



## GOSSIP BASED NODE RESIDUAL ENERGY AODV ROUTING PROTOCOL FOR AD-HOC NETWORK (GBNRE-AODV)

K.Mariyappan

Dept. of CSE,

Aringer Anna College of Engineering and Technology,  
Tamilnadu ,India

Dr.M.Karnan

Dept of CSE,

Aringer Anna College of Engineering and technology,  
Tamilnadu,India

**Abstract:** In traditional/classical routing approach, any newly RREQ packet received at a node is retransmitted with probability of one regardless of node density, received signal power and node's energy level. In MANETs, the network topology is dynamic and the level of residual energy of each node varies over time. Therefore, the forwarding probability used in probabilistic broadcast schemes for the dissemination of broadcast packets should be set dynamically to reflect the local and global information about the network (i.e. neighborhood information, received signal power and the residual energy of a route). In this paper, we have designed a novel energy aware routing protocols called Gossip based Node residual energy AODV (GBNRE-AODV) which uses residual energy, hop count, node received signal power and node density as a cost metric to reduce energy consumption, increase network lifetime and distribute usage of energy among mobile nodes of Mobile Ad hoc Network (MANET). The new protocols, which are referred to GBNRE-AODV are simulated using Network Simulator-2.34 and comparisons are made to analyze its performance based on network lifetime, normalized energy consumption, delivery ratio, normalized routing overhead, average collision rate, and average end to end delay for different network scenarios. The simulation results reveal that the proposed energy aware routing protocols make the network active for longer interval of time by minimizing energy and distributing energy consumption across mobile nodes on the network at the trade off a small amount of end to end delay.

**Keywords:** GBNRE-AODV; Normalized energy consumption; Gossip; AODV; RSS

### 1. INTRODUCTION

MOBILE *ad hoc* network (MANET) [1], [2], [10] is a self-organizing and self-configuring multi-hop wireless network, which is composed of a set of mobile hosts (MHs) that can move around freely and cooperate in relaying packets on behalf of one another. MANET supports robust and efficient operations by incorporating the routing functionality into MHs. In MANETs, the unicast routing establishes a multi-hop forwarding path for two nodes beyond the direct wireless communication range. Routing protocols also maintain connectivity when links on these paths break due to effects such as node movement, battery drainage, radio propagation, and wireless interference

Management of energy resources in wireless ad hoc networks is of paramount importance for battery driven mobile nodes due to the limited availability of energy capacity. The ultimate goals of routing strategies are to increase the network lifetime, reduce energy consumption and distribute energy usage among mobile nodes. The power conservation techniques have been addressed in the literature by several scholars [7-8,13, 31,37].

In MANETs, the network topology is dynamic and the level of residual energy of each node varies over time [5]. Therefore, the forwarding probability used in probabilistic broadcast schemes for the dissemination of broadcast packets should be set dynamically to reflect the local and global information about the network (i.e. neighborhood information and the residual energy of a route). To achieve this, a new energy aware gossip based routing approach referred to as Gossip based node residual energy AODV (GBNRE-AODV for short) is proposed in this paper. Unlike the fixed and adjusted probabilistic route discovery approaches [6, 9,11,12,14-16,21-22,24-25,28-29,36,38-39]

that utilize predetermined forwarding probabilities, the nodes in GBNRE-AODV dynamically compute their forwarding probabilities using a probability function which depends on the minimum residual energy of nodes along a route from source to the forwarding node, Received signal strength and the local neighbor density at a forwarding node. The remainder of the paper is organized as follows. In Section 2, we review some of related gossip based routing protocols for MANETs. We explain in detail our proposed work and its integration with NRE-AODV[30] in Section 3. In Section 4, we compare the performance of our protocol with AODV and Gossip via Network simulator NS-2.34 simulations for a two different network scenarios, and finally, we conclude the paper in Section 5.

### 2. RELATED WORK

In short, every node in the wireless network forwards broadcasting packets with the same probability. This probabilistic scheme is called as GOSSIP. In this scheme, the node sends Route Request (RREQ) packets with the probability  $p$  and discards it with probability  $1-p$ . This scheme is called as GOSSIP ( $p$ ) [17][24].

Gossip protocols were pioneered at Xerox PARC, as a part of the Clearinghouse project [4], where gossiping was used to remove inconsistencies in tables in wide-area database systems. Since then, the popularity of gossip protocols in the distributed systems domain has flourished. In addition to their elegant simplicity, the appeal of gossip protocols lies in the fact that they can be easily implemented in a fully decentralized way and exhibit desirable properties, namely reliability, robustness and scalability.

[20] Luo et al. exploits gossip for reliable multicast in MANET. As in other similar works, the gossip protocol

assumes that a node can send a message to any other node of the network. This means that the protocol is executed above the routing layer. On the contrary our proposal leverages on the local broadcast nature of the transmissions. A node can only gossip to all neighbors via a single local broadcast GOSSIP1( $p, k$ ), GOSSIP2( $p1, k, p2, n$ ) and GOSSIP3( $p, k, m$ ) [24]. Each of the designed gossip based protocols utilizes local information in various ways. For example, GOSSIP1( $p, k$ ) retransmits each newly received messages with probability of 1 for the first  $k$  hops and with probability  $p$  for the remaining number of hops. When the value of both parameters of GOSSIP1( $p, k$ ) is 1 i.e. GOSSIP1(1, 1), it is similar to flooding. In GOSSIP1( $p, k$ ), the parameter  $k$  is used to minimize the likelihood of an early death of gossiping packets. One drawback of GOSSIP1( $p, k$ ) approach is an early death of gossiping packet.

However to minimize shortcomings of GOSSIP1( $p, k$ ), GOSSIP2( $p1, k, p2, n$ ) was proposed. GOSSIP2( $p1, k, p2, n$ ) performs in a similar fashion to GOSSIP1 but it introduces two new variables  $p2$  and  $n$ . In GOSSIP2( $p1, k, p2, n$ ) approach, if a node has fewer than  $n$  neighbors, a node retransmits with probability  $p2$  rather than  $p1$  where  $p2 > p1$ .

Finally GOSSIP3( $p, k, m$ ) approach is also an extension to Gossip1( $p, k$ ) except if a node with  $n$  neighbors receives a message and does not broadcast it, but then does not receive at least  $m = p * n$  duplicate messages from its neighbors within a gossiping timeout period, the packet is forwarded to all its neighbors; otherwise it is dropped. For instance, J.Haas et. al. [17, 24] showed that GOSSIP3( $p, k, m$ ) protocol reduces up to 35% messages than flooding in MANETs. In the networks they have considered gossiping probability between 0.6 and 0.8 and shown that with a gossip probability of 0.65 i.e. GOSSIP3(0.65, 1, 1) almost every node gets the message in every execution. Furthermore, their simulation results showed that there is a bimodal effect with an average node degree of 8.

For reducing routing overhead Neighbor coverage based probabilistic rebroadcast protocol (NCPR) is proposed in [25]. This is essentially neighbor knowledge scheme in which each node maintains its 1-hop neighborhood information. How many neighbors should receive the RREQ packet is decided by Uncovered Neighbor Ratio [Ratio of number of nodes that should be covered by single broadcast to total number of neighbors]. Based on this “rebroadcast probability” is calculated which is used to reduce the number of rebroadcasts. By combining the neighbor coverage knowledge and probabilistic mechanism the number of rebroadcasts are significantly reduced thus reducing the routing overhead. Rebroadcast traffic of NCPR is less than flooding. The performance improvement of NCPR is significant in heavy traffic and high density networks. In sparse networks NCPR performance is slightly better than flooding. The drawback of this algorithm is quite complex.

Authors Roberto Beraldi implemented “The polarized gossip protocol for path discovery in MANETs[18]. Here the gossiping probability of a node is determined by the difference between its proximity to the destination and the proximity to the destination of the node from which the message was received. The proximity is estimated from the “inside” of the network using periodic beacons for determining the time elapsed since a node met the

destination and the dwell time of a node with the destination. This information is then exploited by nodes to modulate their gossiping probability. The protocol allows saving up to 80% of broadcast transmissions compared to a pure flooding, while 60% of nodes have to process a requesting packet.

Geographic routing approaches use the location coordinates of nodes to forward packets toward the destination in a greedy manner [26,27]. By restricting the RREQ flood only in direction of destination rather than network wide, RREQ overhead is reduced. Geographical protocols are scalable since they use localized neighboring information only for next hop selection

Author In [21] proposed a broadcast gossip protocol based on dominating set. They described the problems when applying a dominating-set-based approach in a multicast protocol and solved these problems by introducing four sessions, i.e., join session, connection session, reduce session and dissemination session. Simulations result shows that protocol scaled well in terms of reliability and transmission delay even when the size of the multicast group and the mobility of the network increase.

In a regional gossip approach, proposed in [22] only the nodes within some region forward the routing message with some probability, to reduce the overhead of the routing protocol imposed on the network, region and the estimated network density. Simulations showed that the number of messages generated using this approach is less than the simple global flooding (up to 94%).

Estimated Distance-based Routing Protocol (EDRP) is proposed in [29] which restrict the forwarding range of RREQ messages in the direction of destination. EDRP combines the features of position-based routing into on-demand routing protocols. An algorithm is proposed to estimate the distance, called EstD, between two nodes without positioning system. It considers variations in received signal strength (RSS) at contact time of two nodes, to estimate future geometrical distance between them when they move apart. Propagating RREQs in the direction of destination with the help of EstD, significantly reduces the routing overhead and improves the routing performance

AODV-RG [23] suggests a modification of the rebroadcasting procedure for Received Requests (RREQ) in AODV using Received signal strength Gossip algorithm. Experimental results show that the AODV-RG protocol outperforms that of AODV with gossip probability  $p=0.66$  by minimizing RREQ rebroadcasting messages during route discovery process.

Due to link failures routing overhead in reactive routing protocols increases. Hybrid Location-based ad hoc routing protocol HLAR is proposed in [28] to alleviate this limitation. It uses the greedy geographic routing with reactive protocols. If the location information is not accurate it uses the basic reactive routing and avoids the performance degradation. To discover a route to destination, the source node creates a route request (RREQ) packet that contains location of the source, destination node and then consults its neighbor table to find if there any closer neighbor node towards the destination. If a closer node is available, RREQ is forwarded to that neighbor; if no closer neighbor is available RREQ is flooded to all neighbors. The intermediate nodes follow the same procedure in forwarding the RREQ. The performance evaluation shows that the

routing overhead rate of HLAR is constant for various nodes

densities as compared with AODV, in which it grows exponentially. The end-to-end delay is significantly less. Also, the PDR increases as a function of node density because large node density allows for easy route establishment and repair. This paper does not comment about the effect of overhead arising from inclusion of location information in the RREQ packet.

Signal Strength Based Gossip Flooding scheme RSS-Gossip AODV, was proposed in [29]. In this work the performance of RSS-Gossip AODV in different mobility scenarios is investigated. The performance is analyzed by varying node speeds from 9 km/hr to 90 km/hr, in both faded and non-faded environmental scenarios. Experimental results show that RSS-Gossip AODV performance is superior to conventional AODV in non-faded as well as faded environments. By forwarding 15% lesser RREQ messages signal strength based gossip flooding approach of RSS-Gossip AODV tries to address the broadcast storm problem. At the same time it also improves the network performance by reducing link breakages by 15% and improving average packet delivery ratio by 5.5%.

### 3. THE PROPOSED WORK

In our previous work, we developed a NRE-AODV energy aware routing protocol [30]. The proposed work maximizes network lifetime and distributes battery usage across mobile nodes in a network than the prior related works. However the route discovery process of NRE-AODV still uses flooding to search a route between source and destination nodes. For example, if N is the total number of nodes in the network and the intermediate node does not have a valid route to destination, the number of possible broadcasts of an RREQ packet in both AODV and NRE-AODV is N-1.

These techniques of route discovery can seriously affect the performance of the routing protocol in terms of communication overhead, channel contention, packet collision, end-to-end delay and energy consumption [9]. To reduce the routing overhead associated with the traditional route discovery process of MANET routing protocol several approach was introduced[31]. However none of them consider both minimum residual energy and received signal power as a cost metric to maximize network life time and minimize energy consumption though it's very important energy efficiency metrics for MANET routing protocols. The proposed gossip based energy aware routing approach is developed on top of NRE-AODV [30] and named as Gossip Based Node residual energy AODV Routing Protocol (GBNRE-AODV)

The GBNRE-AODV routing protocol tried to overcome shortcoming of NRE-AODV and traditional routing protocols of MANET by introducing gossiping as a function of normalized minimum residual energy, received signal strength and node density level. In GBNRE-AODV scheme, upon receiving a broadcast packet for the first time, Received signal strength is checked, if it's below threshold( $RSS < S_{TH-MIN}$ ) value the packet is dropped, otherwise the probability P is calculated based on the normalized minimum residual energy (NME) from source to the node itself. Then, a node forwards the packet with a gossip forwarding probability P. If it fails to retransmit the

packet, the GBNRE-AODV protocol examines whether node's neighbors receives the packet or not depending on the number of neighbors in order to protect an early death of the routing packet. Therefore the proposed protocol has two advantages. Firstly, it excludes the weak link and minimum residual energy node during route establishment by assigning small retransmitting probabilities for each energy hungry intermediate node. Secondly; it minimizes an early death of routing packets using neighborhood information. In GBNRE-AODV, when a node Y with n neighbors receives a broadcast packet for the first time and fails to rebroadcast a packet, it sets a timer and waits a copy of the number of received RREQ i.e. C from its neighbor nodes. If a node does not receive  $C_1$  or  $C_2$  number of RREQ packets within a gossiping timeout period, it retransmits the packet otherwise it drops. The algorithm of GBNRE-AODV and its corresponding flow chart is depicted in Figure 3.1 and Figure 3.2. The route reply and route maintenance procedure of GBNRE-AODV is similar to NRE-AODV.

#### Algorithm of GBNRE-AODV scheme For broadcasting RREQ at the Intermediate nodes

```

Get RREQ PACKET
If New Seq No.>1 --Step 1
  Get n, RSS value
  If n=1 --Step 2
    Drop RREQ ; End
  Else
    Update SRE,MRE,Calculate NME
    If  $P_x > R[0,1] \parallel RSS \geq STH$  --Step 3
      Re transmit RREQ ; End
    Else
      Set  $RAD=[0, TMAX]$  Set count=1, Expire
      time= $RAD +$  current time
      If Expire Time>Current Time --Step 4
        Get n
        If  $n \geq nTH$ 
          Then  $C=C2$ 
          If Count>C
            Drop RREQ
          Else
            Re transmit RREQ ; End
        Else
           $C=C1$ 
          If Count>C --Step 5
            Drop RREQ ; End
          Else
            Re transmit RREQ ; End
        Else
          If Same Packet --Step 6
            Count ++, Wait for Additional RREQ
          Else
            Drop RREQ
      Else Go to Step4
  
```

#### Algorithm of GBNRE-AODV scheme for RREQ at the destination nodes

```

Get RREQ PACKET
If New
  Calculate D,Update Routing table
Else
  
```

```

If T Expired
Send RREP To Source ; End
Else
Calculate D
If New D > Routing table D
Update routing table with new D value ;Wait for
Additional RREQ
Else
    
```

```

If New D = Routing table D || New H < routing
table H
Update routing table with new D value ;Wait for
Additional RREQ
Else
Discard RREQ ;Wait for Additional RREQ
    
```

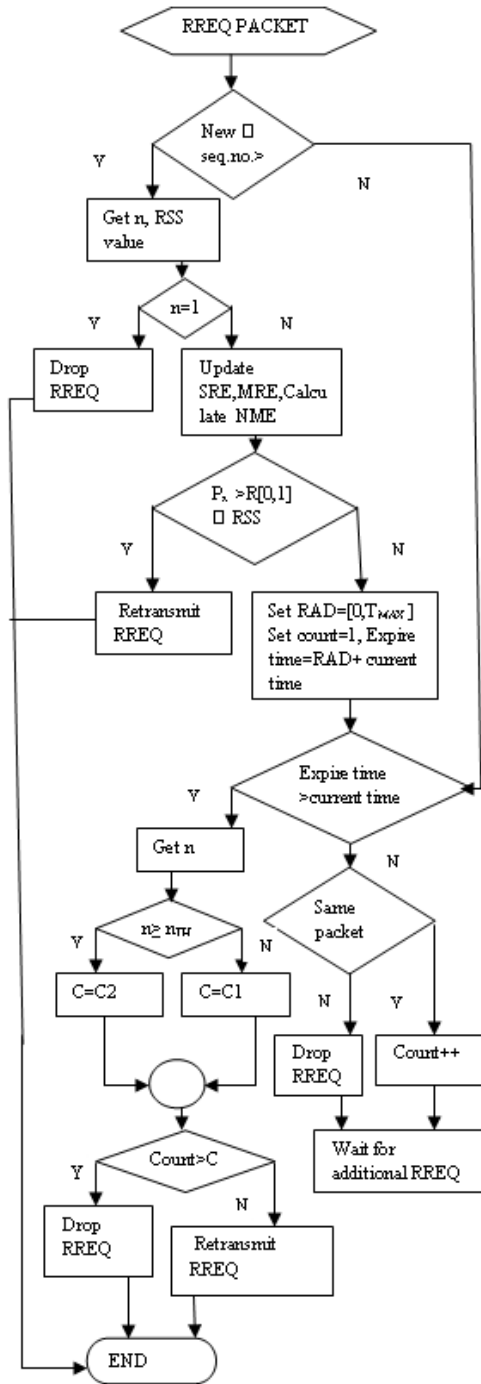


Figure 3.1: Flow chart diagram for the operation of GENRE-AODV at intermediate node

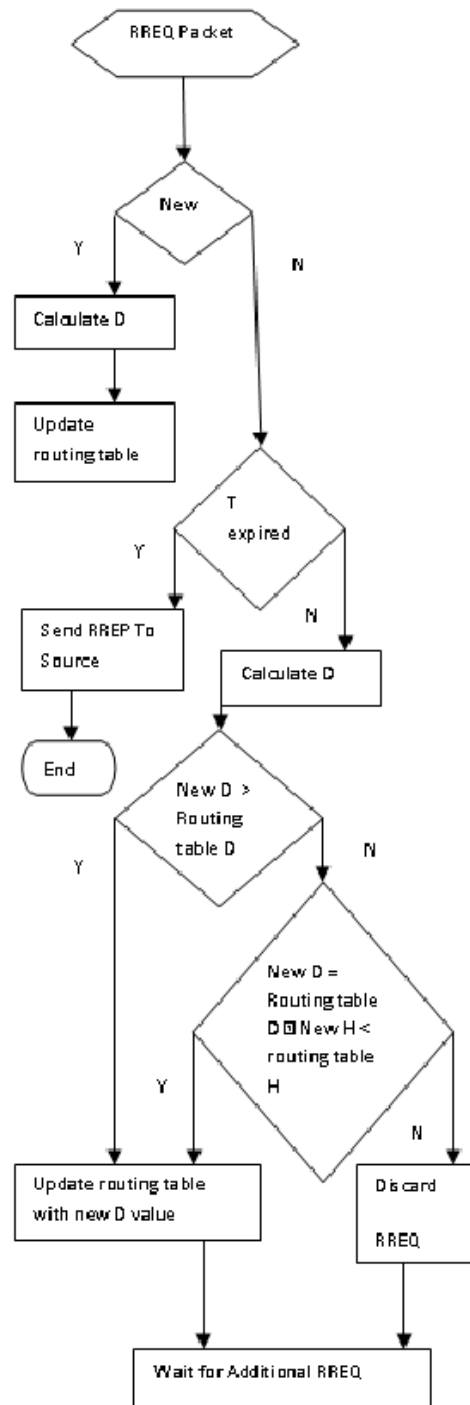


Fig 3.2 Flow chart diagram for the destination node of GENRE-AODV

TABLE 1: Key points

Parameter	Description	Parameter	Description
D	Energy differences of the newly arrived RREQ packet at the destination	n	Number of neighbors of the receiving node
T	Waiting time at the destination node for additional route	Px	Residual minimum energy/initial energy of the node
MRE	Minimum residual energy	RAND	Rand number generated between 0 and Tmax
SRE	Sum of residual energy	Current time	Node current time
h	Hop count of newly received packet	Expire time	Expire time for receiving duplicate RREQ
Th	Threshold	C1,C2	Value for sparse network and dense network respectively
AMRE	Average minimum residual energy	count	Total number of received duplicate RREQ before expire time
ASRE	Average sum residual energy	n-th	Threshold value of n that separate sparse and dense region
RSS	Received signal strength	Sth	Signal threshold

### The Node Degree and RSS in GBNRE-AODV

In a network of random distribution of mobile nodes in MANETs, there are regions of varying node density (i.e. sparse and dense regions). The work on [6, 17] classified regions based on number of neighbors in to two: sparse area and dense area. Furthermore, a node should be assigned a low and relatively high counter values in dense and sparse regions respectively. To achieve this, the neighborhood information at each node is used from the existing hello protocol implementation [32, 17]. Research works in [6, 17, 33, 34, and 35] were also identified node degree of 8 as an

optimal number of node densities to categorize whether a node is in sparse or dense region. Thus node degree 8 is used for GBNRE-AODV protocol as a node degree threshold (nth) for the optimal number of neighbors at each node. Nodes in sparse networks should retransmit at a higher chance than nodes in dense networks to minimize an early death of the broadcasting packets. This could be achieved by altering the threshold value C to adapt to network density in such a way that a large threshold value of C1 is used for sparse networks and a small threshold value C2 for dense networks. They [6,17,33,34,and 35] claimed that a value between 1 and 2 is enough to guarantee the reach ability of the broadcasting packets for dense and between 2 and 4 for sparse network. Furthermore the waiting time, i.e. RAD, for duplicate packets is randomly chosen from [0, 0.1] sec. We choose a counter value of 1, i.e. C2=1, for dense network whereas a counter value of 2, i.e. C1=2, for sparse. The transmitted signal eventually reaches the receiver. The results depend on the Receive Sensitivity of that device -- i.e., the minimum power required to handle arriving frames at a given link speed. The higher the signal, the better the performance of the wireless network. On a typical WLAN, RSS will range from -20 dBm (very close to the AP) to -95 dBm (away from the AP).Referring to 802.11b/g devices can maintain a wireless connection for a signal stronger than -84 dBm. However, a good connection will require at least -75dBm.In our proposed algorithm we use -84dBm as minimum threshold value anything less than that signal power means received RREQ Will be discarded. If the received signal is greater than -84dBm, then gossiping is used to decide probability of RREQ to be transmitted.

### 4. PERFORMANCE ANALYSIS

To evaluate the performance of the gossip based node residual energy routing protocol (i.e. GBNRE-AODV), the implementation of the NRE-AODV routing protocol[30] has been modified to incorporate the functionality of the GBNRE-AODV algorithm. Since GBNRE-AODV developed on top of NRE-AODV and every concepts of NRE-AODV are on GBNRE-AODV, the simulation result of GBNRE-AODV is compared against the traditional AODV and Gossip, i.e. GOSSIP3 (p, k, m)

Each mobile nodes in our scenarios moves according to random way mobility model [41-43] deployed in a topology of 1500m x 1500m area with different number of nodes ranging from 20 to 200 for each simulation. All the simulation experiments were run for a period of 1000sec. In the simulation the Propagation model is Free Space Propagation Model, Queuing model is Drop Tail/Priority Queue, and MAC protocol is 802.11

The evaluation metrics used to conduct the performance analysis include the normalized routing overhead, Average collision rate, delivery ratio, normalized energy consumption, network lifetime, and average end to end delay. The simulation setups consist of two different settings, each specifically designed to assess the impact of a particular network operating condition on the performance of GBNRE-AODV routing protocol. First, the impact of network density is examined by varying the number of mobile nodes placed on an area of 1500m x 1500m. The second simulation scenario investigates the effects of node

mobility on the performance of the routing protocols by varying the maximum speed in a fixed number of mobile nodes placed on an area of 1500m x 1500m.

#### Impact of Network Density

This section examines the impact of network density on the performance of the three protocols namely; AODV, GOSSIP (0.65, 1, 1) i.e. Gossip, and GBNRE-AODV. The network density has been varied by changing the number of nodes deployed over a 1500m x 1500m area from 20 to 200 nodes for each simulation scenarios. Each node in the network moves with a random speed chosen between 0 and 25 m/sec. The pause time is 20 sec. For each simulation trial, 9 identical randomly selected source-destination connections (i.e. traffic flows) and 5 data packets per second generation rate are used. The packet size is 512 bytes.

#### Normalized Routing Overhead:

The normalized routing overhead generated by each of the three routing protocols increases almost linearly as the network density increases. Compared with the AODV and Gossip routing protocols, the generated routing overhead in GBNRE-AODV can be reduced by approximately 10.5% and 6.89% respectively when the number of nodes is relatively small (e.g. 20 nodes). The performance advantage of GBNRE-AODV over the Gossip and AODV is further increased in dense networks. When the number of nodes is increased to 200 nodes, the generated normalized routing overhead in GBNRE-AODV could be reduced by as much as 18.18% and 62.06% less than Gossip and AODV respectively. Generally, GBNRE-AODV reduces the normalized routing protocols by an average percentage of 51.72% than AODV and 14.53% than Gossip.

#### Average collision rate

When the network density is increased, the collision rate for each of the three routing protocols is increased. When the network density is relatively low (e.g. 20 nodes), GBNRE-AODV performed about 20.2% and 38.09% better than Gossip and AODV respectively. But in a dense network, GBNRE-AODV has a clear performance advantage over the Gossip and AODV by as much 22.02% and 54.19% respectively. Generally, the average collision rate of GBNRE-AODV reduced by approximately 25.02% and 42.50% compared to Gossip and AODV routing protocols.

#### Delivery ratio

The percentage of packets delivered for each of the routing protocols decreases when the network density is set high (e.g. 200 nodes) and low (e.g. 20 nodes). Specifically, GBNRE-AODV, Gossip and AODV performs maximum delivery ratio of 83.8%,78.3% and 76.1 respectively. The minimum packet delivery ratio of GBNRE-AODV,, Gossip and AODV are 60.66%, 56.54% and 39.19% respectively. This is due to the fact that, in a dense network there is an excessive redundant retransmissions of control packets (e.g. RREQ packets) because of the channel contention and packet collisions, thereby lowering the bandwidth available for data transmission whereas in sparse network, the request packets fail to reach to destination nodes due to poor connectivity. AODV relatively performs better than both GBNRE-AODV and Gossip by an approximate value of 2.74% and 5.71% respectively in sparse networks (e.g. 20 nodes). However, GBNRE-AODV outperforms both AODV and Gossip when the network density increases. We see an average increment of 9.63% and 6.78% in the percentage of packets delivered by GBNRE-AODV than AODV and

Gossip respectively. The improvement of GBNRE-AODV in a dense network is due to the fact that a destination node has received several energy efficient candidates to select the best energy capable route so that the selected energy efficient route for data transmission spans longer period of time there by reduces the retransmissions of RREQ packets.

#### Normalized energy consumption

GBNRE-AODV routing protocol significantly reduces energy consumption per delivered data packet by an average percentage of 6% than Gossip and 22.03% than AODV. The improvement further increases as the network becomes dense. This is due to the fact that GBNRE-AODV, uses an energy efficient path for data packet transmission so that an established route could still wait for longer period of time without node failure than the other routing protocols and thereby reduces frequent re-initiation of route discovery process. Furthermore, the proposed protocol has also reduced the routing packets injected to the network during route discovery by using gossiping retransmitting probabilities which contributes for the reduction of normalized energy consumption.

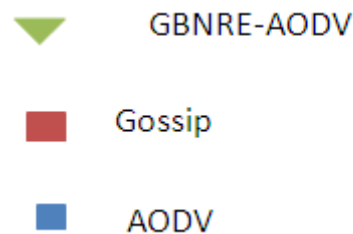
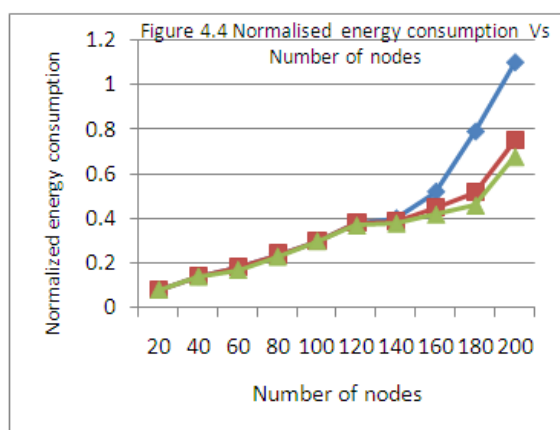
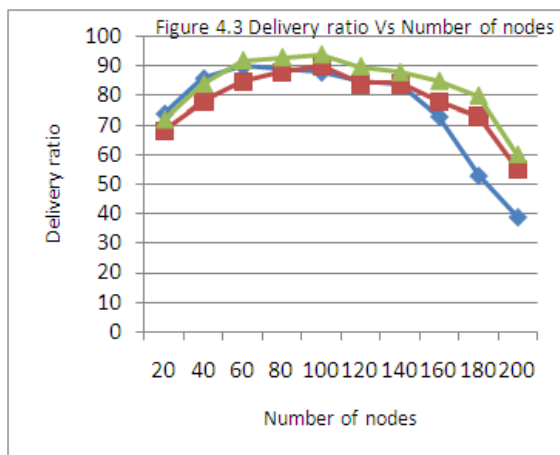
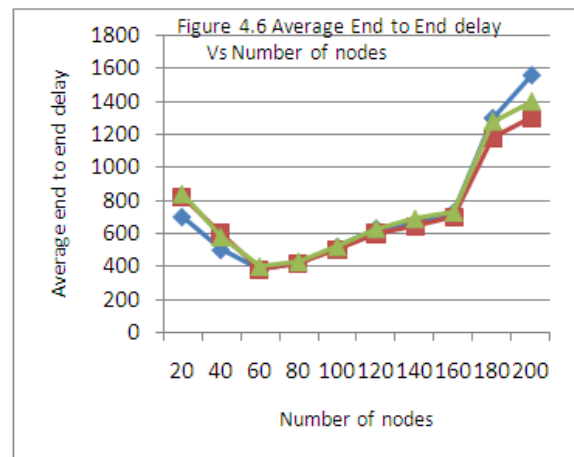
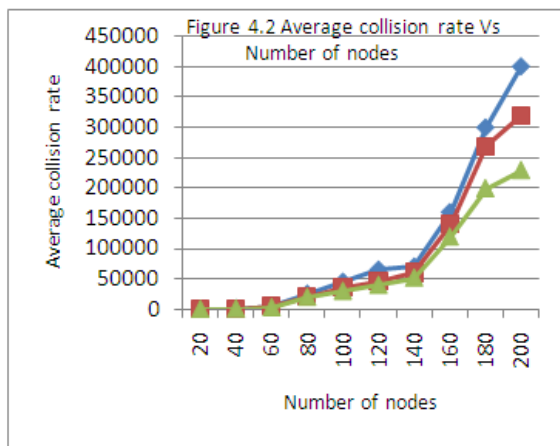
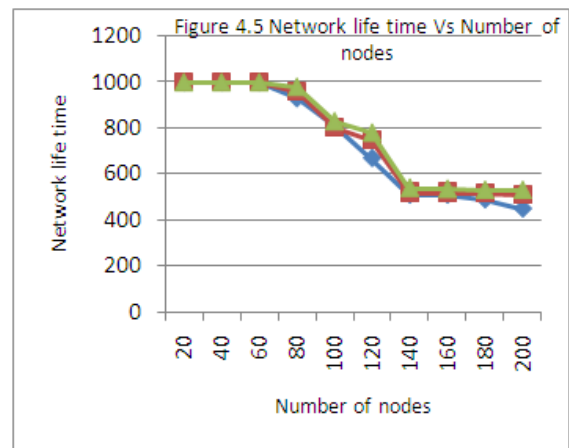
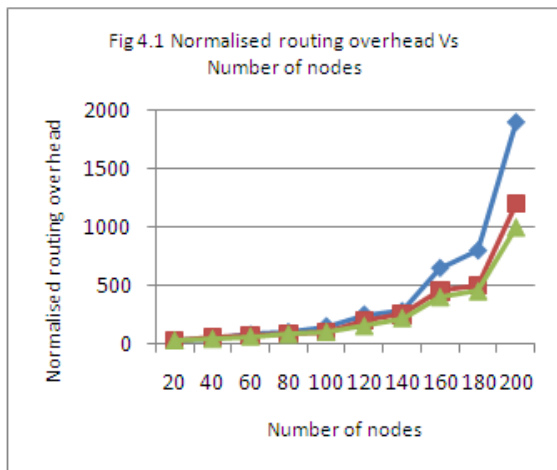
#### Network lifetime

In a simulation scenario of 1000 sec, the network is alive for a minimum value of 530 sec for GBNRE-AODV where as Gossip and AODV make the network alive for a minimum of 510 sec and 450 sec respectively. Generally in GBNRE-AODV we see an average improvement of 4.7% in network lifetime than AODV, while an average improvement of 1.96 % is gain by GBNRE-AODV over Gossip.

#### Average end to end delay

The end-to-end delay for each of the routing protocols sharply increases for both sparse and dense networks. This is due to the fact that when the network is dense more routing packets is generated and disseminated through the network, as a result the interference between neighbor nodes, packet collisions and channel contention increases. Hence the time required to reach to destination also increases. This situation results a cumulative effect of an increase in the end to end delay of the protocols. On the other hand when the network is sparse, due to poor connectivity the routing packets fail to reach to destination nodes and hence increase an end to end delay.

In a sparse network, AODV performs better than both AODV and GBNRE-AODV while GBNRE-AODV outperforms Gossip. The reason is that AODV could easily establish path between source and destination using flooding and hence decrease the amount of time searching an end to end path than both GBNRE-AODV and Gossip routing protocols. However in a dense network, Gossip performs better than all the other two protocols while GBNRE-AODV outperforms AODV. This is because of the significant reduction in both the routing overhead and the collision rate in Gossip and GBNRE-AODV routing protocols. Generally GBNRE-AODV routing protocol increased the average end to end delay by approximately 1.34% and 6.24% compared to both AODV and Gossip routing protocols respectively.



**Impact of node mobility**

This section presents the effects of node mobility on the performance of the three protocols. A set of simulation experiments has been conducted by deploying 200 nodes over a 1500m x 1500m with each node moving according to the random waypoint mobility model with a maximum node speed of  $V_{max}$ . The maximum speed  $V_{max}$  in the network has been varied from 5m/sec to 25m/sec.

**Normalized Routing Overhead**

The routing overhead generated by each of the routing protocols increases with increased maximum node speed. This is because when node mobility increases, the frequency of breaking routes/ route discontinuity increases, thus more RREQ packets are generated and disseminated to maintain broken paths or to establish new paths. These activities potentially contributed an increase on the overall routing overhead. GBNTR-AODV has a clear performance advantage over the AODV and Gossip routing protocols across all node speeds. For instance at high speed (e.g. 25 m/s) the *GBNRE-AODV*, protocol reduces the routing overhead by approximately 18.44% and 57.77% when compared against Gossip and AODV routing protocols

respectively. In general, *GBNRE-AODV* reduces the normalized routing overhead approximately by an average of 16.36% and 50.37% compared to Gossip and AODV routing protocols respectively.

**Average Collision rate**

The average collision rate increases linearly as the node mobility increases. This is because when the mobility is increased the frequency of broken links is increased and hence significant number of RREQ packets regenerated and disseminated through the network to repair the broken link, leading to an increase in packet collisions. For example, when the maximum node speed is increased from 20m/sec to 25m/sec, the average collision rate of *GBNRE-AODV*, Gossip and AODV is increased by around 8.84%, 15.02%, 30%. In general, *GBNRE-AODV* outperforms Gossip and AODV by reducing the collision rate approximately by an average of 39.02% and 51.21% respectively.

**Delivery ratio**

The network delivery ratio of each of the protocols decreases with increased node mobility. The average delivery ratio of *GBNRE-AODV* performs 3.69% and 6.8% better than both Gossip and AODV routing protocols. Even if mobility creates more overheads in all routing protocols, *GBNRE-AODV*, reduces the routing packet in the network by selecting a path having energy capable nodes for data transmission and hence minimizes node failures and packet drops, leading to an increase delivery ratio.

**Normalized energy consumption**

Compared with the Gossip and AODV routing protocols, the average energy consumption per delivered data packet of *GBNRE-AODV*, is reduced by as much as 5.71% and 8.45 % respectively when low speed (e.g. 5 m/s ) is used and

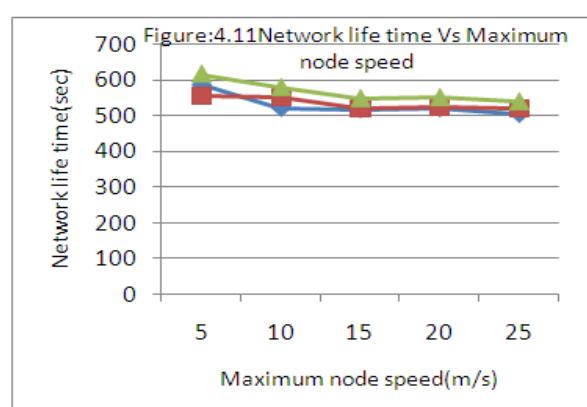
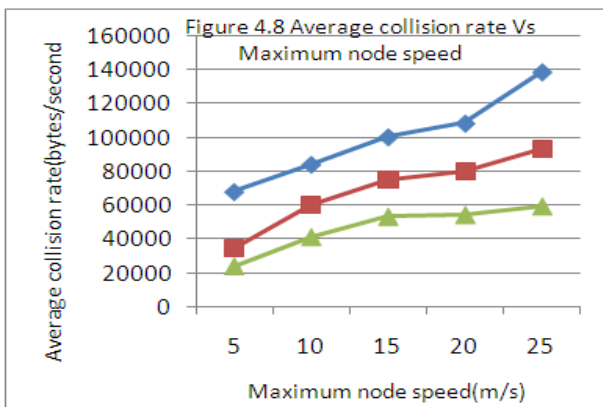
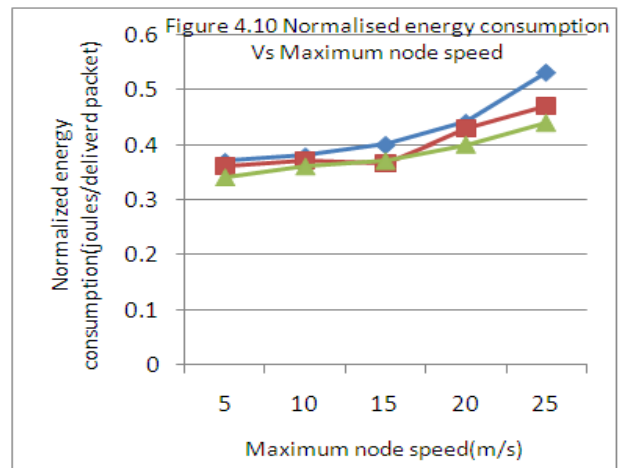
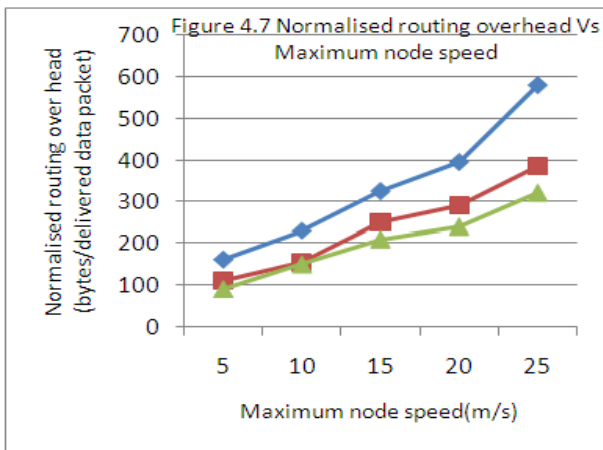
about 6.59% and 18.56% respectively when high speed (e.g. 25 m/s) is used. In general, *GBNRE-AODV* reduced the normalized energy consumption approximately by an average of 4.35% and 10.42% compared to Gossip and AODV routing protocols.

**Network life time**

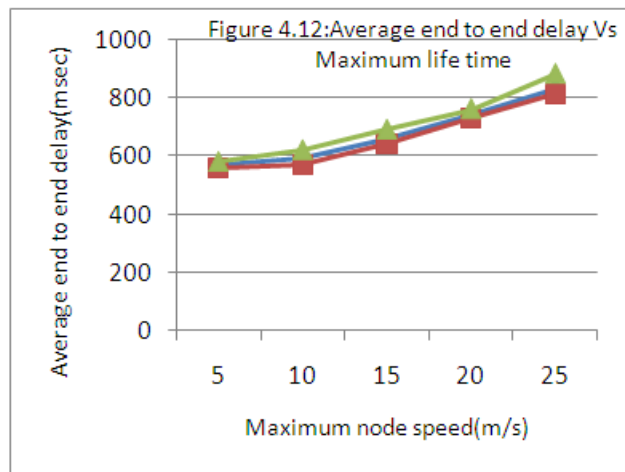
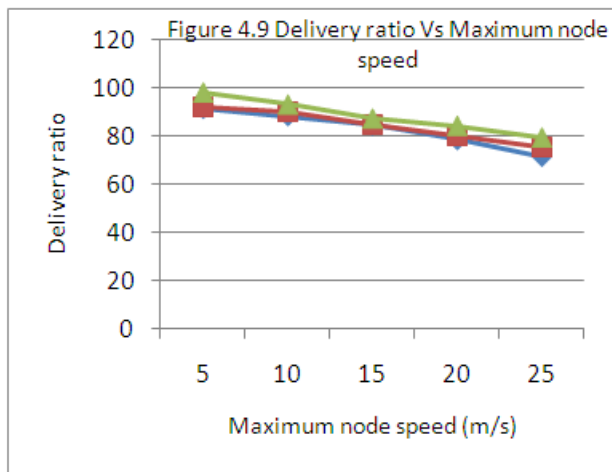
The network lifetime in each of the three routing protocols decreases with increased maximum node speed. This is because when the node speed increases more routing packets are re-initiated and disseminated through the network due to frequent broken links and hence consumes node’s battery, thereby reduces the network lifetime. In a simulation scenario of 25 m/ s, the network is alive for a minimum value of 538 sec for *GBNRE-AODV* where as Gossip and AODV make the network alive for a minimum of 510 sec and 503 sec respectively. Generally in *GBNRE-AODV* we see an average improvement of 6.80% in network lifetime than AODV, while an average improvement of 5.78 % is gain by *GBNRE-AODV* over Gossip

**Average end to end delay**

The average delay incurred in each of the three protocols increases with increased maximum node speed. The average end to end delay incurred in *GBNRE-AODV*, is higher than both Gossip and AODV routing protocols. For instance, at 25m/s, the delay incurred by *GBNRE-AODV*, is increased by approximately 8.28% and 5.84% compared to Gossip and AODV routing protocols respectively. In general both Gossip and AODV routing protocols reduce an end to end delay by approximately 6.43% and 4.04% respectively compared to *GBNRE-AODV*, routing protocol.







## 5. CONCLUSION

This paper has presented new gossip based energy aware routing approach for MANETs, named as Gossip based node residual energy AODV (*GBNRE-AODV*), where the gossiping probability at a node is dynamically computed based on its neighbor density, minimum residual energy from source to the destination node and received signal strength. We compared the performance of *GBNRE-AODV*, against two existing routing protocols, GOSSIP3 (0.65, 1, 1) (i.e. Gossip), and AODV routing protocols.

The performance of the routing protocols is measured in terms of the most widely used performance metrics in the existing performance analysis of MANETs routing protocols that include normalized routing overhead, average collision rate, delivery ratio, normalized energy consumption, network life time, and average end-to-end delay. Performance analysis has been conducted considering various system parameters. First, the impact of the network density on the performance of the routing protocols is conducted by varying the number of nodes placed in a fixed area. Secondly, the performance analysis of the routing protocols has been studied under varying node mobility by varying the maximum node speed in the network.

The simulation results confirm that routing protocols which do not consider node's energy as a cost metric lead to excessive redundant re-transmissions, causing high channel contention and packet collisions, reduces network life time and consumes more energy per data packet in the network. However by introducing gossip based energy aware routing protocol we have reduced the overhead, routing load, power consumption by increasing network life time at the trade off a smaller amount of end to end delay. This paper has presented extensive performance analysis of *GBNRE-AODV* routing protocols based on AODV as a base routing protocol. Since AODV routing protocols have implemented flooding techniques during route discovery, it will be an interesting prospect to examine the effects of these dynamic gossiping broadcasting algorithms on any of the existing routing protocols of MANETs such as Destination-Sequenced Distance-Vector Routing (DSDV), Optimized Link State Routing (OLSR), Dynamic Source Routing (DSR), Zone-based routing protocol (ZRP) as a future work.

## REFERENCES

- [1] M.Frodigh, P.Johansson, and P.Larsson, "Wireless ad hoc networking: The art of networking without a network", Ericsson Rev. 4, pp. 248-263, 2000.
- [2] S.Basagni, M.Conti, S.Giordano, I.Stojme novic, Second Edition, "Mobile ad-hoc networking Cutting Edge Directions," John Wiley & Sons, Inc., 2013.
- [3] P. Nicopolitidis, M. S. Obaidat, G. I. Papadimitriou, and A. S. Pomportsis, *Wireless Networks*: Wiley, 2003.
- [4] C. E. Perkins, E. M. Belding-Royer, and S. Das, "Ad hoc on-demand distance vector (AODV) routing", Network Working Group, RFC 3561, 2003.
- [5] N.Vassileva and F. Barcelo-Arroyo. "A Survey of Routing Protocols for Maximizing the Lifetime of Ad Hoc Wireless Networks". *International Journal of Software Engineering and Its Applications*, 2(3): pp. 77–90, July 2008.
- [6] Y. Sasson, D. Cavin, and A. Schiper, "Probabilistic broadcast for flooding in wireless mobile ad hoc networks," *Proceedings of IEEE Wireless Communications and Networking Conference (WCNC)*, 2003.
- [7] Z.Zhaoxiao, P.Tingrui, and Z.Wenli, "Modified Energy-Aware AODV Routing for Ad hoc Networks", *IEEE Global Congress on Intelligent Systems*, pp. 338-342, 2009.
- [8] A.P.Patil, K. R. kanth, B.Sharanya, M P D. Kumar, and Malavika J, "Design of an Energy Efficient Routing Protocol for MANETs based on AODV", *IJCSI International Journal of Computer Science Issues*, Vol. 8, Issue 4, No 1, pp. 215-220, 2011.
- [9] Y. C. Tseng, S. Y. Ni, Y. S. Chen, and J. P. Sheu, "The broadcast storm problem in a mobile ad hoc network", *Wireless Networks* 8, pp. 153-167, 2002.
- [10] C. S. R. Murphy and B. S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols". New Jersey: Prentice Hall PTR, 2004.
- [11] D. B. West, *Introduction to Graph Theory*, 2nd ed: Prentice Hall, Upper Saddle River, NJ, pp. 116-118, 2001.
- [12] D. Stauffer and A.Aharony, *Introduction To Percolation Theory*, Taylor & Francis 2 ed, 1994.
- [13] Liqiang Zhao, Kun Yang and Guogang Zhao, "Energy Efficient Fundamental Theory and Technical Approach," *Energy Management in Wireless Cellular and Ad-hoc Networks*, Studies in Systems.
- [14] J. Wu and W. Lou, "Forward-node-set-based broadcast in clustered mobile ad hoc networks," *Wireless Communications and Mobile Computing*, vol. 3, pp. 155-173, 2003.
- [15] W. Peng and X. C. Lu, "On the reduction of broadcast redundancy in mobile ad hoc networks," *proceedings of the ACM Symposium on Mobile and Ad Hoc Networking and Computing (MobiHoc'00)*, pp. 129-130, 2000.

- [16]. M. B.Yassein, M. O.Khaoua, L.M. Mackenzi, and S. Papanastasiou, "Performance Analysis of Adjusted Probabilistic Broadcasting in Mobile Ad Hoc Networks," International Journal of Wireless Information Networks, vol. 13, pp. 127-139, 2006.
- [17] Z.J. Haas, J.Y. Halpern, L. Li, Gossip-based ad hoc routing, in: IEEE InfoCom Proceedings, vol. 3, 2002, pp. 1707–1716.
- [18] Roberto Beraldi "The polarized gossip protocol for path discovery in MANETs" Science Direct , Ad Hoc Networks 6 (2008) 79–91.
- [19] A. Demers, D. Greene, C. Hauser, W. Irish, J. Larson, S. Shenker, H. Sturgis, D. Swinehart, and D. Terry. Epidemic algorithms for replicated database maintenance. In ACM, editor, Proceedings of the 6th Annual ACM Symposium on Principles of Distributed Computing (PODC '87), pages 1–12, Vancouver, Canada, August 1987.
- [20] J. Luo, P. Th. Eugster, J.-P. Hubaux, Route Driven Gossip: Probabilistic Reliable Multicast in Ad Hoc Networks, in: Proc. of INFOCOM, 2003.
- [21] Chun Meng, Meina Song, and Junde Song, "A Dominating-Set-Based Broadcast Gossip Protocol in Mobile Ad Hoc Networks" IEEE International conference on computer and communication, 2008.
- [22] Xiang-Yang Li , Kousha Moaveninejad and Ophir Frieder "Regional Gossip Routing for Wireless Ad Hoc Networks" mobile network and application, February 2005, Volume 10, pp 61–77.
- [23] Mohammed Fakrudeen, Sufian Yousef and Shasikala Tapaswi, "Performance analysis of the gossip-based Ad Hoc routing using received signal strength of AODV" ,International journal of engineering and technology volume 6- no5 may 2016.
- [24] Z.J. Haas, J.Y. Halpern, L. Li, Gossip-based ad hoc routing, IEEE/ACM Trans. Networking 14 (3) (2006) 479–491 .
- [25] X. M. Zhang, E.B. Wang, J. J. Xia and D. K. Sung, "A Neighbor Coverage based Probabilistic Rebroadcast for Reducing Routing Overhead in Mobile Ad hoc Networks", IEEE Transactions on Mobile Computing, Vol. 13, No.3, pp. 424-433, March 2013.
- [26] Y.B. Ko and N. H. Vaidya, "Location-Aided Routing (LAR) in Mobile Ad hoc Networks", Journal of Wireless Networks, No. 6, pp. 307-321, July 2000
- [27] B. Karp and H. T. Kung, "GPSR: Greedy Perimeter Stateless Routing for Wireless Networks", Proc. of 6th International Conference on Mobile Computing and Networking (MobiCom 2000), August 2000.
- [28] M. A Rabayah and R. Malaney, "A New Scalable Hybrid Routing Protocol for VANETs", IEEE Transactions on Vehicular Technology, Vol. 61, No. 6, pp. 2625-2635, July 2012 .
- [29] Prasanna J. Shete and R. N. Awale, "Performance Investigation of Signal Strength based Gossip AODV" International Journal of Computer Applications (0975 – 8887) Volume 115 – No. 13, April 2015.
- [30] K.Mariyappan and Dr.Karnan "NRE-AODV Routing Protocol to Maximize Network Lifetime of MANET Based on AODV", International Journal Of Innovative Research In Computer And Communication Engineering, vol.5, issue 7, July 2017 [31] K.Mariyappan and Dr.Karnan, "Literature survey on existing power saving routing methods and techniques for increasing network life time in MANET" ICTACT Journal communication technology, June 2017, volume:8, issue2 .
- [32] A.khelil and N.suri, "Gossiping: "Adaptive and Reliable Broadcasting in MANETs", Lecture Notes in Computer Science Volume 4746, pp. 123-141, 2007.
- [33] V. Kanakaris, D.Ndzi, and K. Ovaliadis, "Improving AODV performance using dynamic density driven route request forwarding," International Journal of Wireless and Mobile Networks, vol 3, iss 3, pp.16-27, 2011.
- [34] S. O. Al-Humoud, L. M. Mackenzie, M. Ould-Khaoua, and J. M. Abdulai, "RAD Analysis of Adjusted Counter-Based Broadcast in MANETs," presented at The 24th UK Performance Engineering Workshop, (UKPEW'08), 2008.
- [35] B.Chen, K.Jamieson, R.Morris, H.Balakrisnan, "Energy-Efficient Coordination Algorithm for Topology Maintenance in Ad Hoc Wireless Networks," Proceedings of Int'l Conf. on Mobile Computing and Networking (MobiCom), 2001.
- [36] Philip Neculescu and Klaus Schilling "Signal Strength Based MANET Routing Protocol :Cost Calculation and Performance Evaluation" 3rd IFAC Symposium on Telematics Applications The International Federation of Automatic Control November 11-13, 2013. Seoul, Korea.
- [37] B.R.Chen and C.H.Chang, "Mobility impact on energy conservation of ad hoc routing protocols," SSGRR , pp. 1-7, 2003.
- [38] Nitin, Manjhi and Nilesh patel, "Signal Strength Based Route Selection in MANET " International Journal Of Computer science & telecommunication , vol 3, issue 7, 2012.
- [39] Optimize Signal Strength and energy efficient mechanism for link failure in MANET, International Journal Of Computer Networking, Wireless and Mobile Communication , Vol 5, issue 1, Feb 2015.
- [40] N. Vassileva and F. Barcelo-Arroyo. A Survey of Routing Protocols for maximizing the Lifetime of Ad Hoc Wireless Networks. International Journal of Software Engineering and Its Applications, 2(3): pp. 77–90, July 2008.
- [41] T. Camp , J. Boleng and V. Davies "A Survey of Mobility Models for Ad hoc Network Research," Wireless Communications and Mobile Computing, vol. 2, no. 5, pp. 483 - 502, 2002.
- [42] G.Lin, G.Noubir, and R.Rajamaran, "Mobility Models for Ad hoc Network Simulation," Proceedings of 23rd Conference of the IEEE Communications Society (INFOCOM), vol. 1, pp. 454-463, 2004.
- [43] W. Navidi and T. Camp, "Stationary distributions for the random waypoint mobility model," IEEE Transactions on Mobile Computing, vol.3, pp.99-108, 2004.