Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 02,Issue 03, March -2015

A Review On Reliable Routing Scheme Using Graph Evolving Theory For VANET

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Abstract — *Wireless ad hoc network is a distributed type of network where it forms and deforms the network spontaneously and automatically. Vehicular ad-hoc networks (VANETs), a promising technology that enables communication among the vehicles and between vehicle and road side units, is a one of the types of ad hoc network .The conventional routing protocols proposed for mobile ad hoc networks (MANETs) work poorly in VANETs, because the communication links break more frequently in VANETs than in MANETs, as vehicles are travelling with a high speed on road. Hence, the routing reliability of such highly dynamic networks needs to be paid special attention. This paper has focused on the review of the various reliable routing protocol for VANET.*

Keywords- MANET, VANET, MRJ, end-to-end delay, PBR, EG-RAODV.

I. INTRODUCTION

VANETs are a special form of mobile ad hoc networks (MANETs) that provide vehicle-to vehicle communications. It is assumed that each vehicle is equipped with a wireless communication facility such as Wi-Fi, WiMax, Bluetooth, zigbee to provide ad hoc network connectivity. Road accidents are prevented and road safety is improved by publicizing the road side information to all the vehicles by VANET. In addition , also it can have some application includes Electronic toll collection, Multimedia, Gaming, Vehicle to home communication, travel and tourism management.

As like MANETs , VANETs also tend to operate without an infrastructure; each vehicle in the network can send, receive, as well as relay messages to other vehicles in the network. In this way, vehicles can exchange real-time information, and drivers can be informed about road traffic conditions and other travel-related information. VANETs are similar to MANETs in many ways. Both networks are multi-hop networks having dynamic network topology. There is no central entity and nodes routes the data themselves across the network. Both VANET and MANET are deployable without any infrastructure.

VANETs also have some attractive and unique features, distinguishing them from other types of MANETs, such as normally higher transmission power, higher computational capability, sufficient storage capacity, enough battery power to support long range communication and some kind of predictable mobility, in comparison with general MANETs .MANET and VANET, both are mobile networks, but VANETs give some advantage over MANETs as the mobility pattern of VANET nodes is predictable ,as the VANET nodes is such that they move on specific paths (roads) and hence not in random direction.

II. Related Work

Table 1. VANET Routing Protocol

Protocol	Description
Vehicle-Heading Based Routing Protocol For VANET [2]	• In this protocol Vehicles are grouped according to their velocity vectors. • It can predict the possible breakage of a route when the route is set up between two vehicles of two different groups. • To avoid link breakages and to guarantee stable routes for communication , routes between vehicles from the same group is preferred. • It uses DSDV protocol to propose this routing protocol. • It increases packet delivery ratio and achieves higher throughput compared to traditional protocol for MANET.
Prediction-Based Routing Protocol For VANET [3]	• It takes advantage of the predictable mobility pattern of vehicles on highways. • The link lifetime is predicted based on the range of communication, vehicles' location, and corresponding velocities of vehicles.

	• Then , it predicts route lifetimes and creates new routes before the existing ones fail. • Its basic operation of creating routes is similar to that of a reactive protocol. • If the source node receives multiple replies, then it uses the route that has the maximum predicted route lifetime.
Movement Prediction Based Routing (MOPR) Protocol For VANET [4]	• This algorithm uses moving information of vehicles to choose the best stable route. • This is done using the location, direction and velocity information of each vehicle. • This idea is applied on the classical on-demand routing protocol, AODV. • It uses cross-layer approach , which focuses on several lower OSI layer, such as physical layer , MAC layer and network layer
AODV-R [6]	• Improvement of AODV Protocol for Reliability purpose for VANET • It extends AODV routing messages RREQ and RREP, and the routing table entries. • It is proactive as well as reactive protocol.

2.1. EG-RAODV Routing Protocol

Here, in this protocol the graph theory is being utilized to understand the topological properties of the VANET , Where vehicles can be modelled as vertices and their communication links as edges in the graph. The graph theoretical model called evolving graph has been proposed to capture the dynamic behaviour of dynamic networks , when mobility patterns are predictable. It has been shown promising results in MANETs .

It can only be applied when the topology dynamics at different time intervals can be predicted : known as fixed scheduled dynamic networks (FSDN). But VANET can not be treated as FSDNs , and hence , this evolving graph theory can not be directly applied to VANETs , as the network topology is not predictable. But fortunately , the pattern of topology dynamics of VANET can be estimated ,so can be categorized as : predicted pattern dynamic network. Hence, extended version of evolving graph for VANET is developed as VoEG by considering link reliability. Link reliability can be defined as the probability that a direct communication link between two vehicles will be continuously available for a specific time interval[1].

The link reliability value r(l) for the given prediction interval Tp for the continuous availability of a specific link l between two vehicles at t is defined as follows:

r(l) = P{To continue to be available until t + Tp | available at t}.

The vehicle's velocity parameter is used to calculate the link reliability . It is assumed that the velocity of vehicles has a normal distribution. Based on this assumption, let g(v) be the probability density function of the velocity of vehicle v and G(v)be the corresponding probability distribution function; then

$$g(v) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(v-\mu)^2}{2\sigma^2}} \quad (1)$$

$$G(v \le V_o) = \frac{1}{\sigma\sqrt{2\pi}} \int_0^{V_o} e^{-\frac{(v-\mu)^2}{2\sigma^2}} dv \quad (2)$$

Where μ and σ^2 are the average value and the variance of velocity, respectively . The distance d between two vehicles can be calculated using the relative velocity Δv and the time duration T, i.e., d=Δv×T, where Δv=|v2−v1|. Since v2 and v1 are normally distributed random variables, Δv is also a normally distributed variable, and we can write Δv=d/T.

Let H denote the radio communication range of each vehicle. The maximum distance where a communication between any two vehicles remains possible can be determined as 2H, i.e., when the relative distance between the two vehicles changes from –H to +H . Let f (T) denote the probability density function of the communication duration T. We can calculate f (T) as follows:

$$F(T) = \frac{4H}{\sigma_{\Delta v}\sqrt{2\pi}}\frac{1}{T^2}e^\wedge\left(-\frac{(\frac{2H}{T}-\mu_{\Delta v})^2}{2\sigma^2_{\Delta v}}\right) \quad \text{for } T \geq 0 \qquad (3)$$

Where $\mu_{\Delta v}$ and $\sigma^2_{\Delta v}$ denote the average value and the variance of relative velocity Δv, respectively.

Here, it is supposed that each vehicle is equipped with a Global Positioning System device to give the location, velocity, and direction information. The continuous availability of a specific link l between two vehicles i and j is defined as Tp. It can be determined as,

$$T_p = \frac{H-L_{ij}}{v_{ij}} = \frac{H-\sqrt{(y_i-y_j)^2+(x_i-x_j)^2}}{|v_i - v_j|} \qquad (4)$$

Where L_{ij} denotes the Euclidean distance between vehicles i and j, and v_{ij} denotes the relative velocity between vehicles i and j. To obtain the probability that the link will be available for a duration Tp at time t, the equation (6) can be integrated from t to t + Tp. Hence, the link reliability value $r_t(l)$ at time t will be as follows:

$$r_t(l) = \begin{cases} \int_t^{t+T_p} f(T)dT, \; if \; T_p > 0 \\ 0, \qquad otherwise \end{cases} \qquad (5)$$

2.1.1. Extended EG for VANET- VoEG

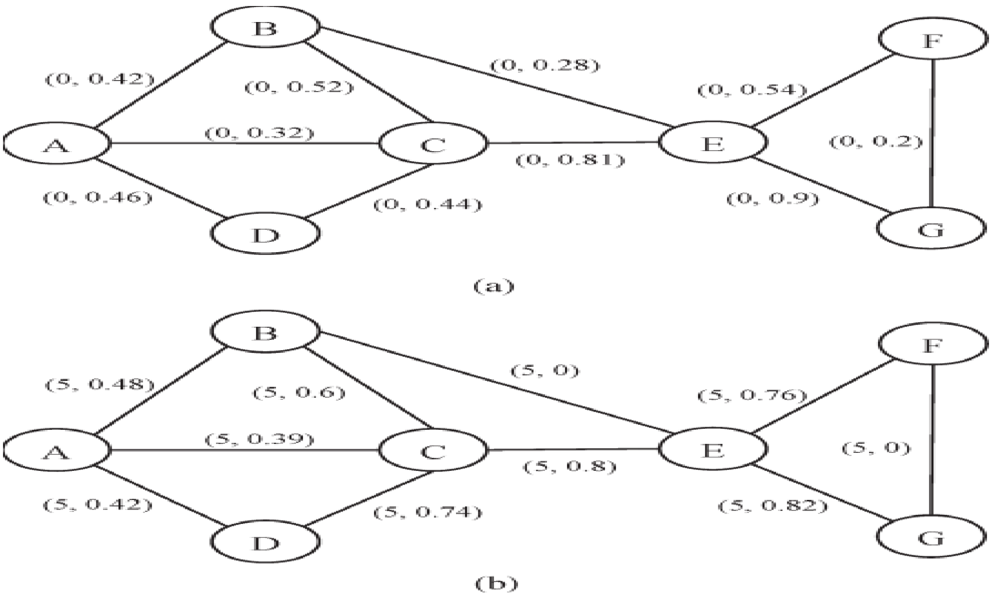

Figure 1. VoEG model at (a) t=0s and (b) t=5s[1]

It associate 2-tuple (t, $r_t(e)$) with each edge, where t denotes current time and $r_t(e) = r_t(l)$ denotes the link reliability value at time t. The communication link is not available if it's link reliability value is equal to zero.

$$Trav(e) = \begin{cases} True, & if \; 0 < r_t(e) \leq 1 \\ False, & r_t(e) = 0 \end{cases}$$

Here, in figure 1 VoEG graph at time t=0s and time t=5s is given in figure-1(a) and (b) respectively. As per the above equation all the communication links are available at time t=0s as all the edges of the graph having nonzero value of link reliability, but for the same graph at time t=5s the communication links BE and FG are not available as their link reliablility value is zero.

2.1.2. EG-Dijkstra

Now, after having VoEG graph , to find the most reliable journey(MRJ) from source to the destination, Dijkstra algorithm has been modified and proposed as the evolving graph Dijkstra's algorithm (EG-Dijkstra) to find the MRJ from VoEG **.**It takes a VoEG graph and a source vehicle Sr as an input and generates an array called reliable graph(RG) that gives the most reliable routes from source vehicle Sr to all other vehicles, and it starts by initializing the journey reliability value RG(Sr)=1 for the source vehicle and RG(u)=φ for other vehicles.

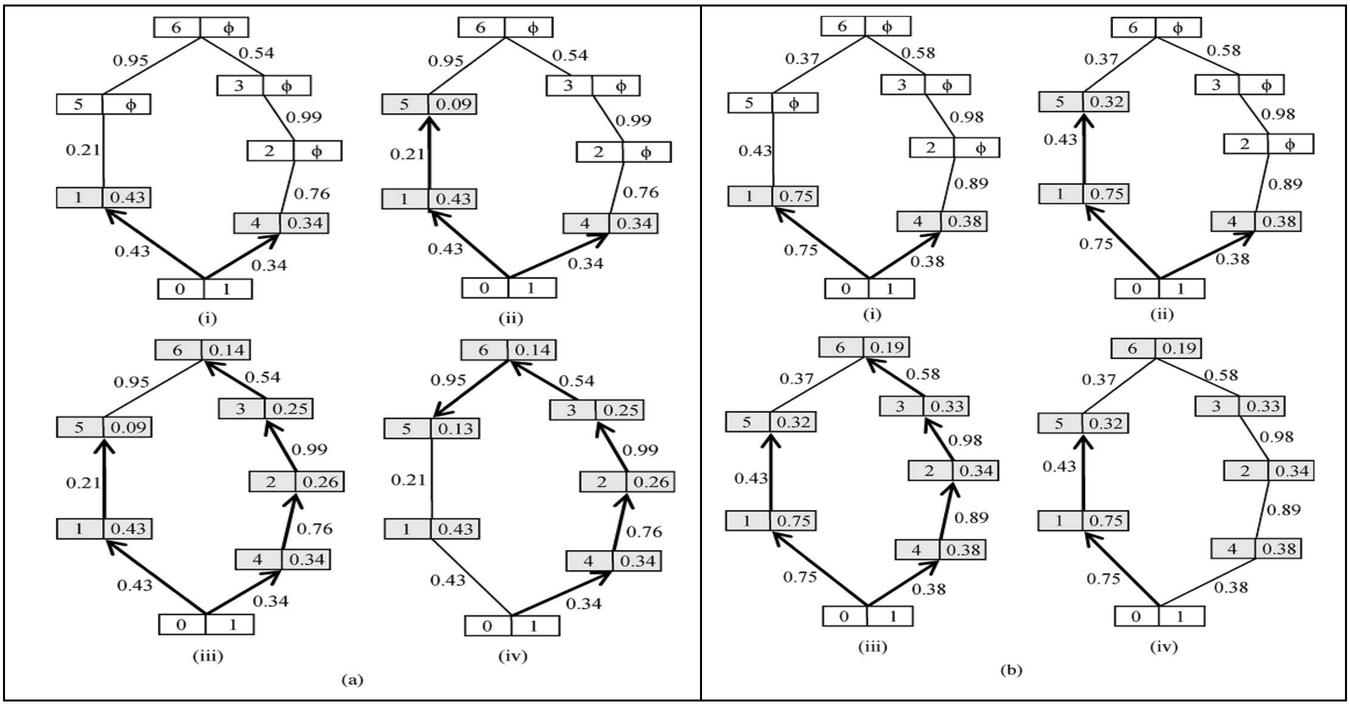

Figure 2. EG-Dijkstra algorithm example on VoEG at t=0s and t=5s[1]

Figure 2 shows a simple example of the EG-Dijkstra algorithm with a simple VoEG at two different time instances : t=0 s and t=5 s. Here, the source vehicle S_r is node 0, and the destination vehicle d_s is node 5. For ease of simplicity, the 2-tuple notation is not used on the links. Instead, only the link reliability value is attached at the current time instant . Each vehicle has its ID and its RG(ID) value. At t=0 s, the current locations of vehicles are being determined by the prediction algorithm. Then, based on the definition in equation(5) the link's reliability values are calculated. EG-Dijkstra discovers vehicles 1 and 4 and assigns the MRJ value as shown in Figure 2(a) (i). Then, it chooses the greatest reliability value and continues to discover vehicle 5. It assigns 0.09 as the MRJ value. Although vehicle 5 is the destination, the algorithm will not stop at this stage, as shown in Figure 2(a) (ii), because it has to check all possible journeys. In Figure 2(a) (iii), the algorithm continues to discover vehicles 2, 3, and 6 and assigns the MRJ value for each vehicle. At the end, it arrives at vehicle 5 again from a different journey, but it is more reliable. Thus, the final reliability value will be 0.13, and the MRJ from vehicle 0 to vehicle 5 at t=0s is 0→4→2→3→6→5. In the same way, Figure 2(b) shows the same process at t= 5s. It can be noticed from Figure 2(b) (iv) that the MRJ now is changed to be 0→1→5, and its reliability value is 0.32 instead of 0.13 at t=0s as it is greater than the 0.13 .

2.1.3. EG-RAODV

It is assumed that the source vehicle has information on the current status of VoEG. When the source vehicle has data to send at time t, it calculates the reliability value for each link in the current VoEG. Then, the EG-Dijkstra algorithm finds the MRJ from the source vehicle to the destination vehicle[1]. At this stage, the source vehicle having knowledge about the most reliable valid journey to the destination. A routing request message (RREQ) will be created by vehicle and the hops of the MRJ will be assigned as extensions to this RREQ. This extension field of the RREQ message was not being used in the traditional ad hoc routing protocols and it was left for the future use. But in EG-RAODV , it uses extension field of RREQ message. By using the extension information in the RREQ message, intermediate nodes are able to forward the routing request to the next hop without broadcasting as MRJ is stored in the extension field.

Now, at each vehicle of the route, when an RREQ message is received, the information about from which vehicle it is heard is recorded and then, the RREQ message will be forwarded to the next hop based on the extension field's information. Here, intermediate vehicles are not allowed to send a routing reply message (RREP) back to the source vehicle, even if they have a valid route to the destination as the time domain is an important part in the routing process and because of the highly dynamic mobility of nodes , the reliability values at intermediate vehicles might be outdated means link reliability value for the particular node pair might be zero. So, when the RREQ arrives up to the destination vehicle, then only an RREP message will be sent back to the source vehicle to start data transfer.

III. CONCLUSION

Safety message are being distributed by VANET to all the vehicles to prevent collision. Because of the high mobility of the vehicles on the road, VANETs having highly dynamic topology. Hence, the communication links breaks more frequent as compared to other networks. So, to relay the safety message in the networks requires to have some reliable link on which message can be flooded. The traditional AODV routing protocol, create a new route on-demand when existing route fails. So there is higher possibility of losing the data packets and also it needs some significant amount of time to establish a new route as a new route is created by propagating the Route Request (RREQ) message procedure. So, there will be a significant time delay.

To avoid this, Prediction based routing (PBR) protocol has been proposed, it predict the lifetime of the links and it create a new route before the existing get breaks. So, Packet lost ratio, end-to-end delay and routing request ratio gets decreased. To improve the performance metrics, EG-RAODV protocol has been proposed. First, it finds the most reliable routes then data packets are being sent through that most reliable route. It gives the highest Packet Delivery Ratio in comparison with proactive , reactive and PBR routing protocols. It has the lowest routing request ratio as the broadcasting technique is not being needed in the route discovery process. In EG-RAODV , the choice of most reliable route to destination is made. So, as a result it gives the highest route lifetime, the lowest link failures and the lowest End to End delay. But there are certain limitations of EG-RAODV. The existing work does not consider the overhead caused by Bidirectional Traffic when every vehicle is Discovering/Building VoEG. And also this work has not addressed the Variable Velocity of Traffic.

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