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A Novel Energy Efficient Cluster Based Routing Protocol for Highly Dense MANET Architecture

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Abstract

With the growth of Mobile Ad-hoc network communications, the need for recent research to moving towards the better and efficient routing protocols. The efficiency of the routing protocols depends of the packet delivery. Nevertheless, due to the nature of battery power devices in the network for MANET and WSN, the power consumption of the routing protocols also to be consider for the betterment of the routing algorithms. Henceforth the applicability of the energy efficiency became the one of the most important criteria for performance evaluation. Thus, this work evaluates the performance of routing algorithms for highly dense MANET architecture. The major outcome of this work is to propose a novel Cluster based algorithm with lesser energy consumption and evaluates improvements over the existing systems.

Keywords: MANET, Energy Awareness, Cluster Based, OLSB, Babel, DSDV, AODV, ASR

INTRODUCTION

The challenge in the Mobile Ad-Hoc Networks is to propose an efficient routing algorithm [1] [2]. The efficiency of MANET does not only depend of the packet delivery rather also depends on the power awareness of the algorithm [3]. A number of studies are been carried out in the space of MANET routing algorithms [4]. The existing space of routing algorithms are been classified into three categories [5]. Based on the strategies of finding the routes of the algorithms, the classifications are proactive, reactive and hierarchical. The proactive routing algorithms are based on the routing table, which is maintained in each node in the network and the routing decisions are based on the tables. As and when the routing needs or the network

topologies changes, the information is been propagated to all the nodes and the routing information table is been updated subsequently [6] [7]. The details of the few of the existing algorithms are studies in this research in the forthcoming sections.

The major difficultly of managing the effectiveness of the routing algorithms is due to the randomness of the network. Also the load balancing of the network routing algorithm adds the complexity for propping a new routing algorithm.

A number of research attempts are made to improve the communication benefits of MANET by studying and applying various techniques. The outcomes of those novel researches are various topologies. Conversely, those proposed topologies results into increasing complexity of the network to understand and implement a new class of routing algorithm.

Henceforth, this work contributes towards the improvement of the energy efficiency of the algorithm for a highly dense MANET architecture without disproving the benefits of the higher congestion control and lower duration of the routing algorithms.

The rest of the work in this light is organized such as, in Section II we discuss and understand the recent advancements of the research attempts, in Section III we understand the classifications and differences of the MANET routing protocols, in Section IV MANET routing algorithms are been discussed with the conditions for dismissals, in Section V this work furnishes the novel algorithms with the benefits and applicability, in Section VI the improvements in terms of the results are been demonstrated and the conclusion of the work is furnished in the Section VII. The conclusion of the work also directs the future scope of improvements and constraints of this research attempt.

RECENT RESEARCH IMPROVEMENTS

Due to the effectiveness of devices and usefulness of the MANET, this area of research has always attracted many researchers to produce their studies.In this section of the work, the prominent outcomes are been listed with the impact of the research to this work.

The most recent approach by Haidar et al in the year of 2014 has made a significant contribution in designing a power aware algorithm for heterogeneous architecture of the MANET. The outlines of the research demonstrates the use of battery status to update the routing table in order to find out the most effective routing path for the packet delivery. Also the outcome of the work demonstrates the load balancing techniques of the network [8]. This work directly motivates to improve the power awareness of the proposed algorithm by considering the battery status of the nodes. The technique used in this work enhances the knowledge of capturing the power status and useful in further research.

The next most powerful outcome by the research of Anjum Asma et al in the year of 2012 demonstrates improvement of the life span of any network in the network by improving the life time of each node in the network. This work of Anjum et al

demonstrates the effectiveness of the power awareness in designing new algorithms for MANET routing to maintain the long duration of the network communications. This work encourages and motivates the proposed algorithm to consider the network communication lifetime without disproving the energy efficiency of the algorithms [9].

The graph theory for finding the shortest path for MANET routing is always the area of consideration for various studies. However, the improvement in defining the shortest part has grown to various techniques. The next notable outcome by Ammar W. M et al in the year of 2007 demonstrated the use of Particle Swarm Optimization for finding the shortest part. The duration of finding the shortest part is considerably an overload on the network, thus fine tuning the duration significantly improves the energy efficiency of the algorithms. This work motivates the further researches to consider various factors to improve the energy efficiency.

SCOPE OF THE ENHANCEMENTS

Furthermore this work considers the shortcomings of the recent research outcomes and proposes the scope for further research in the section.

The enhancement of the power aware algorithms are considered for regular situation MANET topologies, where the constraints like controllability of the devices or nodes are restricted to the human like movements and density of the devices are also considered to be less [10].

The mobility of the devices [11] is nodes play a major role in finding the routing paths as a most well-known fact. The recent researches considered the mobility to be a human like mobility, where the speed of the devices in changing the location is restricted in low speed. Thus that provides partial static routing tables for predictive applicability of the routing algorithms. The use of predictive analysis of the routing tables significantly reduces the duration of the algorithm execution and results in low time computations. This in turn results into the longer life span of the network [12]. Nevertheless the when the devices are attached to some vehicles or detached from the human interaction or enabled for self-movement, the routing table updates frequently. The complexity increases for the algorithm. Thus results in high duration of computations.

Secondly, the density of the MANET topology also significantly disrupts in find the power awareness of the algorithms. The recent researches mostly restricted the work in medium density topologies, thus leaving a scope for improvements and considerations of the existing algorithms for evaluations in dense network situations [13] [14] [15] [16].

Henceforth, considering the limitations of the literature survey, here this work presents the scope of study and evaluation in the newly proposed algorithm:

- Consideration of the high speed movements in the network nodes or the highly changeable network topologies for evaluating the performance of the proposed

algorithm should bring the new dimensions of consideration for adopting the proposed algorithm.

- Secondly, the density of the network to be considered high in order to evaluate the effectiveness of examining the battery status to apply the power awareness of the algorithm.

MANET ALGORITHMS AND DISMISSALS

This section of the work demonstrates and identifies the dismissal criteria for existing algorithms for routing MANET. This analysis is proven to be a knowledge base for proving the proposed algorithm benefits [17] [18]. The existing algorithms with their dismissals are been furnished here:

A. Proactive or Table Driven Routing Algorithms

The Proactive or the table driven algorithms are focused on maintaining a timely and updated routing table containing the information of source and destination with information related to the nodes. Here the details are provided:

- **Optimized Link State Routing Protocol:**The Optimized Link State Routing Protocol (OLSR) is an IP routing protocol optimized for mobile ad hoc networks, which can also be used on other wireless ad hoc networks. OLSR is a proactive link-state routing protocol, which uses hello and topology control (TC) messages to discover and then disseminate link state information throughout the mobile ad hoc network. Individual nodes use this topology information to compute next hop destinations for all nodes in the network using shortest hop forwarding paths [Fig – 1].

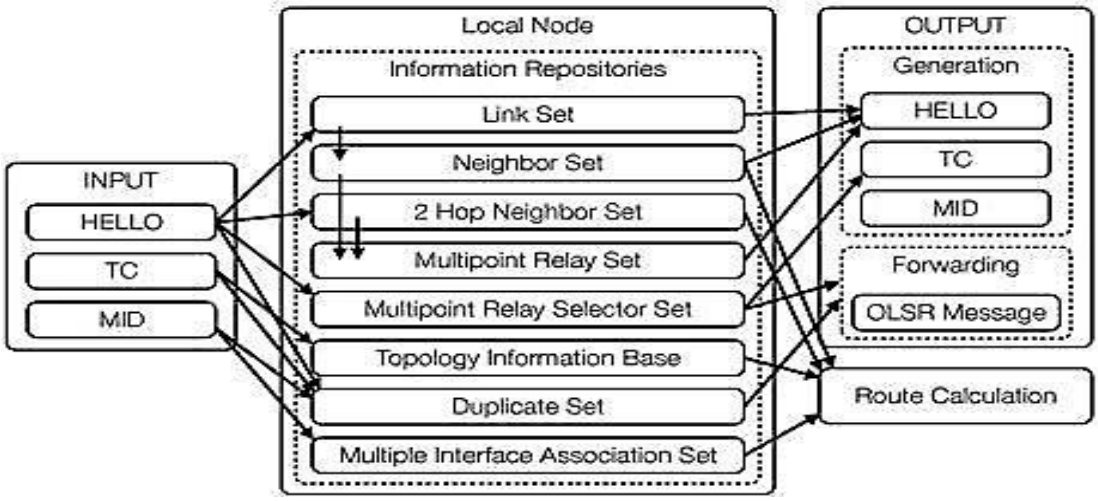

Fig. 1 Data Flow OLSR Protocol

- **BABEL:** The Babel routing protocol is a distance-vector routing protocol for Internet Protocol packet-switched networks that is designed to be robust and efficient on both wireless mesh networks and wired networks. Babel is based on the ideas in Destination-Sequenced Distance Vector routing (DSDV), Ad hoc On-Demand Distance Vector Routing (AODV), and Cisco's Enhanced Interior Gateway Routing Protocol (EIGRP), but uses different techniques for loop avoidance. Babel has provisions for using multiple dynamically computed metrics; by default, it uses hop-count on wired networks and a variant of ETX on wireless links, but can be configured to take radio diversity into account or to automatically compute a link's latency and include it in the metric [Fig – 2].

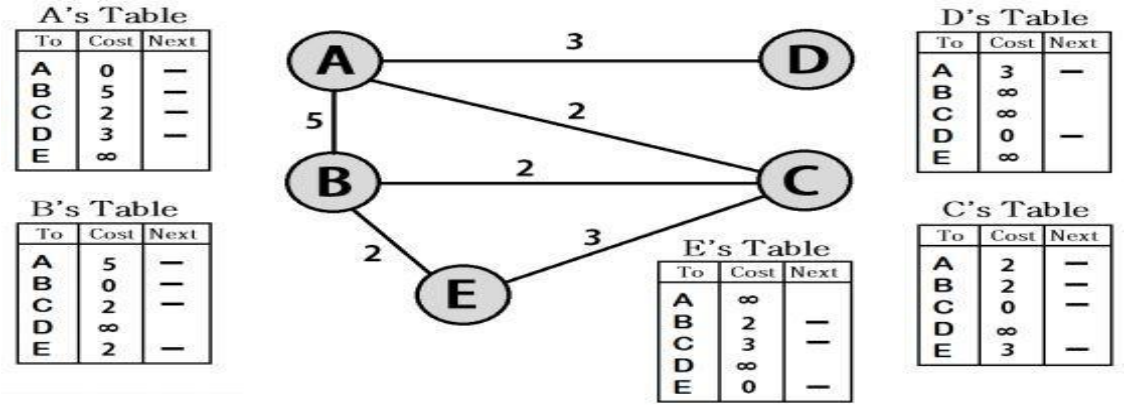

Fig. 2 Babel Method based on Distance Vector

- **Destination-Sequenced Distance-Vector Routing**: Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman–Ford algorithm. It was developed by C. Perkins and P.Bhagwat in 1994. The main contribution of the algorithm was to solve the routing loop problem. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present. Else, an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number. Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently [Table – 1].

TABLE I: ROUTING TABLE EXAMPLE FOR DSDV

Source	**Destination**	**Next Hop**	**Number of Hops**	**Sequence**	**Duration of the Installation in ns**
Node – 1	Node – 1	Node – 1	0	46	2000
Node – 1	Node – 2	Node – 2	1	36	2200
Node – 1	Node – 3	Node – 3	2	28	2500

Dismissals of the listed algorithms are presented here:

- The generic nature of the proactive algorithms are table dependent and in order to proceed for the routing the algorithms need to maintain a timely updated routing table for all the nodes. Thus resulting into high storage requirements in the network node caches.

- Secondly, the network topologies are needed to maintain in the routing tables and any change in the configuration results into the update propagation of the table into all nodes. Thus as and when the restructuring takes place into the network, which causes the complete propagation of the data.

B. Reactive or On Demand Routing Algorithms

The reactive algorithms are based on the concept of flooding the network packets through the network requesting for the routing request. The requesting packets results into activation of the nodes responsive for routing. The details are provided here:

- **Associativity-Based Routing**: Associativity-Based Routing (ABR) is a mobile routing protocol invented for wireless ad hoc networks or also known as MANETs and Wireless Mesh Network. ABR was invented in 1993, filed for a USA patent in 1996, and granted the patent in 1999. ABR was invented by Chai Keong Toh. Toh was working on a different Internet – that of a rapidly deployable, infrastructureless, self-organizing, self-configuring mobile Internet. The challenges in such a network are mobility of nodes and link dynamics. Toh's prime argument is that there is no point in choosing a node to route packets if the route is unstable or going to be broken soon. So, he introduced a new routing metric (known as associativity ticks) and the concept of associativity, i.e., link stability among nodes over TIME and SPACE [Fig – 3].

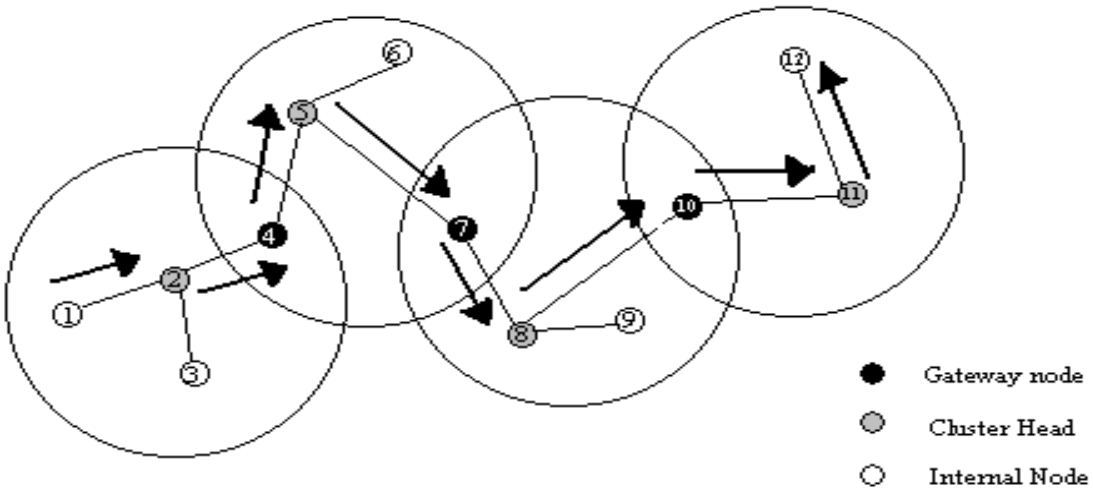

Fig. 3 ABR Techniques Associativity

- **Ad hoc On-Demand Distance Vector Routing:**The Ad hoc On-Demand Distance Vector (AODV) routing protocol is intended for use by mobile nodes in an ad hoc network. It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines unicast routes to destinations within the ad hoc network. It uses destination sequence numbers to ensure loop freedom at all times (even in the face of anomalous delivery of routing control messages), avoiding problems (such as "counting to infinity") associated with classical distance vector protocols [Fig – 4].

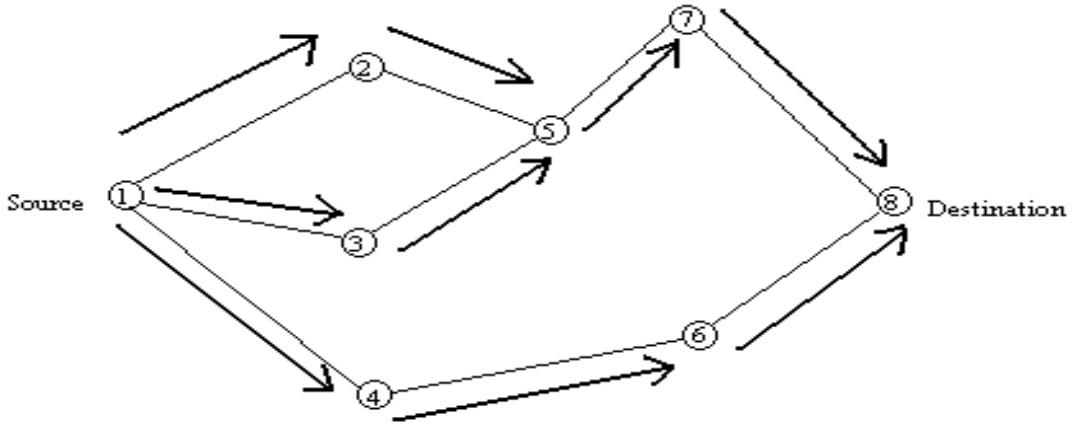

Fig. 4 AODV Vector Based Routing

- **Flow State in the Dynamic Source Routing**: DSRFLOW, the Flow-State extensions to Dynamic Source Routing (DSR), are a set of extensions that provide all of the benefits of source routing, without most of the per-packet overhead that is associated with source routing. It works by allowing most packets to be sent without a source route header, thus substantially reducing overhead. Indeed, one of the disadvantages of DSR was that the longer the source route of the packet was, the bigger the packet header became. The technique used is called implicit source routing. The main idea of DSRFLOW is to introduce a so-called flow table for each network node and thus making DSRFLOW a state full routing protocol. For each flow a node forwards there is one entry in the flow table which minimally must record the next hop address.

Dismissals of the listed algorithms are presented here:

- The algorithms are depending on the finding the routing paths based on the activated nodes during the request phase. This also includes the delay in time for activating the nodes and receiving the responses. The duration finally results into high latency time in finding the optimal route for routing.

- During the request phase of the listed algorithms, the source node sends request packets throughout the network. This increases the traffic in packet flow of the network. Thus the additional mechanism for congestion control need to be implementation and sometimes the bottleneck becomes unavoidable.

C. Hierarchical Routing Algorithms

The algorithms in this category depend solely on the level of the nodes. The initial routing technique is set to the proactive methods and then depends on the additional activities taken place in the network. The routing algorithms are generally the combinations of proactive and reactive class. However, the limitations of those categories are tried to be minimized. The details are provided here:

- **Fisheye State Routing**: Fisheye State Routing (FSR) is an implicit hierarchical routing protocol. Also considered a proactive protocol and is a link state based routing protocol that has been adapted to the wireless ad hoc environment. Relays on link state protocol as a base, and it has the ability to provide route information instantly by maintaining a topology map at each node. Thus will maintain updated information from the neighbour node through a link state table. In each node the network, a full topology map is stored then utilized. According to Kleinrock and Stevens, FSR uses the "fisheye" technique where the technique was used to reduce the size of information required to represent graphical data. The eye of a fish captures with high detail the pixels near the focal point. The detail decreases as the distance from the focal point increases. In routing, the fisheye approach translates to maintaining accurate distance and path quality information about the immediate neighbourhood of a node, with progressively less detail as the distance increases.

- **Order One MANET Routing Protocol**: The OrderOne MANET Routing Protocol is an algorithm for computers communicating by digital radio in a mesh network to find each other, and send messages to each other along a reasonably efficient path. It was designed for, and promoted as working with wireless mesh networks. OON's designers say it can handle thousands of nodes, where most other protocols handle less than a hundred. OON uses hierarchical algorithms to minimize the total amount of transmissions needed for routing. Routing overhead is limited to 1% to 5% of node to node bandwidth between any networks and does not grow as the network size grows. The basic idea is that a network organizes itself into a tree. Nodes meet at the root of the tree to establish an initial route. The route then moves away from the root by cutting corners, as ant-trails do. When there are no more corners to cut, a nearly optimum route exists. This route is continuously maintained. Each process can be performed with localized minimal communication, and very small router tables.

In the next section, this work proposes the novel cluster dependent energy efficient routing algorithm.

A NOVEL CLUSTER DEPENDED ENERGY EFFICIENT ROUTING ALGORITHM

The novel cluster depended approach is efficient and effective by the means of energy efficiency. The clustered depended approach is demonstrated in this section.

In order to establish the mathematical model the following lemmas are considered. The lemmas and the subsequent theory will establish the model by analysing the cluster head detection.

Lemma – 1:Any algorithm must change the cluster head randomly and time to time in order to enhance the life time of the network.

Where,

T(CH) denotes the cluster head deciding function and returns the cluster head for any time instance

G is the set of clusters

N is the set of nodes in any cluster

k is the round number

Proof: In order to prove the above lemma, this work demonstrates that,

$$\forall g \subset G \qquad \text{(Eq. 1)}$$

There exists a cluster g in the total network, such that,

$$\varnothing(g) \neq NULL \qquad \text{(Eq. 2)}$$

The numbers of non-dead or active nodes are not zero.

Further, the selected node, n

$$\forall n \subset N \qquad \text{(Eq. 3)}$$

And the randomly selected node to be considered as the new cluster head, n’

$$\forall n(t) \subset N' \qquad \text{(Eq. 4)}$$

Subsequently to be naturally understood that,

$$N \notin N' \; and \; N' \notin N \qquad \text{(Eq. 5)}$$

So that the recently selected cluster head can be avoided to be similar from the last one.

Considering the R(k) is the percentage of the cluster head available in the N, then

$$1 - R(k)[\mathrm{k}.\mathrm{mod}\frac{1}{R(k)}] \qquad \text{(Eq. 6)}$$

The remaining percentage of the cluster heads, available in the collection N.

Henceforth, the cluster dead deciding the function can be formulated as

$$T(CH) = \frac{R(k)}{1 - R(k)[\mathrm{k}.\mathrm{mod}\frac{1}{R(k)}]} \qquad \text{(Eq. 7)}$$

As the Eq. 5 clearly stand the point of not repeating cluster heads in the subsequent times, thus the energy consumption is also evenly distributed.

Lemma – 2: Any algorithm must select the cluster head based on the comparisons of effective energy available in order to increase the life span of the network.

Where,

Net_LSpan denotes the Life Span of the network

Net_Egydenotes the energy of the network

N_Egy denotes the energy of the node

Proof: In order to prove the above mentioned lemma, this work demonstrates that,

$$\int_{MAX(Net\_Egy)}^{MIN(Net\_Egy)} Net\_Egy \qquad \text{(Eq. 8)}$$

Considering the Max and Min denotes the maximum and minimum energy of the network.

Subsequently,

$$\int_{MAX(N\_Egy)}^{MIN(N\_Egy)} N\_Egy \qquad \text{(Eq. 9)}$$

Here choosing any node n to be the cluster head, will result in

$$\mathrm{Re}s(N\_\mathrm{Egy}) = \frac{N\_Egy(t)}{dx(N\_Egy_n)} \qquad \text{(Eq. 10)}$$

Where, Res denotes the effective energy left in the node.

After the random selection of the any cluster head, the energy varies in the utilized and non-utilized node.

$$\mathrm{Re}\,s(N\_\mathrm{Egy})_{\mathrm{n}} < \mathrm{Re}\,s(N\_\mathrm{Egy})_{\mathrm{n+1}} \quad \text{(Eq. 11)}$$

Further selection of the same node n, will result in

$$\mathrm{Re}\,s(N\_\mathrm{Egy})_{\mathrm{n}} \rightarrow Min(N\_Egy)_{\mathrm{n}} \quad \text{(Eq. 12)}$$

Repeated selection of the same node, will result in

$$\mathrm{Re}\,s(N\_\mathrm{Egy})_{\mathrm{n}} \rightarrow 0 \quad \text{(Eq. 13)}$$

Thus having a random shutdown of the node and result in

$$\begin{aligned} &\mathrm{Re}\,s(Net\_Egy)(t) \\ &\rightarrow \mathrm{Min}(Net\_Egy)(t) \end{aligned} \quad \text{(Eq. 14)}$$

Naturally to be understood that, this will result in

$$Net\_LSpan \rightarrow 0 \quad \text{(Eq. 15)}$$

This effective will be visible in much lesser amount of time.

Henceforth in the light of the Lemma – 1 and Lemma – 2, this work demonstrates the novel algorithm,

Step-1. In the pre-installation step, the list of active nodes will be accumulated,

$$n \subset N \notin D \quad \text{(Eq. 16)}$$

Where n denotes the any available node belongs to the cluster set N and does not belongs to the D, the dead cluster set.

From the Lemma – 1, it is proven that the random selection of the cluster head will improve the life span of the network.

Step-2. In the next step, for the selected node, the energy status will be accumulated.

$$\mathrm{Re}\,s(n) \leftarrow \overline{Max(\mathrm{N\_Egy}(n))} \quad \text{(Eq. 17)}$$

From the Lemma -2, it is also proven that the consideration of the available energy will improve the life span of the network.

Step-3. Henceforth, the cluster head will be decided considering the weight function consisting of the available energy and selection of non-repeating nodes.

Where,

CH denotes the cluster head

From the Eq. 7, Eq. 14 and Eq. 15,

$$CH = \prod_{\mathrm{Re}s(N\_Egy(n))}^{Max(N\_Egy(n))} n \oplus [n \subset N \notin D] \quad \text{(Eq. 18)}$$

Step-4. The information captured for all the nodes in the network will be maintained in the routing table RTab with the following parameters.

$$RTab(\mathrm{N\_Egy_n}, \mathrm{n_{Source}}, \mathrm{n_{Destination}}, \mathrm{n_{Next}}) \qquad \text{(Eq. 19)}$$

Step-5. In the next step, the nearing neighbour node to be decided repeating the step – 1 to 4.

Step-6. After the path is been decided, the data transfer is carried out.

Step-7. In case of the network topology change repeat the step – 1 to 5.

Henceforth the novel cluster based algorithm may show the higher latency, however the algorithm will demonstrate the higher energy awareness compared to the existing algorithms.

In order to prove, the improvements in the next section, this work furnishes the comparative study.

RESULTS AND DISCUSSIONS

In this section, the work demonstrates the comparison of the energy awareness of the existing algorithms with the proposed novel algorithms.

The following scenarios are considered for performance evaluation:

- MANET with 30 Nodes
- MANET with 50 Nodes
- MANET with 75 Nodes

And

- MANET with 100 Nodes

A. Simulation with 30 Nodes

The simulation demonstrates significant improvement. The improvement is been furnished here [Table – 2].

Table II: Energy Awareness with 30 Nodes

Number of Nodes	Energy Disruptions in the Network (Joules)		
	FSR	OORP	Novel Technique
1	0.1486	0.100	0.0984
2	0.1472	0.099	0.0969
3	0.1458	0.099	0.0953
4	0.1444	0.099	0.0937
5	0.143	0.098	0.0919
6	0.1416	0.098	0.0903
7	0.1402	0.097	0.0887
8	0.1388	0.097	0.0871
9	0.1374	0.097	0.0856
10	0.136	0.096	0.084
11	0.1346	0.095	0.0823
12	0.1332	0.095	0.0808
13	0.1318	0.094	0.0792
14	0.1304	0.094	0.0777
15	0.1289	0.094	0.076
16	0.1275	0.094	0.0744
17	0.1261	0.094	0.0729
18	0.1247	0.094	0.0712
19	0.1233	0.093	0.0696

20	0.1219	0.093	0.0679
21	0.1206	0.093	0.0663
22	0.1192	0.092	0.0647
23	0.1178	0.092	0.0632
24	0.1164	0.092	0.0616
25	0.1151	0.091	0.0601
26	0.1137	0.090	0.0586
27	0.1124	0.090	0.0571
28	0.111	0.090	0.0556
29	0.1097	0.090	0.0542
30	0.1084	0.090	0.0526

The improvement is observed visually [Fig – 5].

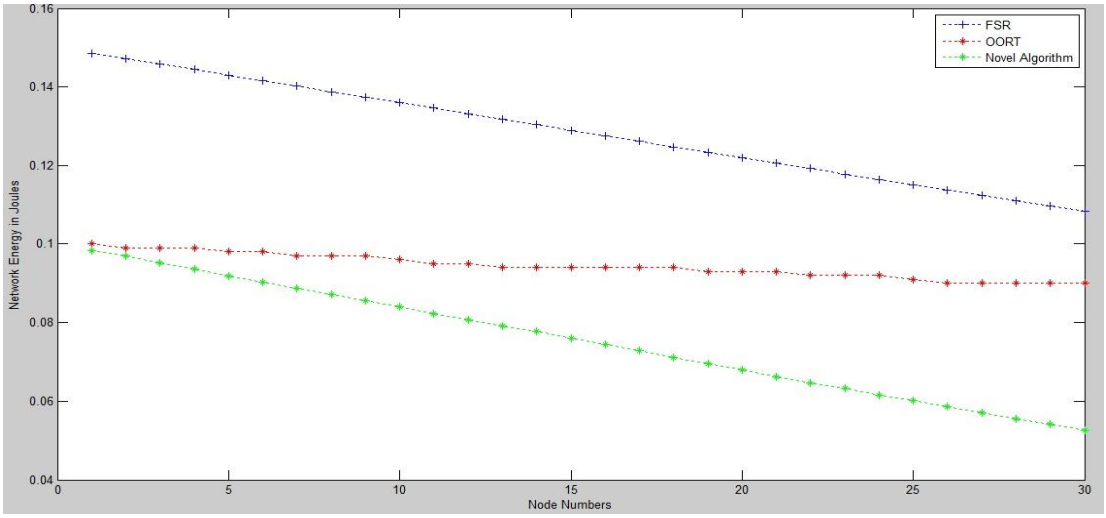

Fig. 5 Improvement in Energy Efficiency

B. Simulation with 50 Nodes

The simulation demonstrates significant improvement. The improvement is been furnished here [Table – 3].

Table III: Energy Awareness with 50 Nodes

Number of Nodes	Energy Disruptions in the Network (Joules)		
	FSR	OORP	Novel Technique
1	0.1486	0.100	0.0984
2	0.1472	0.099	0.0969
3	0.1458	0.099	0.0953
4	0.1444	0.099	0.0937
5	0.143	0.098	0.0919
6	0.1416	0.098	0.0903
7	0.1402	0.097	0.0887
8	0.1388	0.097	0.0871
9	0.1374	0.097	0.0856
10	0.136	0.096	0.084
11	0.1346	0.095	0.0823
12	0.1332	0.095	0.0808
13	0.1318	0.094	0.0792
14	0.1304	0.094	0.0777
15	0.1289	0.094	0.076
16	0.1275	0.094	0.0744
17	0.1261	0.094	0.0729
18	0.1247	0.094	0.0712
19	0.1233	0.093	0.0696
20	0.1219	0.093	0.0679
21	0.1206	0.093	0.0663
22	0.1192	0.092	0.0647
23	0.1178	0.092	0.0632
24	0.1164	0.092	0.0616
25	0.1151	0.091	0.0601

26	0.1137	0.090	0.0586
27	0.1124	0.090	0.0571
28	0.111	0.090	0.0556
29	0.1097	0.090	0.0542
30	0.1084	0.090	0.0526
31	0.107	0.089	0.0511
32	0.1057	0.089	0.0498
33	0.1044	0.089	0.0483
34	0.1033	0.088	0.0469
35	0.102	0.088	0.0456
36	0.1007	0.087	0.0443
37	0.0995	0.086	0.0431
38	0.0982	0.086	0.0419
39	0.097	0.086	0.0407
40	0.0958	0.085	0.0395
41	0.0947	0.085	0.0385
42	0.0936	0.084	0.0374
43	0.0924	0.084	0.0364
44	0.0913	0.084	0.0353
45	0.0902	0.083	0.0344
46	0.0891	0.082	0.0333
47	0.088	0.082	0.0324
48	0.0869	0.082	0.0314
49	0.0858	0.081	0.0305
50	0.0847	0.081	0.0297

The improvement is observed visually [Fig – 6].

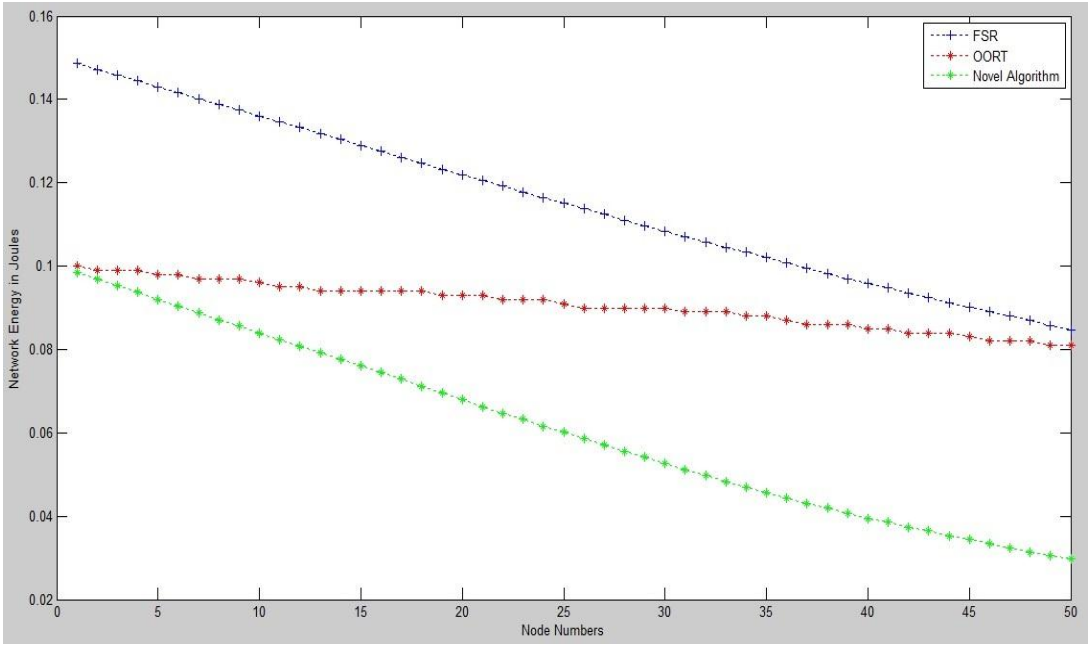

Fig. 6 Improvement in Energy Efficiency

C. Simulation with 75 Nodes

The simulation demonstrates significant improvement. The improvement is been furnished here [Table – 4].

Table IV: Energy Awareness with 75 Nodes

Number of Nodes	Energy Disruptions in the Network (Joules)		
	FSR	OORP	Novel Technique
1	0.1486	0.100	0.0984
2	0.1472	0.099	0.0969
3	0.1458	0.099	0.0953
4	0.1444	0.099	0.0937
5	0.143	0.098	0.0919
6	0.1416	0.098	0.0903
7	0.1402	0.097	0.0887
8	0.1388	0.097	0.0871

9	0.1374	0.097	0.0856
10	0.136	0.096	0.084
11	0.1346	0.095	0.0823
12	0.1332	0.095	0.0808
13	0.1318	0.094	0.0792
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15	0.1289	0.094	0.076
16	0.1275	0.094	0.0744
17	0.1261	0.094	0.0729
18	0.1247	0.094	0.0712
19	0.1233	0.093	0.0696
20	0.1219	0.093	0.0679
21	0.1206	0.093	0.0663
22	0.1192	0.092	0.0647
23	0.1178	0.092	0.0632
24	0.1164	0.092	0.0616
25	0.1151	0.091	0.0601
26	0.1137	0.090	0.0586
27	0.1124	0.090	0.0571
28	0.111	0.090	0.0556
29	0.1097	0.090	0.0542
30	0.1084	0.090	0.0526
31	0.107	0.089	0.0511
32	0.1057	0.089	0.0498
33	0.1044	0.089	0.0483
34	0.1033	0.088	0.0469
35	0.102	0.088	0.0456
36	0.1007	0.087	0.0443
37	0.0995	0.086	0.0431
38	0.0982	0.086	0.0419
39	0.097	0.086	0.0407
40	0.0958	0.085	0.0395
41	0.0947	0.085	0.0385
42	0.0936	0.084	0.0374

43	0.0924	0.084	0.0364
44	0.0913	0.084	0.0353
45	0.0902	0.083	0.0344
46	0.0891	0.082	0.0333
47	0.088	0.082	0.0324
48	0.0869	0.082	0.0314
49	0.0858	0.081	0.0305
50	0.0847	0.081	0.0297
51	0.0838	0.081	0.0288
52	0.0827	0.081	0.0279
53	0.0816	0.080	0.027
54	0.0806	0.080	0.0262
55	0.0796	0.080	0.0256
56	0.0786	0.079	0.0248
57	0.0776	0.079	0.0241
58	0.0766	0.079	0.0234
59	0.0756	0.078	0.0226
60	0.0746	0.078	0.022
61	0.0736	0.078	0.0215
62	0.0726	0.078	0.021
63	0.0717	0.078	0.0204
64	0.0708	0.077	0.0198
65	0.07	0.077	0.0192
66	0.069	0.076	0.0188
67	0.0681	0.076	0.0182
68	0.0673	0.076	0.0177
69	0.0664	0.076	0.0173
70	0.0656	0.075	0.0168
71	0.0648	0.074	0.0164
72	0.0639	0.074	0.016
73	0.0631	0.074	0.0156
74	0.0623	0.073	0.0152
75	0.0616	0.073	0.0148

The improvement is observed visually [Fig – 7].

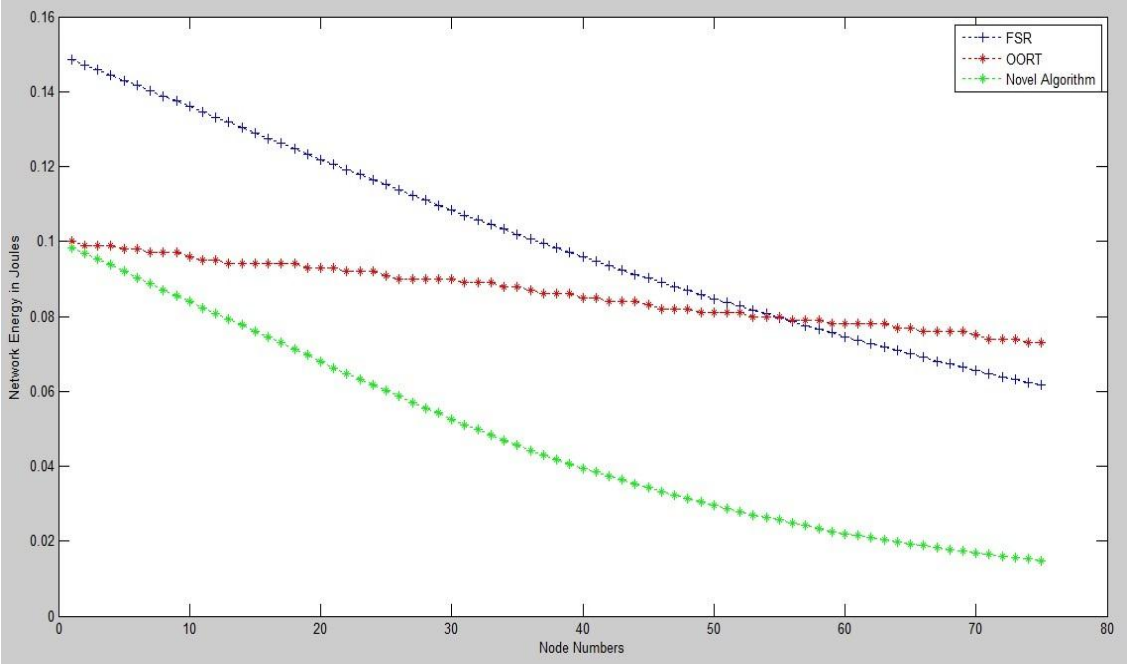

Fig. 7 Improvement in Energy Efficiency

D. Simulation with 100 Nodes

The simulation demonstrates significant improvement. The improvement is been furnished here [Table – 5].

Table V: Energy Awareness with 100 Nodes

Number of Nodes	Energy Disruptions in the Network (Joules)		
	FSR	OORP	Novel Technique
1	0.1486	0.100	0.0984
2	0.1472	0.099	0.0969
3	0.1458	0.099	0.0953
4	0.1444	0.099	0.0937
5	0.143	0.098	0.0919
6	0.1416	0.098	0.0903

7	0.1402	0.097	0.0887
8	0.1388	0.097	0.0871
9	0.1374	0.097	0.0856
10	0.136	0.096	0.084
11	0.1346	0.095	0.0823
12	0.1332	0.095	0.0808
13	0.1318	0.094	0.0792
14	0.1304	0.094	0.0777
15	0.1289	0.094	0.076
16	0.1275	0.094	0.0744
17	0.1261	0.094	0.0729
18	0.1247	0.094	0.0712
19	0.1233	0.093	0.0696
20	0.1219	0.093	0.0679
21	0.1206	0.093	0.0663
22	0.1192	0.092	0.0647
23	0.1178	0.092	0.0632
24	0.1164	0.092	0.0616
25	0.1151	0.091	0.0601
26	0.1137	0.090	0.0586
27	0.1124	0.090	0.0571
28	0.111	0.090	0.0556
29	0.1097	0.090	0.0542
30	0.1084	0.090	0.0526
31	0.107	0.089	0.0511
32	0.1057	0.089	0.0498
33	0.1044	0.089	0.0483
34	0.1033	0.088	0.0469
35	0.102	0.088	0.0456
36	0.1007	0.087	0.0443
37	0.0995	0.086	0.0431
38	0.0982	0.086	0.0419
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41	0.0947	0.085	0.0385
42	0.0936	0.084	0.0374
43	0.0924	0.084	0.0364
44	0.0913	0.084	0.0353
45	0.0902	0.083	0.0344
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47	0.088	0.082	0.0324
48	0.0869	0.082	0.0314
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50	0.0847	0.081	0.0297
51	0.0838	0.081	0.0288
52	0.0827	0.081	0.0279
53	0.0816	0.080	0.027
54	0.0806	0.080	0.0262
55	0.0796	0.080	0.0256
56	0.0786	0.079	0.0248
57	0.0776	0.079	0.0241
58	0.0766	0.079	0.0234
59	0.0756	0.078	0.0226
60	0.0746	0.078	0.022
61	0.0736	0.078	0.0215
62	0.0726	0.078	0.021
63	0.0717	0.078	0.0204
64	0.0708	0.077	0.0198
65	0.07	0.077	0.0192
66	0.069	0.076	0.0188
67	0.0681	0.076	0.0182
68	0.0673	0.076	0.0177
69	0.0664	0.076	0.0173
70	0.0656	0.075	0.0168
71	0.0648	0.074	0.0164
72	0.0639	0.074	0.016
73	0.0631	0.074	0.0156
74	0.0623	0.073	0.0152

75	0.0616	0.073	0.0148
76	0.0608	0.072	0.0145
77	0.06	0.072	0.0141
78	0.0592	0.072	0.0138
79	0.0584	0.071	0.0135
80	0.0577	0.071	0.0131
81	0.0569	0.071	0.0128
82	0.0562	0.071	0.0125
83	0.0555	0.070	0.0122
84	0.0548	0.069	0.0119
85	0.0541	0.069	0.0116
86	0.0534	0.068	0.0113
87	0.0527	0.068	0.011
88	0.0521	0.068	0.0107
89	0.0515	0.067	0.0104
90	0.0508	0.067	0.0101
91	0.0502	0.067	0.0099
92	0.0496	0.067	0.0096
93	0.049	0.066	0.0093
94	0.0483	0.066	0.009
95	0.0477	0.065	0.0088
96	0.0471	0.065	0.0085
97	0.0465	0.064	0.0082
98	0.0459	0.064	0.008
99	0.0454	0.063	0.0077
100	0.0448	0.063	0.0074

The improvement is observed visually [Fig – 8].

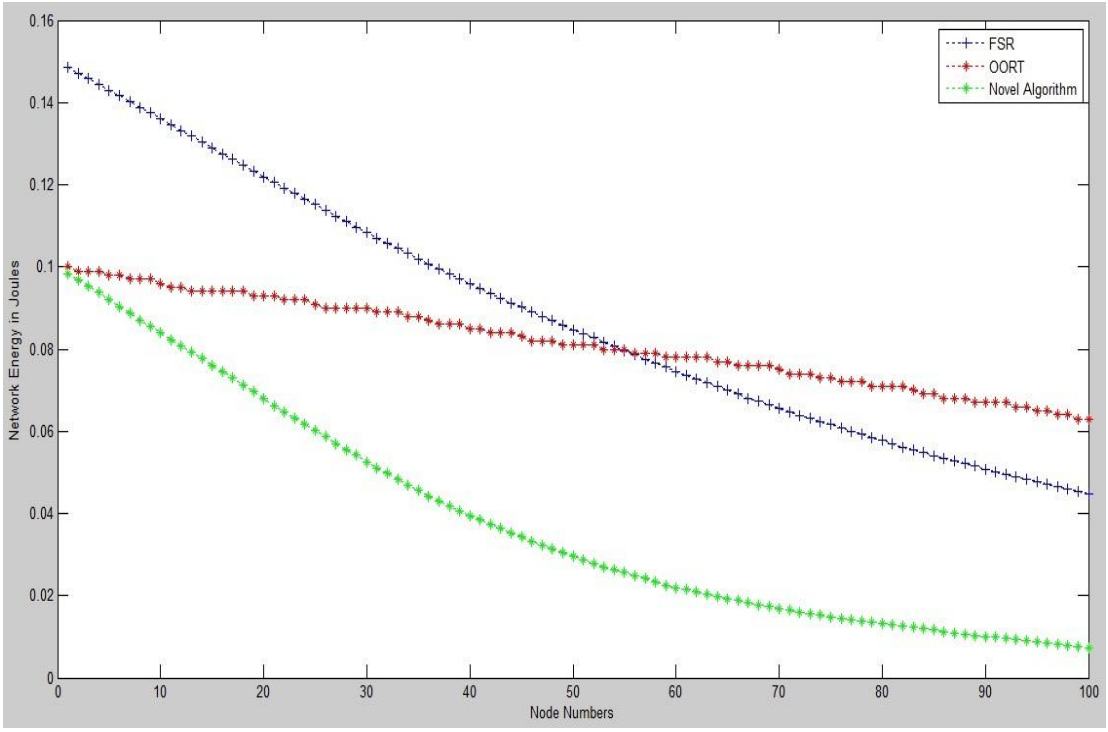

Fig. 8 Improvement in Energy Efficiency

Henceforth with the demonstration of the notable improvements, this work firmly stands the algorithm performance improvements in terms of energy awareness.

CONCLUSIONS OF THE STUDY

With the aim of improving the energy efficiency of the MANET routing algorithms, this work proposes and establishes the novel cluster based routing algorithm. The work establishes the improved results compared to the existing algorithms. In the course of the study, the work presents the classifications of the MANET routing algorithms with their notable dismissal conditions for any given network. The work evaluates the performances of OLSR, Babel and DSDV under the hood of the proactive algorithms, ABR, AODV and DSR under hood of reactive algorithms and finally compares the FSR and OOMRP with the proposed systems. The algorithm is proven to be having higher energy efficiency and consistence for a highly dense MANET. This work finally outcomes in the novel algorithm with nearly 50% improvement in the power awareness and the proposed model for calculating the energy efficiency of any given algorithm for further enhancements.

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