Efficient Routing Protocols For Vehicular Adhoc Network

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Abstract

Vehicular Ad Hoc Network (VANET) is an emerging new technology integrating ad hoc network ,wireless LAN (WLAN) and cellular technology to achieve intelligent inter-vehicle communications and improve road traffic safety and efficiency. .In these networks, vehicles communicate with each other and possibly with a roadside infrastructure to provide a long list of applications varying from transit safety to driver assistance and Internet access. In these networks, knowledge of the real-time position of nodes is an assumption made by most protocols, algorithms, and applications .VANETs are distinguished from other kinds of ad hoc networks by their hybrid network architectures, node movement characteristics, and new application scenarios. Therefore, VANETs pose many unique networking research challenges, and the design of an efficient routing protocol for VANETs is very crucial. In this article, we discuss the research challenge of routing in VANETs and survey recent routing protocols for VANETs. Vehicular ad hoc networks have been envisioned to be useful in road safety and many commercial applications ,

Keywords

Vehicular Ad Hoc Networks (VANET), Mobile AdHoc Networks (MANET), Routing Protocols,

1. "Introduction"

Vehicular Ad hoc Networks (VANETs) are a compelling application of ad hoc networks, because of the potential to access specific context information (e.g. traffic conditions, service updates, route planning) and deliver multimedia services (VOIP, in-car ntertainment, instant messaging, etc.).Vehicular Ad Hoc Network (VANET) is the most important component of Intelligent Transportation System (ITS) [5], in which vehicles are equipped with some short-range and medium-range wireless communication. ITS is the major application of VANETs. VANET provide ubiquitous connectivity while on the road to mobile users, and efficient vehicle-to-vehicle communications that enable the intelligent transportation systems (ITS) [5]. ITS includes a variety of applications such as co-operative traffic monitoring, control of traffic flows, blind crossing, prevention of collisions, nearby information services, and real-time detour routes computation[6],[2]. A Mobile Ad-hoc Network (MANET) is comprised of a group of mobile nodes, which have the capability of self-organization in a decentralized fashion and without fixed infrastructure. VANETs are special case of MANETs. The key differences as compared to MANET environment are following: 1) Restricted mobility constraints 2) Extremely high mobility and time-varying vehicle traffic density 3) Most of the vehicles provide sufficient computational and power resources, thus eliminating the need for introducing complicated energy-aware algorithms. 4) Vehicles will not be affected by the addition of extra weight for antennas and additional hardware. Some parameters that have to be mainly concentrated in VANETs for protocol design are extremely high mobility, restricted movements, fast topology changes and time varying vehicle traffic density.VANET raises several interesting issues with regard to Media access control (MAC), Mobility management, Data aggregation, Data validation, Data dissemination, Routing, Network Congestion, Performance analysis, Privacy and Security [2].

2. "Vehicular Networks"

The entities that are part of a vehicular communications system are private and public vehicles, road-side infrastructure, and authorities, with the latter considered primarily as network entities. An authority will be responsible for the identity and credential management for all vehicles registered in its region (e.g., national territory, state, canton, metropolitan area), similarly to what is currently the case. Public vehicles (e.g. police cars) may have specific roles and be considered as mobile infrastructure[8]. Vehicular networking protocols will require nodes, that is, vehicles or road-side infrastructure units, to communicate directly when in range, or in general across multiple wireless links (

hops). Nodes will act both as end points and routers, since vehicle-to-vehicle communication can often be the only way to realize safety and driving assistance applications, while the deployment of an omnipresent infrastructure can be impractical and too costly. In fact, vehicular networks are emerging as the first commercial instantiation of the mobile ad hoc networking (MANET) technology.

"Figure 1. Vehicular Network"

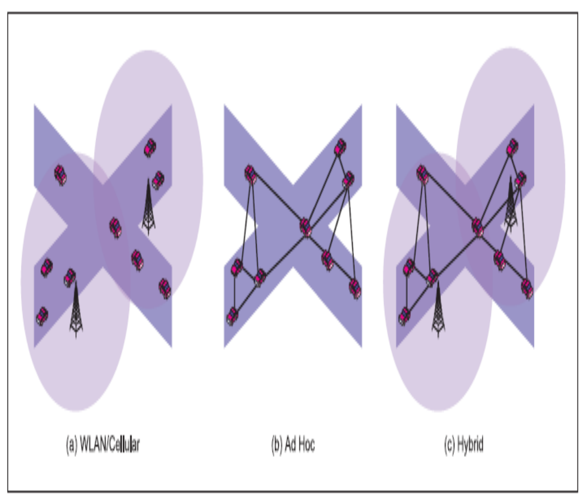
VANETs are an instantiation of mobile ad hoc networks (MANETs). MANETs have no fixed infrastructure and instead rely on ordinary nodes to perform routing of messages and network management functions. VANET will enable both vehicle-to-vehicle and vehicle-to roadside communications. Vehicular ad hoc networks (VANET) [18] are envisioned to support a variety of applications for safety, traffic efficiency and driver assistance, and infotainment. For example, warnings on environmental hazards (e.g., ice on the pavement) or abrupt vehicle kinetic changes (e.g., emergency braking), traffic and road conditions (e.g., congestion
or construction sites), and tourist information downloads will be provided by such systems .
VANETs comprise of radio-enabled vehicles which act as mobile nodes as well as routers for other nodes[3]. In addition to the similarities to ad hoc networks, such as short radio transmission range, self-organization and self management, and low bandwidth, VANETs can be distinguished from other kinds of ad hoc networks as follows:

■ **Geographical type of communication.**
Compared to other networks that use unicast or multicast where the communication end points are defined by ID or group ID, the VANETs often have a new type of communication which addresses geographical areas where packets need to be forwarded (*e.g.*, in safety driving applications).

■ **Mobility modeling and predication.**
Due to highly mobile node movement and dynamic topology, mobility model and predication play an important role in network protocol design for VANETs [4]. Moreover, vehicular nodes are usually constrained by prebuilt highways, roads and streets, so given the speed and the street map, the future position of the vehicle can be predicated.

■ **Various communications environments.**
VANETs are usually operated in two typical communications environments. In highway traffic scenarios, the environment is relatively simple and straightforward (*e.g.*, constrained one-dimensional movement); while in city conditions it becomes much more complex. The streets in a city are often separated by buildings, trees and other obstacles. Therefore, there isn't always a direct line of communications in the direction of intended data communication.

■ **Interaction with on-board sensors.**
It is assumed that the nodes are equipped with on-board sensors to provide information which can be used to form communication links and for routing purposes. For example, GPS receivers are increasingly becoming common in cars which help to provide location information for routing purposes. It is assumed that the nodes are equipped with on-board sensors to provide information which can be used to form communication links and for routing purposes [3]. For example, GPS receivers are increasingly becoming common in cars which help to provide location information for routing purposes.



"Figure 2. Possible network architecture for VANET"

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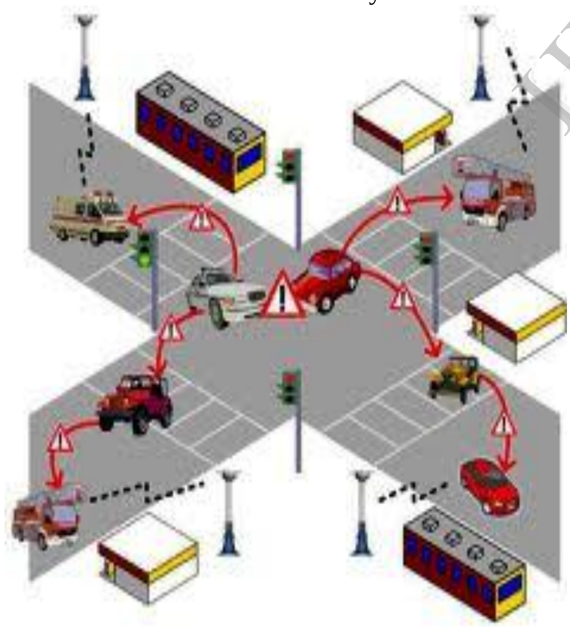
VANETs may use fixed cellular gateways and WLAN access points at traffic intersections to connect to the Internet, gather traffic information or for routing purposes. The network architecture under this scenario is a pure cellular or WLAN structure as shown in Figure 2(a). Stationary or fixed gateways around the sides of roads could provide connectivity to mobile nodes (vehicles‡) but are eventually unfeasible considering the infrastructure costs involved. In such a scenario, all vehicles and roadside wireless devices can form a mobile ad hoc network (Figure 2(b)) to perform vehicle-to-vehicle communications and achieve certain goals, such as blind crossing (acrossing without light control). A hybrid architecture (Figure 2(c)) of combining cellular, WLAN and ad hoc networks together has also been a possible solution for VANETs [1].

3 . "VASNET Topology"

VASNET inherits its characteristics from both Wireless Sensor Networks (WSN) and Vehicular AdHoc Networks (VANET) [11]. The necessity of designing a new architecture to overcome the mentioned challenges is transpicuous. In this paper, we propose a novel topology, which can be a suitable solution to overcome VANET issues. VASNET is a fusion of WSNs and MANET, which can be divided in to three layers.



"Figure 3. VASNET Topology"

The upper layer consisting of traffic monitor stations, e.g. traffic police located at the cities. These are connected by either fiber optic cables to form the backbone of traffic information network [12],[7]. The middle layer is region layer, consisting of traffic check post located through highways. These stations can be connected via the Internet or local networks, and finally the lower layer is the field layer, consisting of WSN nodes deployed on beside the highway and onboard sensors which are carried by the vehicles. These nodes are connected by short-range or medium-range wireless communication. The components are as follows:

(1) Vehicular Sensor Nodes; which are carried by the vehicles. These nodes are supposed to sense the real phenomena e.g. the velocity of the vehicle [3]. The sensor readings are to be sent to the base stations via RSS nodes. These nodes can communicate with each other or the roadside sensor via short-range communication.

(2) Road Side Sensors (RSS); are deployed in a fixed distance beside the road. RSSs act as cluster heads for vehicular nodes. RSS nodes receive the data from mobile nodes and retransmit towards the BSs. These nodes are equipped with two kinds of antenna, unidirectional and bidirectional. Unidirectional antenna is for broadcasting and directional antenna are intended for geo-casting [7], [11]. We need to satisfy the following requirements for deploying the sensor nodes on a road side, such as;

a) High reliability,
b) Long time service and
c) High real time.

(3) Base Station (BS); are Police Traffic Control Check-Post, Rescue Team Buildings or Fire Fighting Stations in some fixed point trough the roads. We can have mobile BS like, Traffic Police patrolling team, Firefighting Truck, or ambulance. After the deployment of various vehicular technologies, such as toll collection or active road-signs, vehicular communication (VC) systems have emerged [15]. They comprise network nodes, that is, vehicles and road-side infrastructure units (RSUs), equipped with on-board sensory, processing, and wireless communication modules. Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure [17] (V2I) communication can enable a range of applications to enhance transportation safety and efficiency, as well as infotainment. For example, they can send warnings about environmental hazards (e.g., ice on the pavement), traffic and road conditions (e.g., emergency braking, congestion, or construction sites), and local (e.g., tourist) information. The unique features of VC are a double-edged sword: a rich set of tools will be available, but a formidable set of abuses and attacks becomes possible.

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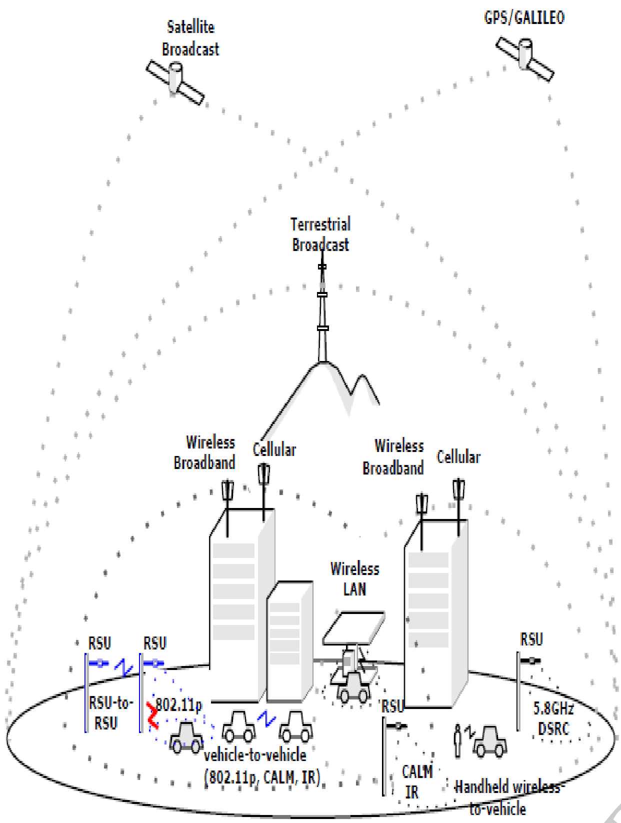


"Figure 4. Vehicular Communication System"

4. "Routing Protocols"

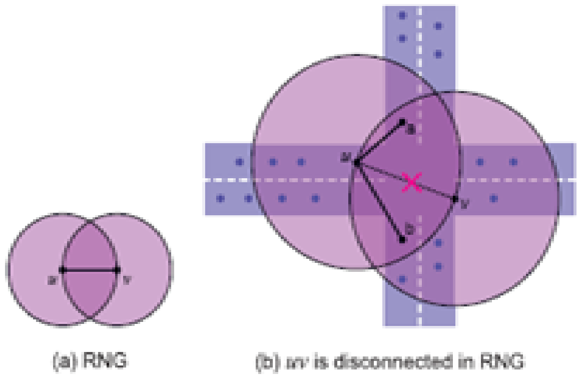
Because of the dynamic nature of the mobile nodes in the network, finding and maintaining routes is very challenging in VANETs. Routing in VANETs (with pure ad hoc architectures) has been studied recently and many different protocols were proposed [5], [9], [16]. We classify them into five categories as follows: ad hoc, position-based, cluster based, broadcast, and geocast routing.

4.1 "Ad Hoc Routing"

VANET and MANET share the same principle: not relying on fixed infrastructure for communication, and have many similarities, *e.g.*, self-organization, self-management, low bandwidth and short radio transmission range. Thus, most ad hoc routing protocols are still applicable, such as AODV (Ad-hoc On-demand Distance Vector) [3] and DSR (Dynamic Source Routing) [4], [18].AODV and DSR are designed for general purpose mobile ad hoc networks and do not maintain routes unless they are needed. Hence, they can reduce overhead, especially in scenarios with a small number of network flows. However, VANET differs from MANET by its highly dynamic topology. A number of studies have been done to simulate and compare the performance of routing protocols in various traffic conditions in VANETs [1], [5]. The simulation results showed that most ad hoc routing protocols (*e.g.*, AODV and DSR) suffer from highly dynamic nature of node mobility because they tend to have poor route convergence and low communication throughput.

4.2 "Position-Based Routing"

Position-based routing bases forwarding decisions on position information. Thus, there are several requirements on the availability of position information: first of all, position-based routing requires position-awareness of all participating nodes. Node movement in VANETs is usually restricted in just bidirectional movements constrained along roads and streets. So routing strategies that use geographical location information obtained from street maps, traffic models or even more prevalent navigational systems on-board the vehicles make sense. This fact receives support from a number of studies that compare the performance of topology-based routing (such as AODV and DSR) [18] against position-based routing strategies in urban as well highway traffic scenarios Therefore, geographic routing (position-based routing) has been identified as a more promising routing paradigm for VANETs. Most position based routing algorithms base forwarding decisions on location information. For example, greedy routing always forwards the packet to the node that is geographically closest to the destination. GPSR (Greedy Perimeter Stateless Routing) [16], [13], [4] is one of the best known position-based protocols in literature. It combined the greedy routing with face routing by using face routing to get out of the local minimum where greedy fails. It works best in a free open space scenario with evenly distributed nodes. GPSR is used to perform simulations in [9] and its results were compared to DSR in a highway scenario. It is argued that geographic routing achieves better results because there are fewer obstacles compared to city conditions and is fairly suited to network requirements. However, when applied it to city scenarios for VANETs [5], [9] GPSR suffers from several problems. First, in city scenarios, greedy forwarding is often restricted because direct communications between nodes may not exist due to obstacles such as buildings and trees. Second, if apply first the planarized graph to build the routing topology and then run greedy or face routing on it, the routing performance will degrade, *i.e.*, packets need to travel a longer path with higher delays. Figure 5 is an example of disconnected VANET due to the first phase of planarization in GPSR. Third, mobility can also induce routing loops for face routing, and last, sometimes packets may get forwarded to the wrong direction leading higher delays or even network partitions.

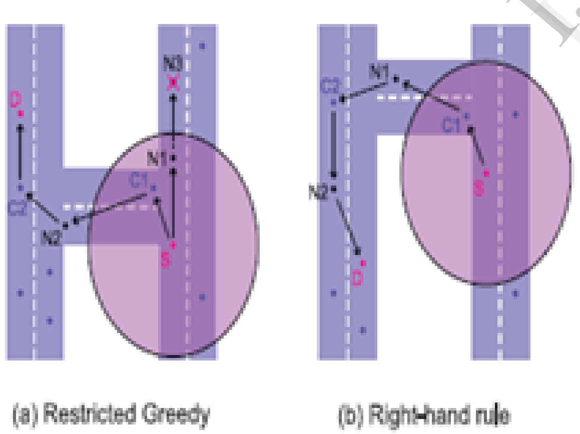


“Figure 5.Example of GPSR’s failure”

(a) The relative neighborhood graph (RNG) is a planar topology used by GPSR, which consists a link uv if the intersection of two circles centered at u and v with radius _uv _ (shaded area) does not contain any other nodes

.

(b) In GPSR, link uv is removed by RNG since nodes a and b are inside the intersection of two circles centered at u and v. However, due to obstacles (such as buildings), there is no direct link ua or ub. Thus the network is disconnected between u and v which causes GPSR’s failure.



“Figure 6. (a) Restricted greedy routing in the area of a junction (b) Right-hand rule”

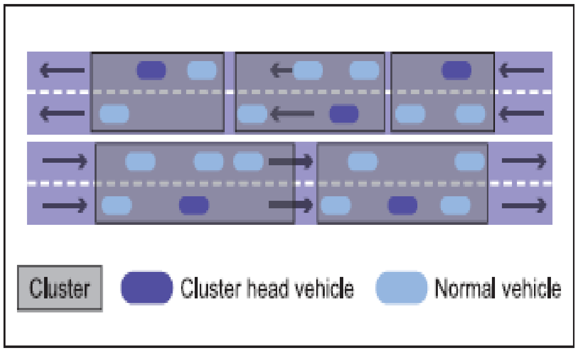
Source S wants to forward the packet to the destination D. If a regular greedy forwarding is used, the packet will be forwarded beyond the junction (Coordinator C1) to N1, then it will be lead to a local minimum at N3. But by forwarding the packet to coordinator C1, an alternative path to the destination can be found without getting stuck in a local minimum. Right-hand rule is used to decide which street the packet should follow in the repair strategy of GPCR. Node S is the local minimum since no other nodes is closer to the destination D than itself. The packet is routed to the first coordinator C1. Node C1 receives the packet and decides which street the packet should follow by the right-hand rule. It chooses the street that is the next one counter-clock wise from the street the packet has arrived on. The packet is forwarded to the next coordinator C2 through the intermediate node N1 along the street. Then the coordinator C2 decides to forward the packet to node N2. At this moment, the distance from N2 to D is closer than at the beginning of the repair strategy at node S. Hence GPCR is switched back to modified greedy routing. The packet reaches D [5].

4.3 “Geographic Source Routing”

(GSR) that assumes the aid of a street map in city environments. GSR essentially uses a Reactive Location Service (RLS) to get the destination position. The algorithm needs global knowledge of the city topology as it is provided by a static street map. Given this information, the sender determines the junctions that have to be traversed by the packet using the Dijkstra’s shortest path algorithm. Forwarding between junctions is then done in a position-based fashion. By combining the geographic routing and topological knowledge from street maps, GSR proposes a promising routing strategy for VANETs in city environments [6],[9]. The simulation results demonstrate that GSR has better average delivery rate, smaller total bandwidth consumption, similar latency of first delivered packet with DSR and AODV

4.4 “Cluster-Based Routing”

In cluster-based routing, a virtual network infrastructure must be created through the clustering of nodes in order to provide scalability. See Figure 4 for an illustration in VANETs. Each cluster can have a cluster head, which is responsible for intra- and inter-cluster coordination in the network management functions. Nodes inside a cluster communicate via direct links. Inter-cluster communication is performed via the cluster-heads. The creation of a virtual network infrastructure is crucial for the scalability of media access protocols, routing protocols, and the security infrastructure. The stable clustering of nodes is the key to create this infrastructure [9]. However, VANETs behave in different ways than the models that predominate in MANETs research, due to driver behavior, constraints on mobility, and high speeds. Consequently, current MANETs clustering techniques are unstable in vehicular networks. The clusters created by these techniques are too short-lived to provide scalability with low communications overhead.

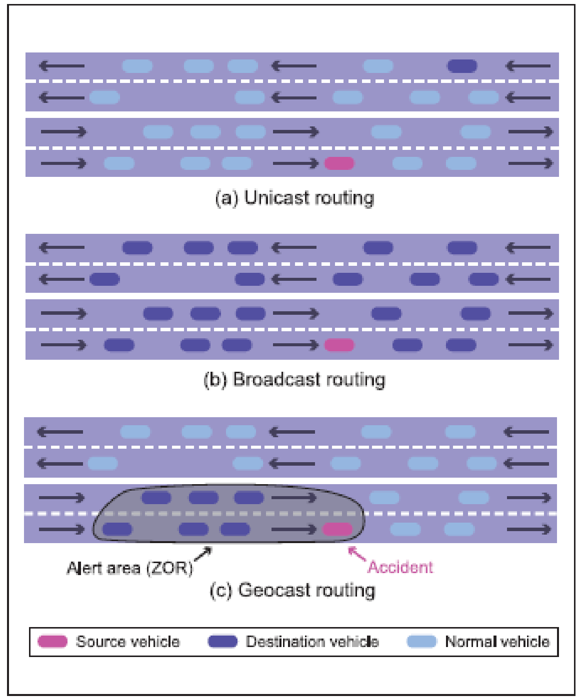


"Figure 4. Vehicles form multiple clusters in cluster-based routing"

Cluster-based method has also been used in data insemination and information propagation for VANETs, such as in [10] the cluster-based message dissemination method using opportunistic forwarding.Cluster-based routing protocols can achieve good scalability for large networks, but a significant hurdle for them in fast-changing VANET systems is the delay and overhead involved in forming and maintaining these clusters.

4.5 "Broadcast Routing"

Broadcast is a frequently used routing method in VANETs, such as sharing traffic, weather, emergency, road condition among vehicles, and delivering advertisements and announcements. Broadcast is also used in unicast routing protocols (routing discovery phase) to find an efficient route to the destination. When the message needs to be disseminated to the vehicles beyond the transmission range, multi-hop is used. The simplest way to implement a broadcast service is flooding in which each node re-broadcasts messages to all of its neighbors except the one it got this message from. Flooding guarantees the message will eventually reach all nodes in the network [9], [14]. Flooding performs relatively well for a limited small number of nodes and is easy to be implemented. But when the number of nodes in the network increases, the performance drops quickly. The bandwidth requested for one broadcast message transmission can increase exponentially. As each node receives and broadcasts the message almost at the same time, this causes contentions and collisions, broadcast storms and high bandwidth consumption. Flooding may have a very significant overhead and selective forwarding can be used to avoid network congestion.



"Figure 5. Different communication scenarios in VANETs"

An emergency broadcast protocol, BROADCOMM, based on a hierarchical structure for a highway network. In BROADCOMM, [7] the highway is divided into virtual cells, which moves as the vehicles move. The nodes in the highway are organized into two level of hierarchy: the first level includes all the nodes in a cell; the second level is represented by the cell reflectors, which are a few nodes usually located closed to the geographical center of the cell [9],[11]. Cell reflector behaves for a certain time interval as a base station (cluster head) that will handle the emergency messages coming from members of the same cell, or close members from neighbor cells. Besides that, the cell reflector serves as an intermediate node in the routing of emergency messages coming from its neighbor cell reflectors and decides which will be the first to be forwarded. This protocol outperforms similar flooding based routing protocols in the message broadcasting delay and routing overhead. However, it is very simple and only works with simple highway networks.

4.6 "Geocast Routing"

Geocast routing [8] is basically a location-based multicast routing. The objective of a geocast routing is to deliver the packet from a source node to all other nodes with a specified geographical region (Zone of Relevance, ZOR).Many VANET applications will benefit from geocast routing. For example, a vehicle identifies itself as crashed by vehicular sensors that detect events like airbag ignition, then it can report the accident instantly to nearby vehicles. Vehicles outside the ZOR are not alerted to avoid unnecessary and hasty reactions. In this kind of scenarios, the source node usually inside the ZOR. See Figure 5 for an illustration of difference among unicast, broadcast and geocast in VANETs. Geocast can be implemented with a multicast service by simply defining the multicast group to be the certain geographic region. Most geocast routing methods are based on directed flooding, which tries to limit the message overhead and network congestion of simple flooding by defining a forwarding zone and restricting the flooding inside it. Non-flooding approaches (based on unicast routing) are also proposed, but inside the destination region, regional flooding may still be used even for protocols characterized as non-flooding. geocast scheme is proposed to avoid packet collisions and reduce the number of rebroadcasts[13],[8].When a node receives a packet, it does not rebroadcast it immediately but has to wait some waiting time to make a decision about rebroadcast. The waiting time depends on the distance of this node to the sender. The waiting time is shorter for more distant receiver. Thus mainly nodes at the border of the reception area take part in forwarding the packet quickly. When this waiting time expires, if it does not receive the same message from another node then it will rebroadcast this message. By this way, a broadcast storm is avoided and the forwarding is optimized around the initiating vehicle.

5. " Conclusion And Future Work"

In this article, we discuss the challenges of designing
routing protocols in VANETs and survey several routing protocols recently proposed for VANETs & summarizes characteristics of these routing protocols (*i.e.* what are their routing types, whether and how they use position information, and whether they have hierarchical structures) and how they are evaluated (*i.e.*, simulators and simulation scenarios). In general, position-based routing and geocasting are more promising than other routing protocols for VANETs because of the geographical constrains. However, the performance of a routing protocol in VANETs depends heavily on the mobility model, the driving environment, the vehicular density, and many other facts. Even though routing in VANETs has received more and more attention in the wireless network community recently as a relatively new area, there are still quite a few challenges that have not been carefully investigated. There is a good future for applications of VANET, ranging from diagnostic, safety tools, information services, and traffic monitoring and management to in-car digital entertainment and business services. However, for these applications to become everyday reality, an array of technological challenges needs to be addressed.

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