International Journal For Technological Research In Engineering
Volume 1, Issue 5, January – 2014 *ISSN (Online): 2347 - 4718*

VOEG-A GRAPH BASED RELIABLE ROUTING SCHEME FOR VANET

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Abstract: **VANETs are a promising technology to enable communications among vehicles on roads. Recently, a graph theoretical model called evolving graph has been proposed to help capture the dynamic behavior of dynamic networks when mobility patterns are predictable. The conventional routing protocols proposed for mobile ad hoc networks (MANETs) work inadequately in VANETs. And as communication links break more frequently in VANETs compared to MANETs, it is required that the routing reliability of such highly dynamic networks needs to be paid special attention. The objective of this paper is to propose a novel evolving graph-based reliable routing scheme for VANETs. The novelty of this work lies in its unique design of a reliable routing protocol that considers the topological properties of the VANET communication graph using the extended evolving graph. Considering that vehicles travel at high speeds on highways, the data delivery service could have many disruptions due to frequent link breakages. The extended evolving graph helps capture the evolving characteristics of the vehicular network topology and determines the reliable routes preemptively. This is a novel work that proposes an evolving graph-based reliable routing scheme for VANETs to facilitate quality-of-service (QoS) support in the routing process. The new algorithm is developed to find the most reliable route in the VANET evolving graph from the source to the destination. The proposed scheme is analyzed through simulations in NS2 and proved to outperform the existing techniques available.**

I. INTRODUCTION

Recently, it has been widely accepted by the academic society and industry that the cooperation between vehicles and road transportation systems can significantly improve driver's safety and road efficiency and reduce environmental impact. Based on this the development of vehicular ad hoc networks (VANETs) has received more attention and research hard work. Much work has been conducted to provide a common platform to facilitate inter-vehicle communications (IVCs) [1]. IVC is necessary to realize traffic condition monitoring, dynamic route scheduling, emergency-message broadcasting and, most importantly, safe driving [2]. It is supposed that each vehicle has a wireless communication equipment to provide ad hoc network connectivity. The VANETs are considered as a special class of mobile ad hoc networks (MANETs), yet they have several key features distinguish them. Network nodes in VANETs are extremely mobile, thus the network topology is ever changing. Hence, the communication link condition between two vehicles suffers from fast variant, and it is prone to disconnection due to the vehicular movements and the unpredictable behavior of drivers. Fortunately, their mobility can be predictable along the road because it is subject to the traffic networks and its convention. VANETs have normally higher computational capability and higher transmission power than MANETs.
The graph theory can be utilized to help understand the topological properties of a VANET, where the vehicles and their communication links can be modeled as vertices and edges in the graph, respectively. Recently, a graph theoretical model called evolving graph [5], [6] has been proposed to help capture the dynamic behavior of dynamic networks when mobility patterns are predictable. This model has shown its promising results in MANETs and delay-tolerant networks [7], [8]. However, the current evolving graph theory can be only applied when the topology dynamics at different time intervals can be predicted; these are known as fixed scheduled dynamic networks (FSDNs). VANETs cannot be treated as FSDNs, and hence, the existing evolving graph theory cannot be directly applied to VANETs. Fortunately, the pattern of topology dynamics of VANETs can be estimated using the underlying road networks and the available vehicular information. Hence, we can categorize this type of dynamic network as a *predicted pattern dynamic network*. Consequently, the current evolving graphs theory could be extended to deal with VANETs.

The objective of this paper is to propose a novel evolving graph-based reliable r outing scheme for VANETs. The novelty of this work lies in its unique design of a reliable routing protocol that considers the topological properties of the VANET communication graph using the extended evolving graph. Considering that vehicles travel at high speeds on highways, the data delivery service could have many disruptions due to frequent link breakages. It is very important to ensure that the most reliable links are chosen when building a route. The major contributions of this paper are given here.

1) A new link reliability model based on the mathematical distribution of vehicular movements and velocities on the highway is developed.
2) The current evolving graph model is extended to capture

the evolving features of the VANET communication graph, and the link reliability metric is considered.
3) A reliable routing protocol is designed to benefit from the advantages of the extended evolving graph model to find the most reliable route without broadcasting the routing requests each time a new route is sought. This way, the routing overhead is significantly reduced, and the network resources are conserved.

In this paper, we assume that vehicles move at a constant velocity along the same direction on the highway and that the source vehicle has full knowledge of a VANET communication graph at any given time. Bidirectional traffic and variable vehicular velocities are left for future study.

II. RELATED WORK

In [9], the authors propose a velocity-aided routing protocol which determines its packet forwarding scheme based on the relative velocity between the forwarding node and the intention node. The region for packet forwarding is determined by predicting the future trajectory of the destination node based on its location information and velocity.

The authors in [13] introduced a prediction-based routing (PBR) protocol for VANETs. It is Specifically considered for the mobile gateway scenario and takes advantage of the predictable mobility pattern of vehicles on highways. PBR predicts way lifetimes and preemptively creates new routes before the existing routes fail. The link lifetime is predicted based on the range of contact, vehicles' location, and related velocities. Since a route is composed of one or more links, the route duration is the minimum of all its connect lifetimes. PBR allows the processing of multiple routing requests to check all the available routes to the target. If the source node receives various replies, then it uses the route that has the maximum predicted route lifetime.

The objective of [16] focuses on providing a thorough study of the topological characteristics and statistical features of a VANET communication graph. Specifically, answers are provided for some critical questions such as the following: How do VANET graphs evolve over time and space? What is the spatial allocation of these nodes? Which are the critical link duration statistics in a VANET when the vehicles move in urban areas? How robust is a VANET? The obtained results could have a wide range of implications for the development of high- performance, reliable, scalable, secure, and privacy preserving vehicular technologies.

In summary, no direct work has been done to design an evolving graph-based reliable routing scheme for VANETs on highways, which is the subject of this paper.

III. PROPOSED SCHEME

The current evolving graph theory cannot be directly applied to VANETs. We mentioned before that the evolving topological properties of the VANET communication graph are not scheduled in advance. Moreover, the current evolving graph model cannot consider the reliability of communication links among nodes.

Motivation

To fulfill VANETs' requirements, we extend the current evolving graph model. The extended version of the evolving graph model, called VoEG, is evolving based on the predicted dynamic patterns of vehicular traffic. These patterns are predicted based on the underlying road network and vehicular information. In addition, VoEG considers the reliability of communication links among vehicles. In the following, we briefly introduce the basis of the evolving graph theory and then extend the current evolving graph model to propose the VoEG model.

Evolving graph RAODV routing protocol

We proposed VoEG to model and formalize the VANET communication graph. For the purpose of routing data packets reliably in VANETs, we design a new routing

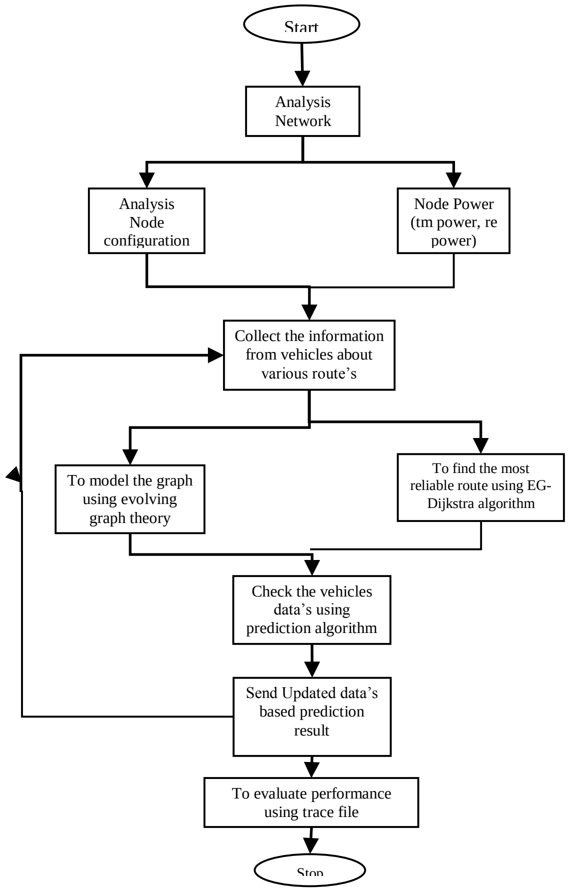

Figure 1.Working Flow Diagram

protocol that can benefit from the VoEG advantages and properties. The new routing protocol utilizes the VoEG model and considers the routing reliability constraint while searching for the route from the source to the destination. A new routing algorithm to find the MRJ is needed first. Then, this algorithm will be applied to design the route discovery process for our proposed EG-RAODV routing protocol. Note that AODV stands for the Ad hoc On-Demand Distance Vector routing protocol.

Route Discovery Process in 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. At this stage, the source vehicle knows the most reliable valid journey to the destination. It will create a routing request message (RREQ) and assign the hops of the MRJ as extensions to this RREQ. Note that this extension field in the RREQ is not used in the traditional ad hoc routing protocols and was left for future use. In EG-RAODV, by utilizing the extension information in the RREQ, intermediate nodes are able to forward the routing request to the next hop without broadcasting. At each vehicle along the route, when an RREQ is received, the information about from which vehicle it heard is recorded. Then, the RREQ will be forwarded to the next hop based on the extension's information. Intermediate vehicles are not allowed to send a routing reply message (RREP) to the source vehicle, even if they have a valid route to the destination. Since the time domain is incorporated in the routing process and the mobility of nodes is highly dynamic, the reliability values at intermediate vehicles might be outdated. An RREP will be sent back to the source vehicle to start data transfer.

Performance evaluation

The performance evaluation of the proposed scheme is analysed to prove the efficiency of the scheme. Packet receive ratio, Packet loss and energy ratio are some of the main parameters considered. The performance evolution can be calculated with different modes. The values can be calculated under various formats

Packet Receive Ratio

The packet receive ratio is one of the Quality of Service (QoS) metric to evaluate the performance of network.

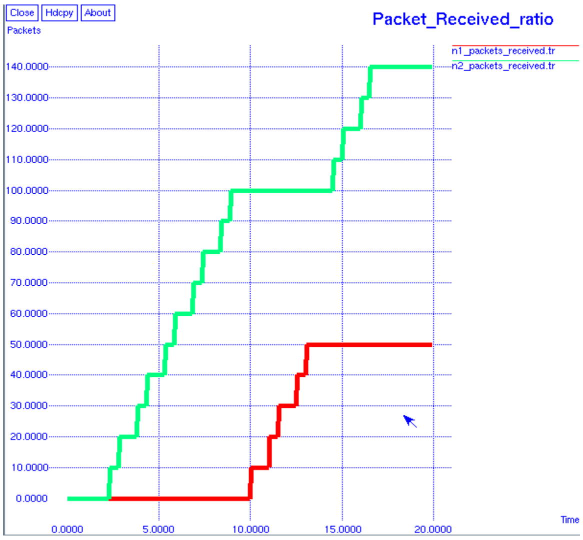

Figure 2. Packet Receive Ratio

Low packet receive ratio depletes the network performance. Figure.2 shows that the proposed system has a good packet receive ratio. The packet received ratio can be calculated for their higher ranges to manage. The packet received ratio can be differ from route 1 to route 2. It can be takes place using variety of tasks. The range of the system can be specified according to various modes to perform different actions.

Packet Loss Ratio

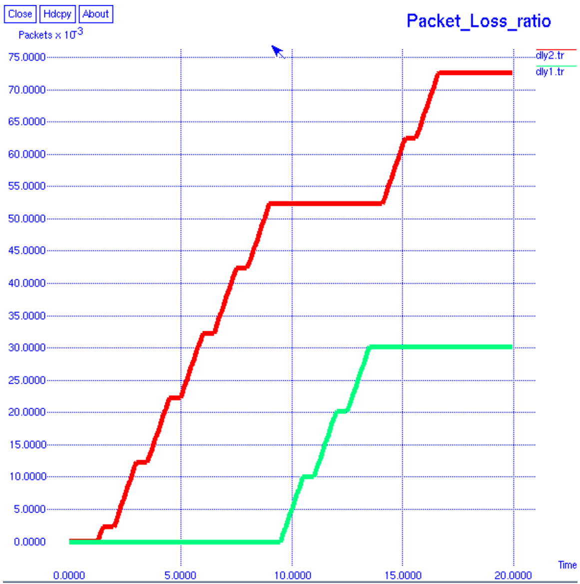

Figure 3. Packet Loss Ratio

The Packet Loss ratio is the maximum number of packets possible to be dropped by a node. Figure 3 shows that the packet loss is lesser for the proposed scheme.

Energy Ratio

The energy ratio gives the energy performance of the existing and proposed system.

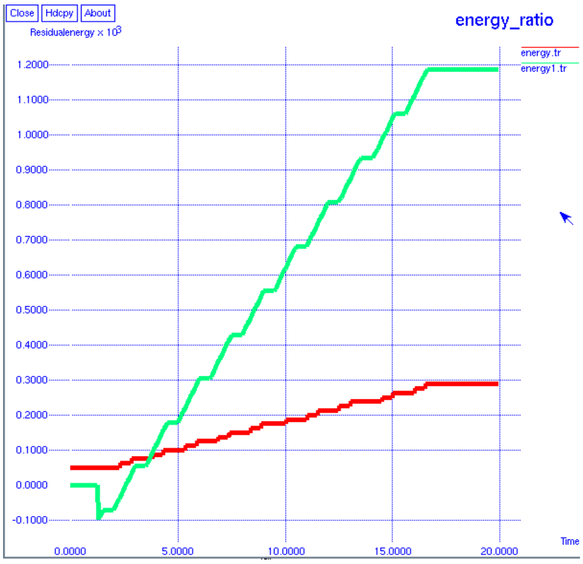

Figure 4. Energy Ratio

The energy performance of the proposed scheme is better as shown in Figure 4.

V. CONCLUSION

We have extended the evolving graph theory and proposed our VoEG model. A new EG-Dijkstra algorithm was developed to find the M RJ in the proposed VoEG. We designed and formalized our EG-RAO DV routing protocol to provide a reliability-based routing scheme for VANETs. The performance of EG-RAO DV has been compared with reactive, proactive, and PBR routing protocols using extensive simulations with different transmission data rates, data packet sizes, and vehicular velocities. The results showed that EGRAODV achieves the highest PDR among all the tested routing protocols. It obtains the lowest routing request ratio because the broadcasting technique is not needed in the route discovery process. As it chooses the most reliable route t o t he destination, it achieves the lowest number of link failures, the highest route lifetime, and the lowest average E2E delay values.

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