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AEGRP: AN ENHANCED GEOGRAPHICAL ROUTING PROTOCOL FOR VANET

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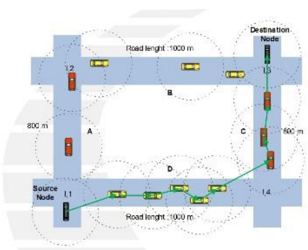
Graphical abstract



Abstract

Vehicular ad hoc network (VANET), is a derivative type of mobile ad hoc networks with its unique characteristics and an essential part of intelligent transportation system (ITS). In VANET, the vehicles can disseminate information to certain or all vehicles within a region for different applications. Applications can be categorized as safety, convenience and comfort of the driver and passengers such as traffic conditions, accident detection, roadway safety, mobile sensing, and infotainment. These promising applications require intelligent and efficient routing protocols, which are capable of adapting rapidly changing topologies, high mobility in the network. Geographic routing protocols have become a popular routing type because of its simplicity and low overhead features, but recent research has recognized these protocols are not considering many particular constraints of the vehicular environment. However, existing routing protocols offered limited performance due to frequent disconnectivity, high signal interference in the presence of obstacles and lead to network delay and overhead issues. The main objective of this paper is to design an enhanced geographical routing protocol that addresses the network delay problems and provide necessary improvements over conventional geographic routing in light of constraints of these environments.

Keywords: VANET, geographical, routing; mobility, urban

1.0 INTRODUCTION

Various forms of wireless technologies have been proposed for Intelligent Transportation Systems (ITS) such as sensor technologies, ad hoc communication, and computational technologies [1]. One of the most popular wireless communication technology is ad hoc networks and classified into two main sub-classes: mobile and vehicular ad hoc networks, but these classes are different with each other by characteristics and nature [2]. Vehicular ad hoc networks (VANETs) have unique features and make it different with traditional mobile ad hoc networks (MANET) such as high mobility, frequently changing topologies [3]. Most of the routing solutions have been proposed for MANET, but these solutions are not suitable for VANET because of its novel and different features. However, VANETs have received intensive attention due to the plethora of new possibilities and services offered for modern ITS systems and play a significant role in the evolution of wireless communication without any wire or cellular infrastructure [4]. These networks have self-repairing, auto-configuration capabilities and do not depend on centralized computers because all nodes have equal status in the network and freely communicate with each other's with IEEE 802.11 ad hoc mode of operation [5]. The VANET consists with mobile clients like sensors, vehicles nodes for forwarding the packets toward the destination and communicate via multi-hop wireless links. In VANET, the vehicles instinctively and wirelessly connect with other vehicles nearby. The vehicle nodes are operational by sensor based onboard units installed in cars and wirelessly connected with roadside units or with pedestrian personal devices or smartphones. The VANETs applications are divided into two main types: comfort and safety applications for drivers and passengers. These applications need smart and efficient routing strategies for in time data delivery to the destination. However, most of existing routing protocols are not feasible to deal with VANETs characteristics and have been suffered from different types of routing challenges such as network disconnectivity, packet delay and network overhead. In this context, we proposed an enhanced geographical routing protocol (AEGRP) for VANET urban environment in order to improve the network performance in terms of packet delivery ratio, routing overhead.

The rest of paper is organized as follows: Section 2 presents VANETs architectures and applications. In Section 3, most recent routing protocols in VANETs are discussed. Section 4, describes our proposed protocol design with an example. Simulation results are presented in Section 5. Finally, Section 6 concludes the paper and provide some insights on future trend.

2.0 VANET ARCHITECTURES & APPLICATIONS

The VANETs are divided into three main architecture types: cellular/WLAN, pure ad hoc, and hybrid. In cellular or Wide Local Area Networks (WLANs), the network has a permanent cellular gateway and WLAN-based access points or base stations, installed at junctions or the roadsides and connected to the internet for collecting the information from vehicle nodes. This type of network is called vehicle-to-infrastructure (V2I) [6] network, where services are available related to infotainment, web browsing, and parking information applications. However, this type of architecture has been suffered from fixed infrastructure deployment issues. Local area network (LAN) and dedicated short range communication (DSRC) are the most considered technologies in V2I communications, there are some other heterogeneous wireless technologies used in this architecture such as IEEE 802.11 and .16e, 3G, LTE and Advance LTE working [7].

The second type is pure ad hoc or vehicle-to-vehicle (V2V) network. In this type, the vehicle nodes are engaged with each other and establish the connections with each other and act like a router. Pure ad hoc networks are self-organized with limited communication range. This type of architecture is suitable for emergencies situations in spite of nonexistent infrastructure such as alerting the vehicles about the accident and assisting the police in tracing the criminals [8]. The third type is a combination of cellular and ad hoc network [9], where the wireless devices or vehicle nodes are communicating with each other and with infrastructure. The applications of the hybrid network are screening, security, and entertainment and offer richer contents and superior flexibility in content sharing.

The main system architecture components in VANET are application unit (AU), roadside unit (RSU), and on-board unit (OBU) using for wireless communication. The roadside unit is a service provider and an on-board unit is a service user. On board unit is a set of different sensors with short radio range installed in the vehicles for collecting and processing the data through Wireless Access in Vehicular Environments (WAVE) standard. The IEEE 802.11p standard is used for channel radio frequency for communication between OBUs and with RSUs. Another radio technology standard is IEEE 802.11a/b/g/n, used for infotainment applications. The main functions of the OBUs are providing wireless radio access, message delivery, security, and mobility for congestion control between vehicle and infrastructure. The system also carries the AU capable of connection establishment. The AU can be connected with the OBU with the wireless or wired connection. The AU is dedicated for safety applications and just like a normal device for instant Personal Digital Assistant (PDA) for the internet. The difference between OBUs and AU is logical because AU communicates with the network via OBU. The RSU is fixed along the roadside or any suitable place and provides short-range wireless communication for vehicles by using radio technology IEEE 802.11p. The function of RSU is redistributing the information between other RSUs and for other OBUs. The RSU is providing the internet connection to OBUs. The Figure 1, shows the three types of VANET architectures.

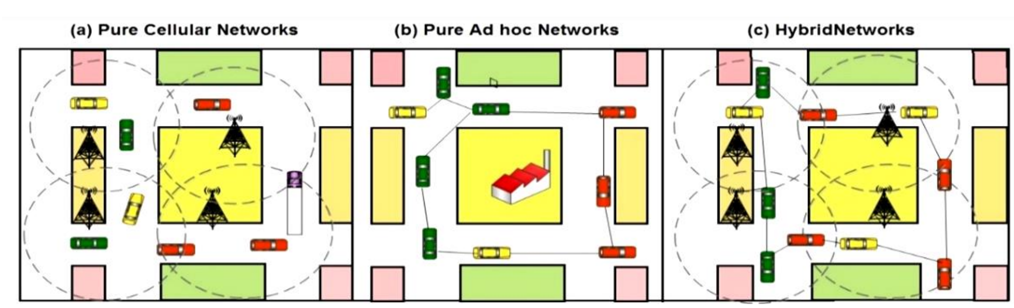


Figure 1 Three types of architectures of VANET: (a) Pure Cellular /WLAN Networks, (b) Pure Ad-hoc Networks, (c) Hybrid Architecture.

VANETs applications are classified according to their purpose such as safety applications, comfort/entertainment applications. The safety applications are referred to improve the road safety and avoid the risk of car accident, pre-crash collision, etc. These types of applications are real time and rely on one-hop broadcasting and multi-hop V2V and V2I communication. The comfort applications aim to provide comfort and infotainment services to drivers and travelers and enhance the traffic efficiency. These applications have very different communication requirements. These applications are used for play online games, internet, instant messaging, etc. [10, 11]. The Figure 2, shows the VANET applications.

3.0 RELATED WORK

History of VANET routing protocols started from MANET protocols [12]. However, VANET requires a new kind of routing protocols for maximizing throughput, control overhead and minimize packet loss. There is a need and challenge for researchers to design competent routing protocols for dynamic and unpredictable VANET network. The nodes in VANET are dynamic in nature and it is a challenge for nodes to find and maintain routes. The routing strategies have been defined based on architecture and need of applications or scenarios. The first scenario is communication between one vehicle node to another vehicle (V2V), and the second type is communication between vehicles to infrastructure (V2I). Further protocols are distinguished based on applications and suitable area. All MANET protocols are not useful in VANET but various types of protocols used in VANET [13]. In this section, we discuss some popular geographical based routing protocols.

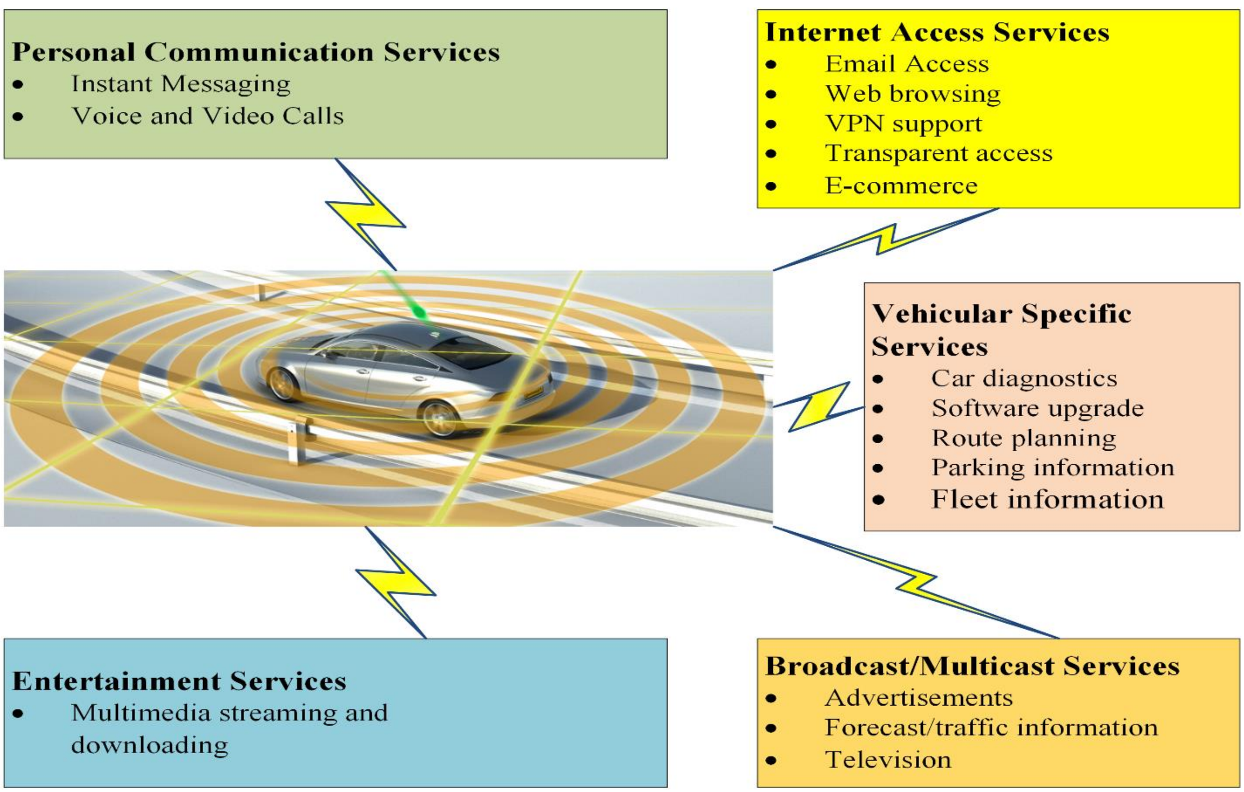


Figure 2 VANET applications

1) Grid-based Predictive Geographical Routing (GPGR)

The protocol GPGR was proposed in [14], based on grid predictive approach, where it makes road grids for the path movement and forecast the precise movement position along the road grids. The protocol considers the road topology information, which offers through the static street map. Then starts the process of packet forwarding with the help of vehicle position, movement, velocity, position and road topology information between vehicles and this approach improves the routing in Inter-Vehicular Communication (IVC). The protocol assumes that vehicle knows its location by Global Positioning System (GPS). GPS is the most correlated geographical system, which provides street map and vehicles locations. The GPGR generates a road grid and predicts the moving position for relay node selection. Due to the dynamic changing topology of VANET, the prediction of moving position of relay node leads to delay the decision and in some cases not suitable due to the congested urban environment.

2) Diagonal Intersection-based Routing (DIR)

The DIR protocol was proposed in [15] based on the enhancement of Connectivity-Aware Routing (CAR) protocol. The protocol creates a sequence of diagonal intersections between sender and target node. The protocol depends on the geographical information for advances the data packet towards the diagonal intersections until the last diagonal joint geographically reached to the destination. The auto-adjustability is one of the efficient feature of the protocol and attained when each path dynamically selected with consideration of the data packet delay. The selected sub-path with lowest delay automatically reroute the route. Because of this the data packet delay is reduced. DIR protocol efficiency is greater in terms of throughput, data packet delay and packet delivery ratio. It is best for real-time applications such as video streaming, video advertisement, and online games. However, protocol always selects unnecessary nodes as an anchor and cannot adjust with different sup-path when traffic environment changes.

3) Border Node-based Most Forward within Radius (B-MFR)

Border Node-based Most Forward within Radius (B-MFR) protocol was proposed in [16], based on border nodes with maximum projection. The protocol selects the border node within the sender transmission range and minimizes the number of vehicle nodes between source and destination. The protocol categorized vehicle nodes into three classifications: interior, border, and outer nodes. The interior nodes are neighbor's node inside the circle range and the border nodes are near with the edge of circle range and the outer node is outside the range. The source vehicle node beacon the packets to its neighbors for getting the information. The nodes, which are within the range of source nodes called the one-hop neighbor, the source node finds the list of one-hop nodes information and then selects the next forwarding node. Then, B-FMR selects the border node for forwarding the packet because it is farthest from the source and nearest from the destination node. The packet sent to best movement border node between source and destination projected on the line drawn from the source to destination. The vehicular urban environment is not constant and changing rapidly and sometimes the roads are more dense and sparse. To categorize the nodes into different types, protocol takes a long time and lead to packet delay in the network especially when the environment is opposite to protocol ideal situation.

3.1 AEGRP Protocol

The main idea of AEGRP is select an ideal route based on road segments. The only vehicle position information is not sufficient for routing decisions due to different types of obstacles in urban environment. The proposed protocol selects the road segments with some parameters such as road lengths, vehicle velocities, distance and traffic densities. The every packet can compute and select the ideal route to deliver the packets with road segments parameters. If the source node finds two routes, then it will check the network transmission quality with vehicles densities for ideal route to forward the packets. This process will continue till finding the destination node. First we discuss how these parameters selected for find an ideal route for packet forwarding.

The protocol calculates the road lengths, vehicle velocities and distance with road densities for routing decision. When the source node sends the packet to the destination, it will broadcast route request packet to its neighbors for check the distance and vehicle velocities. The request packet contains the road length information, number of lanes, the number of the intersection, etc. In addition, the protocol selects a far node with high-speed compared to the near node with slow speed. Again this process will continue until find the destination in the network. This information retrieved from preloaded map in GPS. The traffic density estimated through on the fly density collection scheme proposed in [17]. When the destination node receives the first request packet from source node it sends back a reply to source and then source node starts to send the packets.

In geographically based routing protocols, the hello or beacon messages are broadcasted and contain the source and destination locations, due to this process information is outdated and effected on the network. AEGRP uses neighbor location prediction, where source node predicts the neighbor location based on their own position, vehicle velocity and distance information, which is broadcasted in the last time interval. If the node cannot find neighbor node then node carry and forward the packet until finding the optimal neighbour. The first priority is road length; if road length is lower but the road density is high then protocol go with density because of transmission quality. If road densities are same then protocol selects less length road segment. The velocities of vehicle nodes also compute with density. Normally in urban areas the vehicle velocities are same because of density and traffic lights but in case of night time when density is low this parameters will more efficient to select the route with high velocities. The complete procedure of proposed routing protocol shows in Figure 3.

In Figure 3, the source node first checks roads lengths which are already available in the pre-loaded map. After checking the roads lengths, the road A length is shorter with the length of 800m. Then checks traffic density through beaconing messages and selects road D with the length of 1000m because of transmission quality, then check vehicle velocities and distance, if velocities have less difference compared to other roads then uses traffic density parameter to select the route. In the case of night time, usually traffic density is low, protocol computes vehicle velocities and distance for routing decisions. At an intersection I, 4 the road C will select because it is toward the destination.

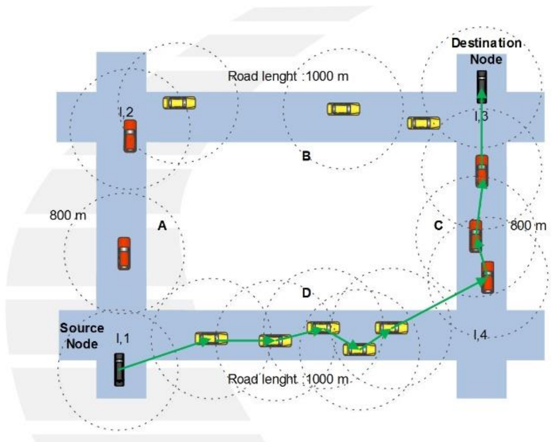


Figure 3 Route selection of proposed protocol

After this, the vehicle node relays messages with the same procedure and to find the destination node. The source and destination node locations already store in the packet header. The selected route is road D and road C instead of A and B.

4.0 SIMULATION RESULTS

The proposed routing protocol simulated in NS2 (ns-2.33) with the help of mobility generator MOVE to make complex vehicle movement. The simulation area was set 2000 * 2000 square meters. The total number of intersections are four (I1, I2, I3, I4) with four routes A, B, C and D. The number of vehicles are varied with 200 transmission range. The simulation time was 900 seconds. The four metrics are used to evaluate the proposed protocol, packet delivery ratio, protocol overhead and packet delay. The proposed protocol compared with GPGR, DIR, and B-MFR because these protocols are geographical based and work with map information. Details of simulation parameters are listed in Table 1.

In the first experiment, we simulated the packet delivery ratio of received numbers of packets at the destination and divided by the total number of packets sent into the network. Figure 4 shows the proposed routing protocol highest data delivery ratio (above 90%). This is because of protocol strategy and selects the route Source, D, C, and destination. As shown in Fig 4, GPGR and B-MFR give second and third highest data delivery ratios, respectively.

Table 1 Simulation parameters

S/No	Parameters	Value
1	Simulation Area	2000 * 2000
2	Number of Lanes	2 Lanes per direction
3	Number of nodes	20-30
4	Vehicle Speed	20-40 miles/hour
5	Packet Size	512 Bytes
6	Buffer Size	64 KB
7	Transmission Range	200

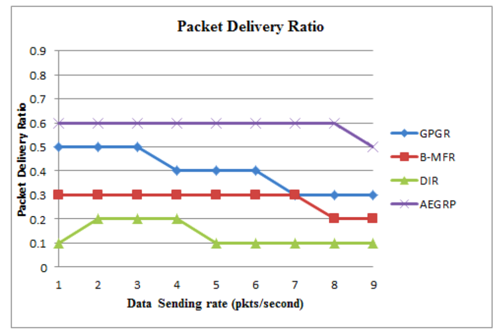


Figure 4 Packet delivery ratio

The second result is based on protocol routing overhead and results clearly shows that an enhanced geographical routing protocol is better compared with other protocols and the GPGR and DIR are the second and third better in routing overhead. The B-MFR protocol is not efficient in the term of routing overhead.

The last graph Figure 6 shows the packet delay in the network, the proposed routing protocols performance is better in terms of packet delay compared with state of the art routing protocols. Another positive point is the stability of proposed AEGRP protocol compared with DIR, GPGR, and GPGR. The Figure 6, shows the evaluation of AEGRP with DIR, B-MFR, and GPGR with different nodes, speed and time. The results clearly show that performance of proposed routing protocol is greater than previous protocols. AEGRP is better in terms of packet delivery ratio, routing overhead and packet delay.

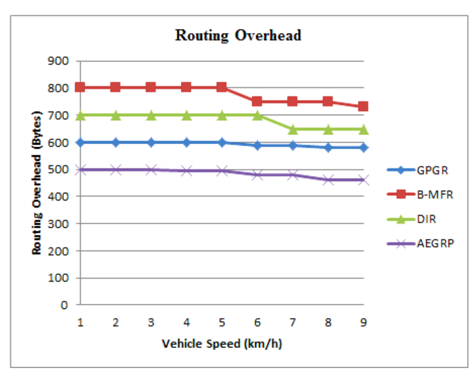


Figure 5 Routing overhead

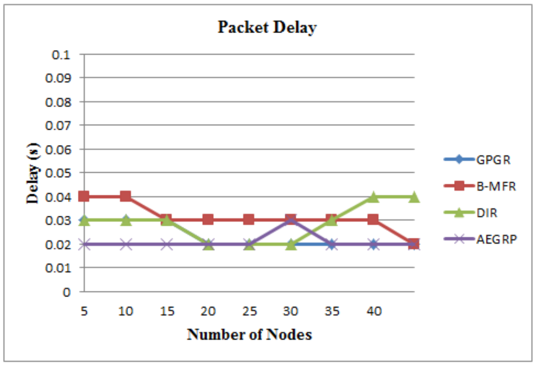


Figure 6 Packet delay

5.0 CONCLUSION

In this paper, a novel geographical routing protocol AEGRP (An enhanced Geographical Routing Protocol) is proposed for the urban environment. The simulation results showed the better packet delivery ratio with higher number of successfully delivered packets, little routing overhead and reasonable packet delay. In future, we will consider this protocol performance in night time when the density of traffic is low and no one follow the traffic lights.

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