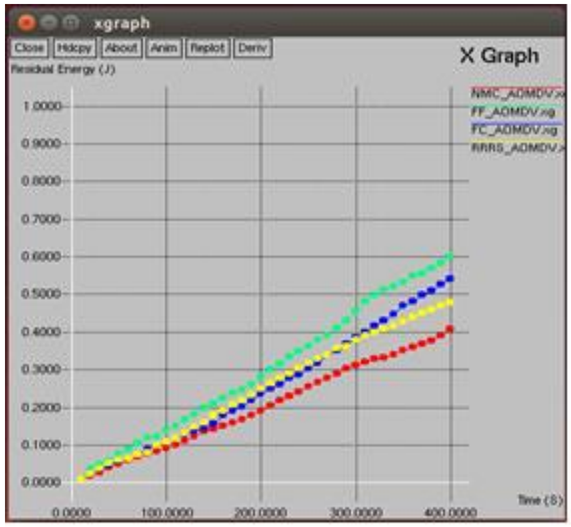

Figure 8: Residual Energy for EN_AMODV, TRUST_AOMDV and NMCs _AOMDV Protocol for 100 Nodes

After 400 rounds, Figures 8 and 9 compare the Residual Energy of EN AMODV, TRUST AOMDV, and NMCs AOMDV to the existing protocols PAAOMDV, TS AOMDV, and FF_AOMDVs.

The total residual energy of the proposed EN AMODV, TRUST AOMDV, and NMCs AOMDV Protocols, as well as the current PAAOMDV, TRUST AOMDV, and NMCs AOMDV Protocols, is taken for 100 and 200 MNs, respectively.

Finally, the suggested protocol EN AMODV, TRUST AOMDV, and NMCs AOMDV receives 20% more energy in 100 MNs and 19% more energy in 200 MNs than the existing PAAOMDV, TS AOMDV, and protocols based on FF_AOMDVs, which receive max energy amongst existing protocols.

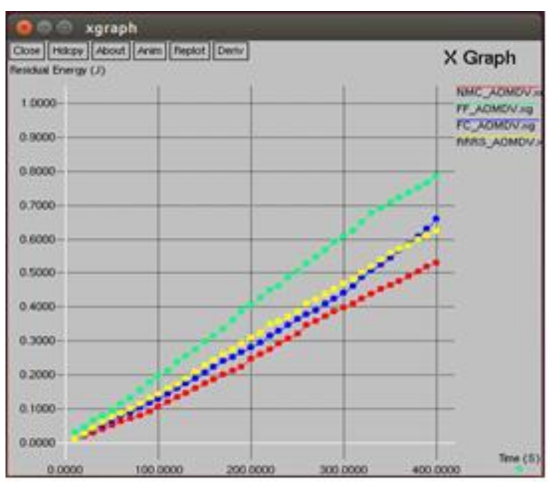

Figure 9: Residual Energy for EN_AMODV, TRUST_AOMDV and NMCs _AOMDV Protocol for 200 Nodes

Table 4: Energy Consumption for 100 and 200 Nodes

Time (Seconds)	(EE_OMDV)	(TS_AOMDV)	(LQ_AOMDV)	Proposed (NMCs _AOMDV)
Energy Consumption for 100 Nodes				
10	26	18	14	7
25	35	30	24	18
50	51	45	41	34
75	62	58	49	32
100	78	61	55	33
Energy Consumption for 200 Nodes				
10	29	21	17	9
25	37	31	24	20
50	53	47	42	33
75	71	72	64	44
100	90	83	70	52

7. CONCLUSION

The proposed system evaluated the performance of this work using the Network Simulator-2 simulator. The **6** Hierarchical Energy Efficient Design

The Network Simulator utility is used to simulate the Routing Algorithm (EE-OHRA) (NS 2.34). 100 mobile Ad-hoc MNs are installed in a 1000m * 1000m square space in the simulation lasting 41 ms. Each MNs moves at a distinct speed across the network in a random fashion. The transmission range of all MNs is 250 metres.

EE-OHRA must allocate a way so that communication does not break down under a critical circumstance. It must also analyses all MNbehaviour and discriminate between similar and network features.

The related MN discovery algorithm is intended to discover and communicate with comparable MNs.

It minimizes energy usage while increasing network longevity.

The EE-OHRA route discovery paradigm for MANETss is intended to handle the concerns of minimising energy usage while maximising route lifespan. Routing failure is reduced because the suggested route discovery procedure uses the route's lifetime as a criterion while picking the route. This minimizes route discovery process counts and computing overheads of MNsduring route discoveries and in turn affects routing protocol's overall performances.

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