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Improvement of AODV Routing Protocol Algorithm with Link Stability and Energy Efficient Routing for MANET

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Abstract -A major challenge that lies in MANET (Mobile Ad-hoc Network) communication is the unlimited mobility and more frequent failures due to link breakage. Conventional routing algorithms are insufficient for Ad-hoc networks. Because major problem MANETs is limited power supply, dynamic networking. But our proposed protocol methods provided by link stability, minimizing the overhead, maintaining the route reliability & improve the link utilization, low delay, less packet drops and improve throughput. We propose a stable AODV routing protocol where node stability is more in comparison with the previous methods like probability based approach where each node broadcast the message that is received for the first time with some fixed probability p and counter based approach, cluster based approach and other approaches like Distance based approach and location based approach. In concerned the energy consumption of nodes of the network. Here we proposed an algorithm by which we save energy of each participating nodes. So the links of the network and between the nodes are more stable. For an infrastructure less ad-hoc network. Our Stability is based on the link stability by increasing the node lifetime by finding the discard limit of each node in the network and we also studied about various overheads in AODV like link breakage, network scalability, packet flooding ratio, network capacity and link and node capabilities etc. We demonstrate, through extensive simulations in NS-2, that the increased route stability afforded by stable AODV leads to substantially better performance. Here we used algorithm which saves the energy of each node of topology while simulating AODV. And find the discard limit of each node in the network .Our results show that under a variety of applicable network loads and network settings, our protocol achieves better packet delivery ratio and less routing overhead in compression with old routing overhead algorithms. Here we increase the energy efficiency of our network and the energy consumption of network is less after applying our proposed algorithm. And our Network gets more stable.

Keywords: MANETs, Routing Protocol, Energy efficiency, Stability, AODV, Flooding.

I. INTRODUCTION

Mobile ad hoc networks (MANETs) are infrastructure less networks consist of wireless mobile nodes which dynamically exchange data among themselves. Position of nodes in MANET changes frequently [14]. Design of efficient routing protocols in such dynamic networks is a challenging issue [6],[11]. Many routing protocols have been proposed to improve the performance of ad-hoc networks [13]. The nodes in ad hoc network do not depend on any fixed infrastructure (e.g., base stations or access points) for their communication. Communication is done through wireless links among mobile hosts through their antenna [9].The nodes close to each other communicate directly while nodes that are not in the range of each other communicate via the intermediate nodes [3]. The nodes that communicate directly are said to be neighboring nodes [16]. The intermediate nodes act as a router. Furthermore, due to the movement of nodes, the network topology changes rapidly [1]. Therefore, an efficient routing protocol is needed for better communication between the nodes [11]. Routing protocols in ad hoc networks are divided in to two categories: proactive (Table driven) routing protocols and reactive (On Demand) routing protocols [13]. MANETs is a reactive routing protocol, meaning that it establishes a route to a destination only on demand [6]. In contrast, the most common routing protocols of the Internet are proactive meaning they find routing paths independently of the usage of the path [13]. AODV is an example of such routing algorithm. AODV avoids the counting-to-infinity problem of other distance-vector protocols by using sequence numbers on route updates [8].

A. Proactive protocols

In this type of routing protocol, each node in a network maintains one or more routing tables which are updated regularly. Each node sends a broadcast message to the entire network [7]. However, it incurs additional overhead cost due to maintaining up-to-date information and as a result: throughput of the network may be affected but it provides the actual information to the availability of the routes. Destination Sequenced Distance Vector (DSDV) protocol [ ], Fisheye State Routing (FSR) protocol [] and OLSR [] are the examples of such routing protocols [2].

B. Reactive Protocols

In this type of routing protocol, each node in a network discovers a route based on-demand. Whenever a node receives packets from its upper layer for transmission. It floods a control message for route discovery and after of this route discovers data transmission become possible along the discovered routes [6]. The main advantage is that these protocols needs less routing information but the disadvantages are that it introduces latency in packet transmission due to discovery of route before transmission and it also resource provision for route maintenance as topology changes during transmission which occurs frequently in MANETs. And it incurs higher latency. The examples of this type of protocol are Dynamic Source Routing (DSR)[2], Ad-hoc On Demand Routing (AODV) [2] and Associativity Based Routing (ABR) protocols[2].

C. Comparison of proactive & reactive protocol

AODV is a classical routing protocol for MANET that compromise the trade-off problems like large packet header in reactive source protocol and large messaging overhead due to periodic updates in proactive protocols. It uses a distributed approach i.e. it keeps track of the neighbor nodes only and it does not establish a series of paths to reach the destination. Proactive protocols lead to relatively high overhead on the network due to exchange of information periodically [13]. On the other hand, reactive routing protocols creates routes only when one node wants to communicate with another node which reduces routing overhead and increases bandwidth utilization.

In Ad hoc networks link break occurs frequently due to nodes mobility, greater error rates, interference of signals, fading environment[14] etc. But an actual route break occurs due to mobility of nodes. In AODV node that finds link break send a RERR (Route Error) message to the source. Source none after receiving the RERR starts a new fresh route discovery process if it wants further communication with the destination node.

II. Problem Description

As MANETs is a collection of wireless nodes without any infrastructure support and nodes in MANETs consumes energy from battery. The nodes in MANET can act as either the router or source and the control of the network is distributed among nodes. The nodes in MANETS are highly mobile and it maintains dynamic interconnection between those mobile nodes. MANTEs have been considered as isolated stand-alone network.

In AODV the network is silent until a communication is needed. At that point the network node that needs a communication broadcasts a RRER. Other nodes forward this message, and record the node that they heard it from, creating an explosion of backward route to the needy node or node in the destination. When a node receives such a message and already has a route to the desired node. It sends a reply message backwards through this route to the requesting node. The needy node then begins using the route. Unused entries in the routing tables are recycled after a time. When a link fails, a routing error is passed back to a transmitting node and the process repeats. Flooding of route request message by all nodes imposes major concern in energy consumption [6]. A new approach to reduce the routing overhead and energy during the route discovery phase [4].

A. Objective

Reactive routing protocol eliminates the routing overhead during the periodic information interchange in the proactive routing protocol. In reactive or on demand protocols the up-to date routing table is not retained. It will discover the route only when it is having the data to send. In reactive protocol, the first step of data dissemination is to find the route [16]. This increases the time delay to establish the route. In order to get the advantages of both table driven and on- demand routing protocols.

Here we work on prior algorithms and check the performance of the algorithms. And calculate the overhead in many different algorithm .And develop an algorithms which is better performance in mobile ad-hoc networks and which has a reduced overheads for the route establishment and for the route discovery [10]. We use the simulation techniques for check the performance of algorithms and use the network simulator NS2. Our main objective is to develop an algorithm which has a reduced route establishment and route discovery overheads [4] [3].

Our main objectives are:

1: Reduced Routing Overheads.

2: Reduce the energy consumption by limits the Broadcast.

3. Background and Literature Survey

III. MANETs

Mobile ad-hoc networks (MANETs) are a self-configuring infrastructure less network of mobile devices connected by wireless. Ad hoc is Latin and means "for this purpose". Each device in a MANETs is free to move independently in any direction, and will therefore change its links to other devices frequently. Each node bound to forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet [2]. MANETs are a kind of wireless ad hoc networks that usually has a routable networking environment on top of a Link Layer ad-hoc network. The growth of laptops and 802.11/Wi-Fi wireless networking have made MANETs a popular research topic since the mid-1990. Several researchers evaluate protocols and their abilities, assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other. Different protocols are then evaluated based on measure such as the packet drop rate, the overhead introduced by the routing protocol, end-to-end packet delays, network throughput etc.

Mobile ad hoc network or MANETs is a decentralized, peer-to-peer wireless, self-configurable ad-hoc network. MANETs uses wireless connections, such as Wi-Fi or satellite transmission, to connect to other networks and devices. Some MANETs are limited to local area network (LAN) devices, such as LAN laptops, while others can connect to the Internet. A protocol is a set of rules that defines the format, signaling, presentation and transmission of data over a communication medium [1] [2] [5].

A. Characteristics of MANETs

When a node wants to communicate with another node, the destination node D must lies within the radio range of the source node S that wants to initiate the communication show in fig 1. The intermediate nodes within the network, aids in routing the packets for the source node to the destination node. These networks are fully self-organized, having the capability to work anywhere without any infrastructure [15]. Nodes are autonomous and play the role of router and host at the same time. MANETs are the self-governing, where there is no centralized control and the communication is carried out with blind mutual trust amongst the nodes on each other. The network can be set up anywhere without any geographical restrictions. One of the limitations of the MANETs are the limited energy resources of the nodes [7].

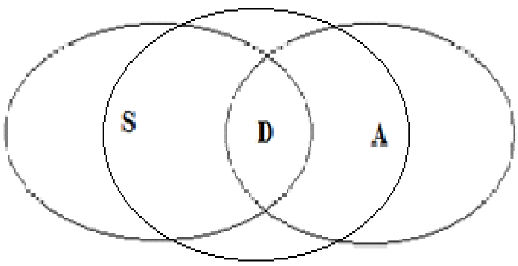

Fig. 1 Multichip MANETs

B. MANETs Routing Protocols

Routing protocols in MANETs are classified into three different categories according to their functionality fig 2:

1. Reactive protocols
2. Proactive protocols
3. Hybrid protocols

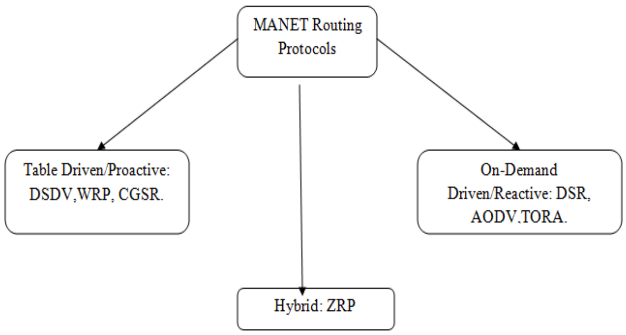

Fig. 2 Types of Routing Protocol

C. Security in MANET

A lot of research was done in the past but the most significant contributions were the PGP(Pretty Good Privacy) and the trust based security but none of the protocols made a decent trade-off between security and performance. In an attempt to enhance security in MANETs many researchers have suggested and implemented new improvements to the protocols and some of them have suggested new protocols in fig. 3.

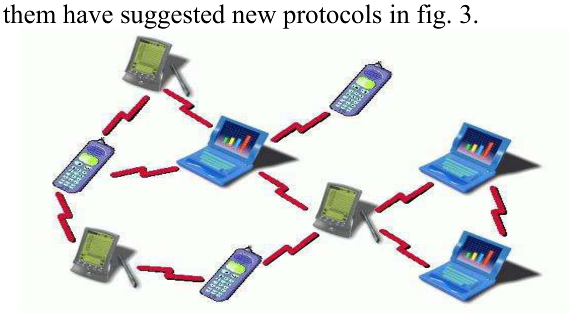

Fig .3 MANET

IV. AODV

Ad hoc On Demand Distance Vector (AODV) is a routing protocol designed for ad hoc mobile networks. AODV is a reactive protocol, capable of both unicast and multicast routing. It searches for routes between nodes only when desired by source node and maintains these routes only as long as they are needed by the sources [6][8].

Working of AODV

AODV builds routes using a route request/route reply cycle. When a source node needs a route to a destination, it broadcasts a route request (RREQ) packet, as shown in figure 4.

1. Nodes that receive this packet add backward pointers in their routing tables for the source. The nodes also keep track of source's IP address, current sequence number and broadcast ID. The RREQ also contains the most recent sequence number for the destination, of which the source node is aware.

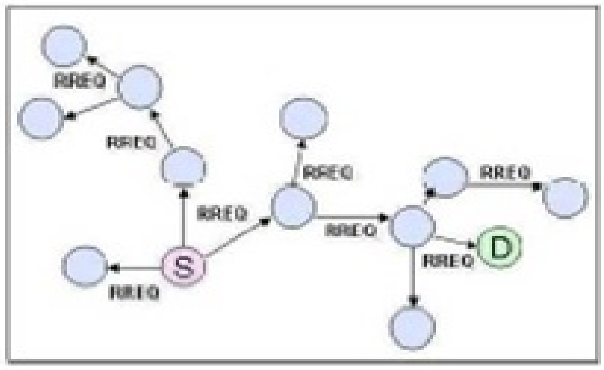

Fig .4 Node S broadcasts RREQ.

2. A node receiving the RREQ may send a route reply (RREP) in the following cases:

If it is the destination (shown in Figure 5.)

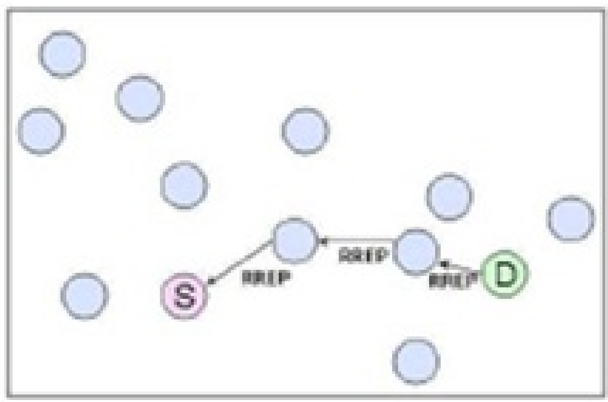

Fig. 5 Node D send RREP to Node S.

If it has a route to the destination with sequence number greater than or equal to that contained in the RREQ, indicating that it has recent information about the destination. If none of the above cases are satisfied then the RREQ is forwarded using a broad-cast. The broadcast ID is used by nodes to detect already processed RREQs. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward.

3. After establishing the path source sends data to destination, as shown in Figure 6.

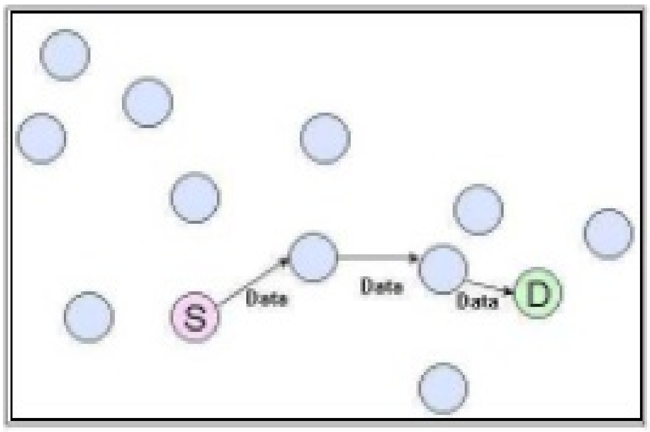

Fig. 6 Node S send data to node D.

(1) RREQ- A route request message is transmitted by a node requiring a route to a node. as an Optimization AODV uses an expanding ring technique when flooding these messages. Every RREQ carries a time to live (TTL) value that states for how many hops this message should be forwarded. This value is set to a predefined value at the first transmission and increased at retransmissions. Retransmissions occur if no replies are received. Data packets waiting to be transmitted (i.e. the packets that initiated the RREQ). Every node maintains two separate counters: a node sequence number and a broadcast_ id.
(2) RREP- A route reply message is unicasted back to the originator of a RREQ if the receiver is either the node using the requested address, or it has a valid route to the requested address. The reason one can unicast the message back, is that every route forwarding a RREQ caches a route back to the originator.
(3) RERR- Nodes monitor the link status of next hops in active routes. When a link break again an active route is detected, a RERR message is used to notify other nodes of the loss of the link. In order to enable this reporting mechanism, each node keeps a precursor list containing the IP address for each its neighbors that are likely to use it as a next hop towards each destination in Figure 7.

Structure of routing table entries for an AODV :

Destination	Sequence no.	Hop count	Next Hop	Expiration Time out

Fig. 7 AODV routing table structure.

V. ALGORITHMS ENVIRONMENT

A. Route Discovery

When a node wants to communicate with another node in the network a unique communication path is established between the sender and the receiver nodes. The source node scans the neighborhood vector for the destination. If the destination node is identified to be the single hop neighbor of the source, the source nodes starts transmitting data packets. The transmission of data will be uninterrupted until there is no change in the geographical positions of the source and the destination nodes [4] [16].

The neighbors in the neighborhood vector are stored in the increasing order of their distances. The source node generates a RREQ packet and forwards it to n/k neighbors (where n is the total number of the neighbors and K1 – ratability parameter - a random Number between 3 and 7) from the neighborhood vector targeting the farthest nodes from the source node (Figure1). The intended neighbors check their neighborhood vectors and locate the destination else the same procedure is repeated till the destination is located. The algorithm in fig 8. explains the method of finding path from the source to the destination mobile host.

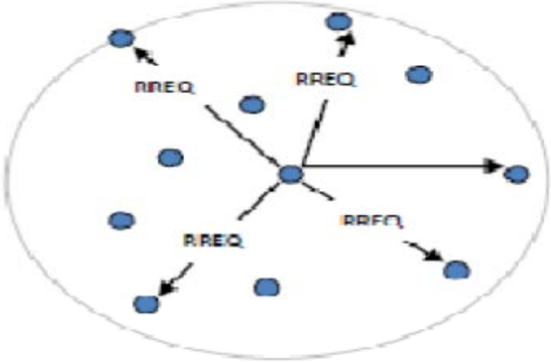

Fig. 8 Controlled RREQ. Broadcast in Route Discovery.

B. Determination of Number of Rebroadcast

The number of rebroadcasts is determined by the rehabilitee parameter K which ranges between 3 and 7. The number of route requests to be rebroadcast by each node to determine an optimal path depends on the chosen rehabilitee parameter and the local density of the network. Selecting half of the neighbors from the neighborhood vector in a dense network establishes a shortest path between the source and the destination nodes reducing the control overhead to half from the one that is actually required.

C. Approach to Reduce the Route Requesting Flooding

Route request flooding is a major concern in route request phase in AODV. It is possible that the destination is unreachable or request lost due to transmission errors. In these cases, source initiates the route discovery process again. Even though routing overhead is less compared to proactive protocols, route discovery overhead leads to wastage of the limited resources in the network [10].
The main intention is to propose a simple method, having less overhead for route search
in AODV. The proposal also has minimal computational complexity and communication
Overhead. This method considers the probability of success to connect to the destination. The probability depends on the previous behavior of a node to get the destination through an outgoing link. To calculate this probability, connectivity index (μ k) is used as
the probability of choosing the neighbor to initiate a route request.

$$\mu_k = \frac{\text{Number of Success Obtained}}{\text{Number of Attempts Made}} = \frac{S_{1....k}}{A_{1....k}}$$

For each attempt, each node updates the μ k for each outgoing link using.

$\mu k \leftarrow \mu k\ \alpha + (1 - \alpha)\ \mu k\text{-}1$, where α is a constant, $0 < \alpha < 1$.

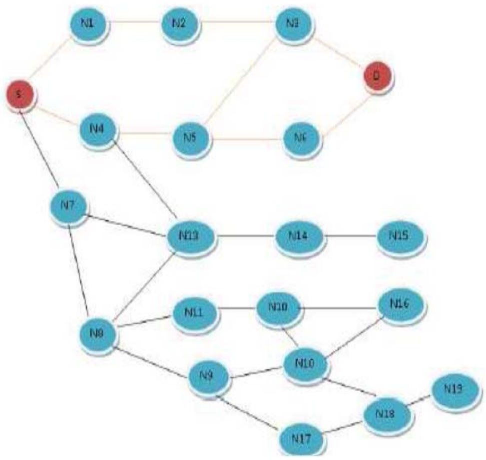

Fig. 9 A typical network showing the flooding overhead; though there are only three paths from S to D, the flooding is wide spread.

In initial attempt each node's connectivity index on each outgoing link is considered as 1.
Second time onwards μ k is calculated in each attempt. A threshold value for μ k is assigned as .5. Any μ k >.5 is considered as eligible to be explored for connectivity. It can be seen that the buildup of μ k depends upon and could be often slow. Accordingly, the first few route requests are made on all the outgoing links. Subsequently, the most favored links alone are chosen corresponding to the higher values of μ k.
In figure there are many routes from source S to destination D. These routes identified are
<S,N1,N2,N3,D>, <S,N4,N5,N6,D>, <S,N4,N5,N3,D>. Initially s creates the route request packet and sends to its neighbors. The Intermediate node has no history of destination node. Then it again sends the packet to its neighbors. This process continues till it reaches the destination. During this route search process each node flood the request packet to its neighbors. Even if some of the node never reaches the destination it also takes part to flood the message. In the figure 9.nodes 17 gets the control message form node S and node13 will get the message from node 4. But that node does not find the destination So those nodes are unwanted in route searching process.
In order to avoid this unwanted searching each node maintains a connectivity index table. Sample connectivity index table of three nodes are given in table1, 2 and 3. In the 11th iteration node 7 does not forward route request message to its neighbors N13 and N8.

This way we can block the unwanted routing of route request messages. In case any new link is created after some time then this is informed by the neighboring nodes. If the new link is creating a route to the destination then the intermediate nodes in the path slightly increase their connectivity index of the neighboring nodes.
This approach always considers the previous behavior of each node to detect the destination node in the route discovery process. This method ensures the maximum reduction of route request message flooding in the network. By updating the connectivity index table each node is aware of the connection potential of the requested destination. With this awareness the node blocks the unwanted forwarding of RREQ control message generated by the source node.

D. Algorithm Development

Routing is a backbone of network communication, there are various routing protocols are designed and implemented to find an efficient way of data delivery. Some of them are table driven and some of them are table less.
In both cases at the time of route discovery required to flooding RREQ packets that adds some time over head, additionally it consumes energy too. Thus required to design and develop an advance algorithm for minimize the flooding of packets and reduces the battery consumption [16].
There are various methods are available by which flooding is minimize, here we provide a distance and location based trust improvement algorithm that helps to reduce the RREQ flooding.
In this approach we manage a history table under AODV routing environment, this table help the router to keep information about number of hops and their physical distance. On the basis of provided information we improve the route discovery and minimize the packet flooding over network [11]. The algorithm is defined as:
Below given steps are the basic steps of algorithm that are required to adopt. In first step first node checks the RREQ when a new packet arrives. In next step this node calculates the discard limit from the previously defined sessions. And in next step system check the limit with arrived packets. If received RREQ greater than limit then that is unknown node. Else it is known node [6].

E. Proposed Algorithm

1] Begin
  If intermediate node k receives RREQ from
  node i
2] Determine the RREQ Discard limit (or D Lim) of RREQ receives in all sessions on each node from their neighbors node.
3] AVG_VAL = AVG [S1, S2, S3, S4, S5]
4] RATE_LIMIT =max no of RREQ [Si] - AVG_VAL
5] RREQ Discard limit(D _
Lim)=(AVG_VAL+RATE_LIMIT)+1
6] If received RREQ >RREQ Discard limit
  Drop the RREQ packet
  Set the node a UNKNOWN NODE.
7] If received RREQ <RREQ Discard limit
  Process the packet
  Set as KNOWN NODE

VI. SIMULATION AND EVALUATION

According to Shannon [12] simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behavior of the system and/or evaluating various strategies for the operation of the system. With the dynamic nature of computer networks, we thus actually deal with a dynamic model of a real dynamic system.

A. Simulation tool

NS2 is an open-source event-driven simulator designed specifically for research in computer communication networks. Since its inception in 1989, NS2 has continuously gained tremendous interest from industry, academia, and government. Having been under constant investigation and enhancement for years, NS2 now contains modules for numerous network components such as routing, transport layer protocol, application, etc. To investigate network performance, researchers can simply use an easy-to-use scripting language to configure a network, and observe results generated by NS2. Undoubtedly NS2 has become the most widely used open source network simulator, and one of the most widely used network simulators. Here we have selected NS2 for our simulation [12].

B. SIMULATION PARAMETR

Channel type	Channel/wireless channel
Radio propagation model	Propagation/two-ray ground
Network interface type	Phy/wirelessphy
Mac type	Mac/802_11
Interface type	Queue/droptail/priqueue
Linklayer type	LL
Antenna	Antenna/omni antenna
Max. packet in infq.	50
Routing protocol	AODV
X dimention of topography	750
Y dimention of topography	550
Time of simulation	60.0 s
Model for simulation	Energy model
Initial energy in joules	100 joules

C. AODV Simulation

AODV Simulation is shown in given figure. Here 6 nodes are given. First when simulation starts then source node first searches the neighbors and sends the RREQ. Packets and find the routes.

Ad hoc On Demand Distance Vector (AODV) is a routing protocol designed for ad hoc mobile networks. AODV is a reactive protocol, capable of both Unicast and Multicast routing. It searches for routes between nodes only when desired by source node and maintains these routes only as long as they are needed by the sources [4], [11] and [6].

AODV builds routes using a route request/route reply cycle. When a source node needs a route to a destination, it broadcasts a route request (RREQ) packet.

A node receiving the RREQ may send a route reply (RREP) in the following cases:

– If it is the destination.

– If it has a route to the destination with sequence number greater than or equal

To that contained in the RREQ. Indicating that it has recent information about the destination.

After establishing the path source sends data to destination.

D. RREQ. Calculation

We calculate the number of RREQ. of every node sending the neighbors node at each session. A node sending multiple RREQ.

Here we also find the total number of RREQ. Packets send by every node in normal case. And the number of RREQ. Packet received by nodes. A graph is given which shows the number of RREQ. Packets sending and receiving by every node in normal case of AODV simulation.

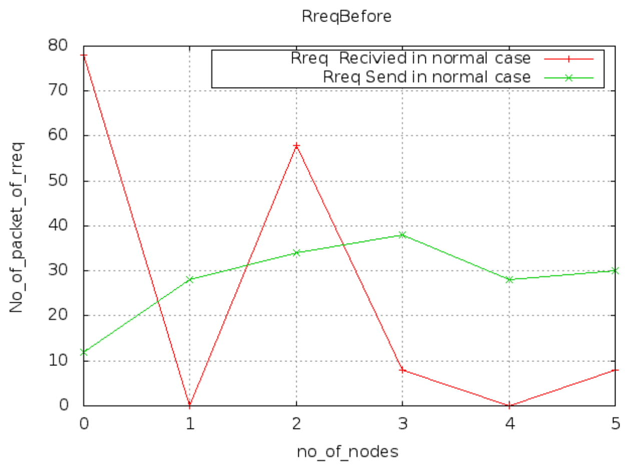

Fig. 10 RREQ. Graph of each Node.

E. Our Work

We applied our algorithm for sending the RREQ. Packets in AODV here we calculate the discard limit (D_ Limit) each node for sending the multiple RREQ. Packets. And on the basic of this D_limit we can find the unknown node of each session. Unknown node is one which cannot send or receive any RREQ. Packets for finding the route . Hence on the basic of this algorithm we can find the number of unknown nodes at each session. so we can minimize the RREQ. Packets send or receive and we also saves the energy of nodes which participates in simulation.

F. Result Analysis

In the previous chapters we have compared the AODV and our algorithm. In this chapter we presenting the energy consumption by both algorithms and comparing energy consumption.

Energy Consumption of nodes in AODV

When normal AODV is run the energy consumption is more in normal case. There is no method for detection of unknown node. And the number of RREQ [8]. Packets send is more so the energy consumption in normal AODV is more. We plot a energy graph for normal AODV after simulation. Each node have 100 joules of initial energy and after simulation the energy graph of each node is given below:

Energy of Node 0 = 69.974833 Joule.
Energy of Node 1 = 59.505685 Joule.
Energy of Node 2 = 70.185276 Joule.
Energy of Node 3 = 67.140168 Joule.
Energy of Node 4 = 57.661450 Joule.
Energy of Node 5 = 66.786425 Joule.
Average Energy Consumption = Total Energy of all Nodes No of Nodes.
Average Energy Consumption = 69.98+59.51+70.20+67.14+57.67+66.80
Average Energy of Nodes = 65.2166 Joules.

Energy Graph

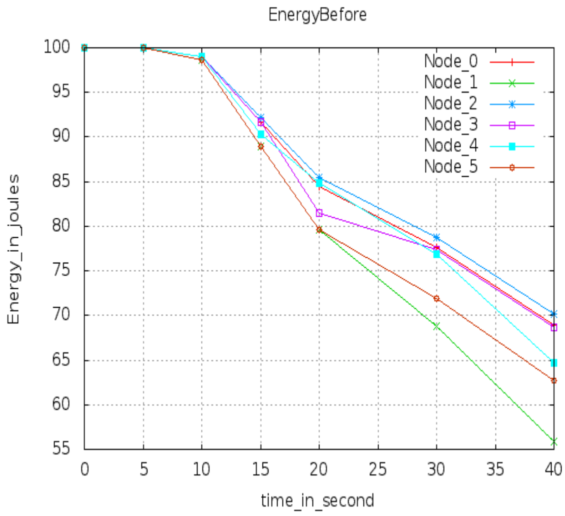

Fig. 11 Energy Graph of each Node.

Energy Consumption after Algorithm applied
After applied this algorithm in AODV we minimize our energy consumption of each node. The energy of each node after this algorithm is given below with the help of energy graph.

Energy of Node 0 = 60.558119 Joule

Energy of Node 1 = 71.534384 Joule

Energy of Node 2 = 70.466267 Joule

Energy of Node 3 = 70.068719 Joule

Energy of Node 4 = 68.546242 Joule

Energy of Node 5 = 63.895127 Joule

Average Energy of Nodes = Energy of all Nodes No of Nodes
Average Energy of Nodes =60.58+71.52+70.47+70.068+68.55+66.90
Average Energy of Nodes = 68.20 Joules

After applied this algorithm our network energy consumption is less as compared to prior one. Because the average energy consumption of each nodes after applied this algorithm is less. and our network is more energy stable.

Energy graph is shown below:

Energy Graph

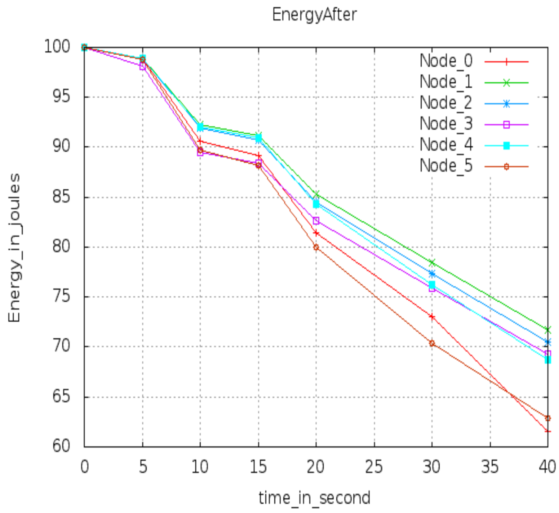

Fig. 12 Energy after the algorithm applied.

VII. CONCLUSION

In this we simulate the normal AODV without applying our proposed algorithm and find the route request send in each session. we also calculate the energy consumption of each node in this we calculate the average energy consumption of each node and generate the energy Graph[6] [11].
After this we apply our proposed algorithm and then again calculate the energy consumption of each participating node and calculate the average energy of consumption of each node . here we find the discard limit of each node on the basis of route request send in each session. After applying this algorithm the average energy consumption is less as compared to earlier and our network is more energy stable. Average energy of all participating node is 65.2166 joules before applying the algorithm. the energy of all nodes after applying the algorithm is 68.20 joules when we apply our proposed algorithm. So the energy consumption of the network is reduced with our proposed algorithm, & our Network gets more stable.

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