World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 4.326

RELIABLE CLUSTER FORMING PROTOCOL IN VANET

E.N. Bhargava[1], Dr. K.S. Meena*[2], Dr. T. Vasanthi[3]

[1]UG Scholar (III B.E-CSE), Dept. of Computer Science and Engineering, Angel College of Engineering and Technology, Tirupur, India.

[2]Assistant Professor, Dept. of Mathematics, Angel College of Engineering and Technology, Angel Nagar, P.K.Palayam, Tirupur-641655,Tamilnadu, India.

[3]Assistant Professor (Senior Grade), Dept. of Mathematics, PSG College of Technology, Peelamedu, Coimbatore, Tamilnadu, India.

Article Received on 28/02/2017 **Article Revised on 21/03/2017** **Article Accepted on 10/04/2017**

***Corresponding Author**
Dr. K.S. Meena
Assistant Professor, Dept. of Mathematics, Angel College of Engineering and Technology, Angel Nagar, P.K.Palayam, Tirupur-641655,Tamilnadu, India.

ABSTRACT

Now-a-days, the technocrats of automobile companies are very much concerned about the security and safety of vehicles and passengers. As the wireless technology has become pervasive and cheap, Vehicular Adhoc Network (VANET) is found to be a good candidate to address the safety related issues. VANETs are a special case of MANETs. Due to the dynamic topology, VANET is vulnerable in reliability. This work is intended to provide a reliable clustering protocol for VANET named as RCFP (Reliable Cluster Forming Protocol) for transmitting road safety information among the vehicular nodes, by organizing them into clusters according to the transmission range. Cluster head is elected by considering various parameters such as Degree, Degree of Difference, Sum of Degree, Battery power, Node movement, Delivery Delay and Delivery Drop. An algorithm has been formulated to enhance the link reliability from the vehicular node to other ongoing vehicles on the roadside.

KEYWORDS: MANET, Link Reliability, RCFP, Transmission Probability, Universal Generating Function.

Acronym

UGF	Universal Generating Function
TP	Transmission Probability
CH_i	Cluster Head i
i	Node i
u(i)	UGF of node i
$u(CH_i)$	UGF of ClusterHeadi
$LR_{n:D}$	Link Reliability between n and D
M	Number of possible Links
*	Composition Operator
N	Member of Clusters

INTRODUCTION

Road traffic grows exponentially with growth in developed countries. This can sometimes be chaotic to the general public with death as high as 50,000 and 2 million injuries as reported worldwide every year. Economy, environment also gets affected by fuel waste. The sensory applications of wireless technology give rise to the manifestation of Vehicular Ad-hoc Networks shortly known as VANETs. Vehicular Ad-hoc Network (VANET) represents a demanding class of mobile ad-hoc networks in which the moving vehicles are considered as nodes that enables vehicles to communicate with each other using roadside infrastructure. In MANETs, the nodes are moving in a random manner where as in VANETs, vehicles tend to move in an organised manner. VANET provides vehicle to vehicle connectivity to create a balance in traffic jam to reduce travelling time. It is also useful to send message to ambulance and traffic police in the case of traffic emergency and relay emergency signal to the drivers behind the accident.

In our day-to-day life, we face many difficulties to reach our destination on time due to accidents, traffic congestion and unnecessary parking of vehicles on the road. Alert messages should be delivered to vehicular nodes when an accident or emergency situation occurs. So the vehicles which are coming towards the accident spot would take another direction to reach the desired place. This reduces unwanted traffic and congestion in the road. Nodes in a vehicular network are classified into normal nodes and selfish nodes. A selfish driver can tell other vehicles that there is congestion on the road ahead and they must choose an alternate path. The selfish node may ask for incentive for forwarding the advertisements or any other type of messages to reach the destination. Normal nodes actively participate in the message dissemination process and hence the number of forwarders to forward the traffic messages gets increased.

Related Work

Traffic related activities have a significant role in our day to day life. VANET (Vehicle Ad-hoc Networks) is a promising technology which deserves the attention of the industry and the academic institutions. In order to enhance the vehicular communication, a routing protocol is essential. Routing is the process of forwarding the traffic alert messages from source node to destination node through number of intermediate nodes in a network.Lochert et al (2005) have designed GPCR (Greedy Perimeter Coordinator Routing) which is a position-based routing for urban environment. GPCR protocol is very well suited for highly dynamic environments such as inter-vehicle communication on the highway or city. Zhao and Cao (2008) have designed VADD: Vehicle Assisted Data Delivery in Vehicular Adhoc Networks in order to concentrate on the problem of delay tolerant application in sparse network.

Naumov and Gross (2007) have proposed Connectivity Aware Routing (CAR) protocol which establishes a routing path from source to destination by setting the anchor points at intermediate junctions.To improve the CAR protocol, Chen et al (2010) have developed a diagonal-intersection-based routing (DIR) protocol. The key difference of CAR and DIR protocols is that DIR protocol constructs a series of diagonal intersections between the source and destination vehicles. The DIR protocol is a geographic routing protocol. To improve the routing reliability, Taleb et al (2007) have proposed ROMSGP (Receive on Most Stable Group-Path) routing protocol in a city environment. In contrast with routing results developed in the highway or the city environments, it is very interest that Wan et al. (2008) specially proposed a reliable routing protocol in the rural environment. Wan et al (2008) have developed two reliable routing strategies for roadside to vehicle (R2V) communication.

Fan et al (2011) used a utility based cluster formation technique. Utility function is used as parameter to perform clustering. Clustering is done based on the destination which uses current location of the vehicle, speed and vehicle density. Ahamed et al (2011) have proposed LICA: Location Improvement with Cluster Analysis. It helps to improve the accuracy of GPS device. Tian et al (2010) demonstrated a clustering method based on Euclidean distance for which the position and the direction of vehicle are used as parameters to form a cluster. A vehicle with minimum distance parameter is elected as a cluster head. Remaining nodes are used to form a cluster. Santos et al (2003) presented CBLR (Cluster Based Location Routing) algorithm to perform clustering in VANET. Bali et al (2014) defined the taxonomy, challenges and solutions of clustering in vehicular adhoc network.

This work integrates the performance of RCFP in VANET domain. It implements RCFP in five phases namely identifying neighbouring nodes, calculation of combined weight, cluster formation, achieving the connectivity among clusters and obtaining link reliability. Link Reliability (LR) in a VANET is enhanced by considering the probability of successful delivery of message from a source vehicle to target vehicle. Different types of UGFs are introduced to obtain the link reliability. Meena and Vasanthi (2014, 2015 and2016) have evaluated the reliability of MANET using universal generating function techniques (UGFT). This work considers the reliability of VANET using UGFT.

MATERIALS AND METHODS

The VANET and RCFP

In recent years many routing protocols have been developed to achieve scalability and efficiency in delivering information from one node to another node. It is a challenging task to produce a reliable and efficient routing protocol for VANET due to the difficulty in handling a large number of nodes and the reachability relation between two nodes. Also network connectivity continuously changes as the nodes roam about. This paper introduces a Reliable Cluster Forming Protocol (RCFP) which is applicable for large scale network. This RCFP protocol discovers a reliable path from a source node to destination node efficiently. This protocol focuses on calculating the reliability using Universal Generating Function Technique (UGFT). RCFP uses the following 5 approaches to find the reliability.

1. Identifying Neighbouring nodes
2. Table Formation
3. Cluster Formation
4. Achieving the connectivity among clusters
5. Routing

In RCFP, nodes are grouped into clusters in which a leader is elected among clusters so that the message is delivered to the desired destination node through CH. It reduces overhead, delay and improves the reliability. UGFT is one of the important techniques applied to determine the link reliability. Transmission Probabilities are defined between, and also within the clusters and are used to calculate MANET reliability. Due to the vibrant nature of the mobile nodes, their association and dissociation with clusters will lead to the frequent change of cluster heads. This is an important issue and will disturb the stability of the network. Hence, implementing a reliable cluster forming protocol is required. Various heuristics have been proposed to choose cluster heads based on highest-degree and lowest-identity.

This work proposes a Reliable Cluster Forming Protocol in which the cluster head selection is done based on the combined weight of nodes. The combined weight of a node is accounted using the parameters such as neighbourhood (nbd), degree (D), degree of difference (DOD), sum of degree of difference (SOD), battery power (Bp), node movement (Nm), delivery delay (DD) and delivery drop (DP). In RCFP, the nodes are performing unicasting whereas CHs are practicing multicasting approach. The cluster head selection process invoked as rarely as possible to reduce the computation and communication costs. The following outlines are considered while executing RCFP

The degree (D) of a node is the total number of its neighbours. The neighbouring nodes are identified by considering the nodes which enter into the transmission range of that node. Battery power plays a prominent role in electing the cluster head. Battery Power (Bp) will be reduced significantly, if the number of members in a cluster is increased. In order to overcome the frequent battery drainage, it is considered that each cluster head can ideally support only 3 members. Bp is allotted based on the degree of a node. If the degree of a node is 4 or higher, then its Bp is 0. The allotted battery power is 1 when the degree is 3. In the same way, Bp is considered as 3 while the degree is 2.

The DOD of a node is obtained using $|D-\lambda|$, where D is the degree of the node and λ denotes the total number of members of the cluster where the node lies. SOD of a node is calculated by adding the degrees of all its neighbours. Nm describes the speed of a mobile node. Nm is denoted as 0 when there is no movement and it is represented as 1 when there is a slow movement and also it is given as 2 when there is fast movement.

Another important factor that will affect the stability of a link in VANAET is Delivery Drop (DP). The roaming nature of nodes in a VANET will lead to frequent link breakage and delivery drop. Likewise, Delivery Delay (DD) will also be there due to the traffic environment. As the parameters DD and DP are considerably important in a successful delivery, they are also included in calculating the Combined weight (Cw) of a node.

The Combined weight (Cw) of a node is calculated by

Cw = (DOD$\times$ w_1) + (SOD $\times$ w_2)+(Bp$\times$ w_3) + (Nm $\times$ w_4)+ (DP$\times w_5$) +(DD$\times$ w6), where w_1,w_2,w_3,w_4, w_5 and w_6 are arbitrarily selected random weights such that $w_1+w_2+w_3+w_4+w_5+w_6 = 1$.

Cluster is formed by grouping the neighbouring nodes and Cw is used to elect the cluster head. CH is selected as the node whose combined weight is minimum among all the nodes in a cluster. If there is a tie, the one which comes as first is elected as a CH. Source node finds a reliable path to the destination node during the route discovery. Route maintenance is done when there is a link breakage or node failure. Connectivity is achieved between the clusters as they are neighbours to each other.

Mathematical modelling

In VANETs, the information is passed by a flow of transition from node to node to reach the required destination. For a successful packet delivery, reliable routes are necessary.A route is constructed by a series of links. The link lifetime is very important issue for designing a reliable routing. A node can participate only one time in a link. Once the message is reached the cluster, where the destination node is present, further it will not be transmitted.

The link reliability is calculated usingUGFT. It is obtained by the composition relation $u(i)*u(CH_i)$. Each transmission has its own probability. Hence, each transmission requires a unique representation. The probability of transmission of messages from any node to its CH and reaching the destination D is denoted by $u(i) = p_{i:CH,D}X^D$. If the message starts from node i, passes through the path via CHs and reaches the destination D successfully then the corresponding TP is $P_{i:CH_i,\mathrm{CH}_j,D} = P_{i:CH_i} \times P_{\mathrm{CH}_i:\mathrm{CH}_j} \times P_{\mathrm{CH}_j:D}$

Definition 1: The node UGF for a member node i denoted by u(i) is defined as a polynomial in X such that $u(i) = p_{i:CH}X^{CH}$ where $p_{i:CH}$ represents the probability of passing the packets from node i to the CH. Here CH is the head of the cluster where the node i is located.

Definition 2: The node UGF for a CH is defined as a polynomial in X such that $u(CH_i) = \sum P_{CH_i:CH_j,\ldots:D}X^D$ where the summation runs over all the possibilities through which the data can reach D from CH_i.

Definition 3: The link reliability generating function is defined as the composition of node UGF and CH UGF and is given by $LR_{i:D} = \sum P_{i:D} X^D = u(i) \otimes u(CH_i)$,where $P_{i:D}$ denotes the probability of transmitting the information from node i to destination D via various CHs'. This is achieved by combining the UGF of node i and its CH which is denoted as $u(i) \otimes u(CH_i)$. If the source node is a CH, then $LR_{i:D} = u(CH_i)$.

Algorithm for Electing the Cluster Head

The RCFP protocol is executed as follows:

Step 1: For each node i, Identify all the neighbourhood nodes (nbd_i)

Step 2: Calculate the degree of a node.

Step 3: Obtain the degree of difference (DOD) as DOD = $|D- \lambda|$

Step 4: Find SOD = Sum of degree of neighbourhood nodes of i.

Step 5: Allot battery power based on number of neighbours of a node i.

Step 6: Assign the node movement, delivery drop and delivery delay.

Step 7: Calculate the combined weight Cw as:

$$Cw = (DOD \times w_1) + (SOD \times w_2) + (Bp \times w_3) + (Nm \times w_4) + (DP \times w_5) + (DD \times w_6)$$

Step 8: Organize the nodes into clusters.

Step 9: Elect the Cluster Head and achieve the connectivity by determining the neighbours of each other.

Step 10: Calculate the link reliability.

RESULT AND DISCUSSION

VANETs are becoming a key component for the intelligent transportation systems. They alert drivers as well as passengers by disseminating road safety messages. A routing protocol will enhance the reliable communication between vehicles. The RCFP protocol works well when a network has more number of nodes. It groups the nodes of a network in to clusters and calculates the reliability of a link. The algorithm 2.3 is applied and validated for the network given in Figure. It has 21 nodes which are represented in different colours. Each node of this network stands for individual vehicle.

For implementing the algorithm, neighbours of each node should be identified. The tree diagram given in Figure 2 expounds the neighbours of each node of the network given in Figure 1.

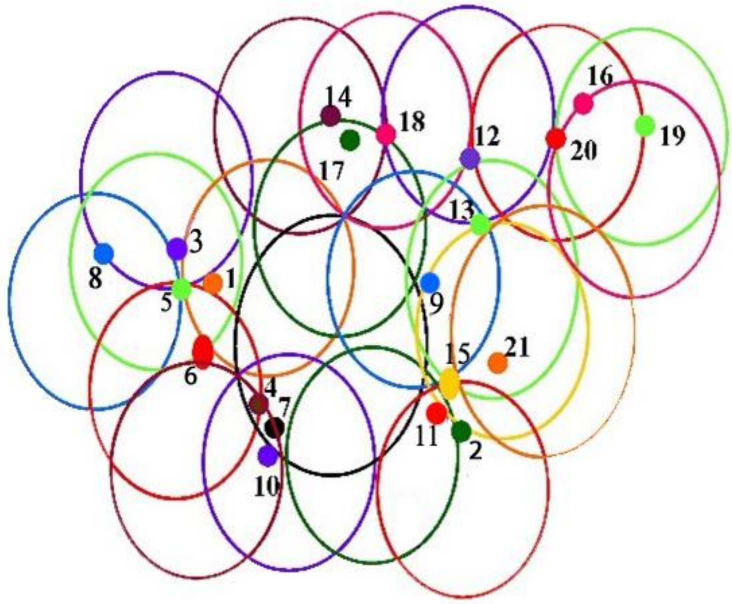

Figure 1: RCFP - transmission range.

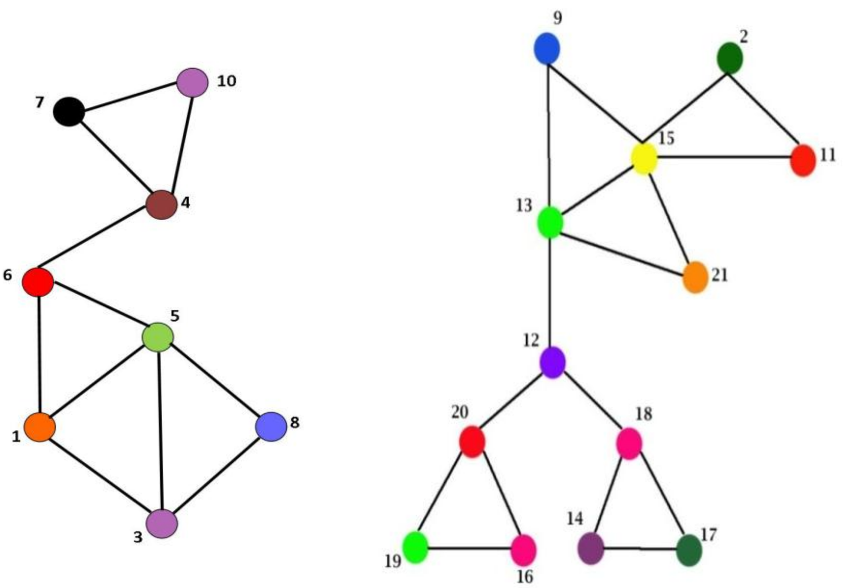

Figure 2: Tree diagram.

After identifying neighbour nodes, the parameters like neighbours (nbd), the degree (D), the degree of difference (DOD) , the sum of degree of difference (SOD), battery power (Bp), node movement (Nm), delivery drop (DP) and delivery delay (DD) related to each node of the network given in Figure 1 are calculated and listed in table 1.

Table 1: Parameter values of various nodes.

Nodes	nbd	D	DOD	SOD	Bp	Nm	DD	DP
1	3,6,5	3	0	10	1	0	3	1
2	11,15	2	1	6	3	1	2	2
3	1,5,8	3	0	9	1	3	0	4
4	10,7,6	3	0	7	1	3	0	2
5	3,1,8,6	4	1	11	0	1	2	2
6	1,5,4	3	0	10	1	2	1	3
7	4,10	2	1	5	3	1	2	2
8	5,3	2	1	7	3	2	1	3
9	13,15	2	1	8	3	2	1	3
10	4,7	2	1	5	3	1	2	2
11	2,15	2	1	6	3	1	2	2
12	13,18,20	3	0	10	1	1	2	2
13	9,15,12,21	4	1	11	0	1	2	2
14	18,17	2	1	5	3	0	3	1
15	2,9,11,13,21	5	2	12	0	1	2	2
16	19,20	2	1	5	3	2	1	3
17	14,18	2	1	5	3	3	0	4
18	12,14,17	3	0	7	1	0	3	1
19	16,20	2	1	5	3	3	0	4
20	12,16,19	3	0	7	1	2	1	3
21	13,15	2	1	8	3	0	3	1

The weights w_1,w_2,w_3,w_4,w_5 and w_6 are selected arbitrarily as w_1= 0.2, w_2= 0.1, w_3= 0.2 w_4= 0.2, w_5= 0.2 and w_6= 0.1 based on the weightage of the parameters. After obtaining the weighing parameters in cluster head selection, the Cw is calculated for each node and are reported in table 2. Different colours that are used to denote the nodes are given in the first column.

Table 2: Cw of various nodes.

Nodes	DOD $\times$0.2	SOD $\times$0.1	BP $\times$0.2	Nm $\times$0.2	DD $\times$0.1	DP $\times$0.2	Cw
1 (orange)	0	1	0.2	0	0.1	0.6	1.7
2 (dark green)	0.2	0.6	0.6	0.2	0.2	0.4	2.2
3 (violet)	0	0.9	0.2	0.6	0.4	0.6	2.5
4 (brown	0	0.7	0.2	0.4	0.3	0.6	2.3
5 (light green)	0.2	1.1	0	0.2	0.2	0.4	2.1
6 (red)	0	1	0.2	0.4	0.3	0.6	2.3
7(black)	0.2	0.5	0.6	0.2	0.2	0.4	2.1
8 (blue)	0.2	0.7	0.6	0.4	0.3	0.6	2.6
9 (blue)	0.2	0.8	0.6	0.4	0.3	0.6	2.7
10 (violet)	0.2	0.5	0.6	0.2	0.2	0.4	2.1
11 (brown)	0.2	0.6	0.6	0.2	0.2	0.4	2.2
12 (violet)	0	1	0.2	0.2	0.2	0.4	2

13 (light green)	0.2	1.1	0	0.2	0.2	0.4	2.1
14 (brown)	0.2	0.5	0.6	0	0.1	0.6	1.8
15 (yellow)	0.4	1.2	0	0.2	0.2	0.4	2.4
16 (pink)	0.2	0.5	0.6	0.4	0.3	0.6	2.4
17 (dark green)	0.2	0.5	0.6	0.6	0.4	0.8	2.7
18 (pink)	0	0.7	0.2	0	0.1	0.6	1.4
19 (red)	0.2	0.5	0.6	0.6	0.4	0.8	2.7
20 (light green)	0	0.7	0.2	0.4	0.3	0.6	2
21 (orange)	0.2	0.8	0.6	0	0.1	0.6	2.1

The nodes are organised to form clusters by grouping the neighbourhood nodes and the cluster head is elected. CHs are responsible for maintaining the route discovery in the network. Hence, the connectivity between various clusters are done by determining the neighbours of CHs. This is expounded in Figure 3.

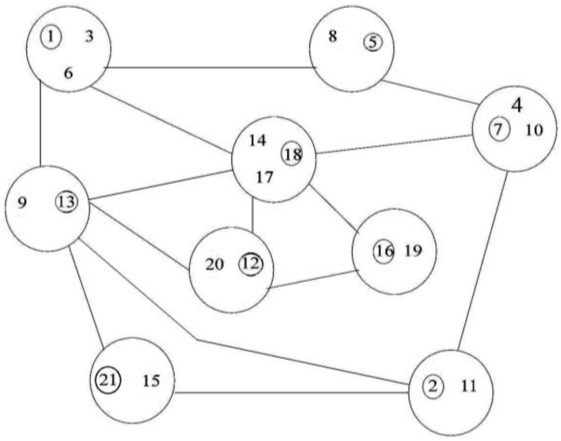

Figure 3: Cluster formation.

Once the connectivity is achieved, the UGFs are designed for nodes and CHs and the reliability of links between nodes are obtained using the composition of node and CH UGFs. The link reliability is verified numerically by assigning the probability values for the transition between nodes and CH as well as between CHs randomly. These values are reported in Table 3 and 4.

Table 3: Transmission probabilities between CHs.

Communicable Clusters	TP	Communicable Clusters	TP
1,5	0.8	13,2	0.3
1,13	0.7	13,21	0.4
1,18	0.9	13,12	0.4
2,21	0.6	13,18	0.3
2,7	0.9	16,18	0.6
7,5	0.4	16,12	0.8
7,18	0.7	18,12	0.5

Table 4: Transmission probabilities within clusters.

C.No	Within CH_S	TP	C.No	Within CH_S	TP
1	1-3, 1-6	0.6,0.5	6	4-7,7-10	0.8,0.6
2	5-8	0.5	7	16-19	0.5
3	13-9	0.5	8	15-21	0.4
4	12-20	0.6	9	2-11	0.6
5	14-18, 17-18	0.7,0.6			

For numerical computation of link reliability, the link between nodes 3 and 8 has been taken. This link considers the transmission of data from node 3 to its CH- node 1 and all the possible transmissions from node 1 to the CH- node 5, where the destination node 8 lies.

The link reliability between nodes 3 and 8 is obtained from the composition function

$$u(3)\otimes u(CH_1)=\sum p_{3:8}X^8$$
$$=(P_{3:1,5,8}+P_{3:1,18,7,5,8}+P_{3:1,18,16,12,13,21,2,7,5,8}+P_{3:1,18,12,13,21,2,7,5,8}+P_{3:1,13,12,18,7,5,8}+$$
$$P_{3:1,13,20,16,18,7,5,8}+P_{3:1,9,21,2,7,5,8}+P_{3:1,13,11,7,5,8}+P_{3:1,13,18,7,5,8})\,X^5$$

and is evaluated as 0.94

Data transmission from node 12 to node 11 is possible by transferring the message from node 12 (itself a CH) to the destination node 11 through the intermediate CHs . Reliability calculation is made by using

$$u(CH_{12})=\sum P_{12:11}X^{11}$$

The Reliability of link is achieved as 0.7.

CONCLUSION

This work focusses the link reliability in a VANET environment based on UGFT. The problem addressed in this paper designs a scalable and reliable protocol to achieve the link reliability of a VANET.Link Reliability (LR) in a VANET is enhanced by considering the probability of successful delivery of message from a source vehicle to the target vehicle. Node UGF is formed for cluster heads and member nodes separately based on the nature of the work assigned to them. The numerical example ensures that the RCFP works well. It is worthy of research if we extend this model by introducing safety measures which will ensure a secured transition through a noisy channel.

REFERENCES

1. Ahammed F et al., "LICA: robust localization using cluster analysis to improve GPS coordinates", in: First ACM International Symposium on Design and Analysis of Intelligent Vehicular Networks and Applications, 2011; 39-46.
2. Bali Rs et al., "Clustering in vehicular ad hoc networks: Taxonomy, challenges and solutions", Vehicular Communications, 2014; 1(3): 134-152.
3. Chen YS et al., "A Diagonal-Intersection-Based Routing Protocol for Urban Vehicular Ad Hoc Networks", Telecommunication System, 2010; 46.
4. Fan et al., "A mobility metric based dynamic clustering algorithm (DCA) for VANETs", in: International Conference on Communication Technology and Application, Beijing, 2011; 752-756.
5. Lochert C et al., "Geographic routing in city scenarios", ACM SIGMOBILE Mobile Computing and Communications, 2005; 9(1): 69-72.
6. Meena KS and Vasanthi T "Reliability Design for a MANET with Cluster Head Gateway Routing Protocol", Communication in Statistics-Theory and Methods, 2015; 45(13): 3904-3918.
7. Meena KS et al., "Reliability Analysis of MANET with RCFP: Reliable Cluster Forming Protocol", International Journal of Applied Engineering Research, 2016; 11(1): 440-447.
8. Meena KS and Vasanthi T "Reliability Analysis of Mobile Adhoc Networks using Universal Generating Function", Quality and Reliability Engineering International, 2014; 32(1): 111-122.
9. Naumov V and Gross T "Connectivity-Aware Routing (CAR) in Vehicular Ad Hoc Networks", IEEE International Conference on Computer Communications (INFOCOM), 2007; 1919-1927.
10. Santos RA et al., "Inter vehicular data exchange between fast moving road traffic using an ad-hoc cluster-based location routing algorithm and 802.11b direct sequence spread spectrum radio, in: Post Graduate Networking Conference, 2003.
11. Taleb T et al., "A stable routing protocol to support ITS services in VANET Networks", IEEE Transactions on Vehicular Technology, 2007; 56(6) 3337-33347.
12. Tian D et al., "A VANETs routing algorithm based on Euclidean distance clustering", in: 2nd IEEE International Conference on Future Computer and Communication, Wuhan, 2010; V1-183–V1-187.

13. Uma Maheswari P et al., "Reliability calculation of VANET with RSU using UGFT", International Journal of Advance Foundation and Research in Computer, 2015; 2(12): 7-17.
14. Wan S Tang J and Wolff RS "Reliable Routing for Roadside to Vehicle Communications in Rural Areas", IEEE International Conference on Communications (ICC), 2008; May 2008; 3017-3021.
15. Zhao J and Cao G "VADD: vehicle-assisted data delivery in vehicular adhoc networks", IEEE transactions on, Vehicular Technology, 2008; 57(3): 1910-1922.