Impact of routing protocol on performance of wireless ad hoc vehicular 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. 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 paper, we discuss the impact of routing protocol on performance of wireless ad hoc vehicular network along with recent routing protocols. Ad hoc network characteristics are explained in brief. We propose a routing framework based on the enhanced cooperation between the medium access layer and network layers. An algorithm is discussed which takes onto account position, direction and speed of vehicles .Then this concept is applied to reactive routing protocol and introduced preliminary simulation results using ns-2.It is observed that network performance gets improved .**

***Keywords:* Routing protocols, ad hoc network, VANET, MANET, AODV**

I. INTRODUCTION

Emerging vehicular networks are rapidly becoming a reality. Nowadays, several organizations are supporting standardization activities that will enable a variety of applications such as safety, traffic efficiency, etc. Vehicular ad hoc networks (VANETS) share some common features with the traditional mobile ad hoc networks (MANETs), namely in terms of self-organization of the nodes. But they also differ in some issues: in VANETs the level of node's mobility is generally higher, the mobility is constrained by the roads and in terms of energy the nodes are not so constrained as in MANETs. Due to the fast change of the topology, VANETs demand for routing protocols focused on decreasing the number of path breaks.

When thinking at V2VC as a special case of MANET communications, not only the nodes are vehicles and not simple laptops or PDAs, but also: don't have constraints on power resources. Having more resources for V2VC is an important advantage, since these networks provide larger capacities in terms of both storage and power) on the nodes, which can then have long transmission ranges and virtually unlimited lifetimes [2]. Furthermore, in vehicular networks, the nodes can be equipped with a positioning system, such as GPS, that can be used continuously, without power constraints.

Another advantage in such networks is the nonrandom mobility of the nodes (vehicles); generally it is limited by roads which can be represented by digital maps. Also, the vehicle movements are limited by road rules which again may be digitally mapped. An efficient support of access and routing protocols in vehicular environment is then facing issues like: available bandwidth, hidden and exposed nodes, high mobility, heterogeneity, node movement, fast speed, obstacles and fast handover.

In this paper initially we will discuss ad hoc network characteristics and then some available routing protocols along with different mobility models. To study the impact of one of the routing protocol AODV and its modified version m-AODV is proposed for improving network performance. Finally simulated results using ns2 is analyzed and concluded.

II. AD HOC NETWORK CHARECTERISTICS

MANETs generally do not rely on fixed infrastructure for communication and dissemination of information. VANETs follow the same principle and apply it to the highly dynamic environment of surface transportation. The architecture of VANETs falls within three categories: pure cellular/WLAN, pure ad hoc, and hybrid.

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. VANETs can combine both cellular network and WLAN to form the networks so that a WLAN is used where an access point is available and a 3G connection otherwise. 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 to perform vehicle-to-vehicle communications and achieve certain goals, such as blind crossing (a crossing without light control. VANETs comprise of radio-enabled vehicles which act as mobile nodes as well as routers for other nodes. 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:

i) Highly dynamic topology.
ii) Frequently disconnected network.

iii) Sufficient energy and storage. .
iv) Geographical type of communication.
v) Mobility modelling and predication.
vi) Various communications environments.
vii) Hard delay constraints.

III. REVIEW OF 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. We classify them into five categories as follows: ad hoc, position-based, cluster-based, broadcast, and geocast routing.

Ad Hoc Routing

As mentioned earlier, 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*) [6] and DSR (*Dynamic Source Routing*) [7]. 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 [8]–[11]. 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. In [11], AODV is evaluated with six sedan vehicles. It showed that AODV is unable to quickly find, maintain, and update long routes in a VANET. Also in their real-world experiment, because packets are excessively lost due to route failures under AODV, it is almost impossible for a TCP connection to finish its three-way handshake to establish a connection. Thus, certain modification of the existing ad hoc routing protocols to deal with highly dynamic mobility or new routing protocols need to be developed.

In [12], AODV is modified to only forward the route requests within the *Zone of Relevance* (ZOR). The basic idea is the same as the *location-aided routing* (LAR) [13]. ZOR is usually specified as a rectangular or circular range, it is determined by the particular application [14]. For example, for the road model of the divided highway, the ZOR covers the region behind the accident on the side of the highway where the accident happens.

Position-Based Routing

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) against position-based routing strategies in urban as well highway traffic scenarios [8], [9]. Therefore, geographic routing (position-based routing) has been identified as a more promising routing paradigm for VANETs.

Even though vehicular nodes in a network can make use of position information in routing decisions, such algorithms still have some challenges to overcome. 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*) [15] 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 [8], [9], [16], 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. Lochert *et al*. [19] also proposed another solution GPCR (*Greedy Perimeter Coordinator Routing*) later without the use of either source routing or availability of street maps. It utilizes the fact that the nodes at a junction in the street follow a natural planar graph. Thus a restricted greedy algorithm can be followed as long as the nodes are in a street. Junctions are the only places where actual routing decisions are taken. Therefore packets should always be forwarded to a node on a junction (called *Coordinator*) rather than being forwarded across the junction.

Position-based routing for VANETs faces great challenges in a built-up city environment. Generally, vehicles are more unevenly distributed due to the fact that they tend to concentrate more on some roads than others. And their constrained mobility by the road patterns, along with more difficult signal reception due to radio obstacles such as high-rise buildings may lead VANETs unconnected. A new position-based routing technique called A-STAR (Anchor-*based Street and Traffic Aware Routing*) [8] has been proposed for such city environments. A-STAR uses the street map to compute the sequence of junctions (anchors) through which a packet must pass to reach its destination. But unlike GSR, A-STAR computes the anchor paths with traffic awareness. A-STAR differs from GSR and GPSR in two main aspects. Firstly, it incorporates traffic awareness by using statistically rated maps (counting the number of city bus routes on each street to identify anchor paths of maximum connectivity) or dynamically rated maps (dynamically monitoring the latest traffic condition to identify the best anchor paths) to identify an anchor path with high connectivity for packet delivery. Secondly, A-STAR employs a new local recovery strategy for packets routed to a local minimum that is more suitable for a city environment than the greedy approach of GSR and the perimeter-mode of GPSR. In the local recovery state, the packet is salvaged by traversing the new anchor path. To prevent other packets from traversing through the same void area, the street at which local minimum occurred is marked as “out of service” temporarily. The “out of service” streets are not used for anchor computation or re-computation during the “out of service” duration and they resume “operational” after the time out duration. With traffic awareness, A-STAR shows the best performance compared to GSR and GPSR, because it can select paths with higher connectivity for packet delivery. As much as 40% more packets are delivered by A-STAR compared to GSR.

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 1 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. Many cluster-based routing protocols [20]–[22] have been studied in MANETs. 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.

Blum *et al*. [23] proposed a *Clustering for Open IVC Networks* (COIN) algorithm. Cluster head election is based on vehicular dynamics and driver intentions, instead of ID or relative mobility as in classical clustering methods. This algorithm also accommodates the oscillatory nature of inter-vehicle distances. They show that COIN produces much more stable structures in VANETs while introducing little additional overhead. COIN increases the average cluster lifetime by at least 192% and reduces number of cluster membership changes by at least 46%.

Santos *et al*. [10] presented a reactive location based routing algorithm that uses cluster-based flooding for

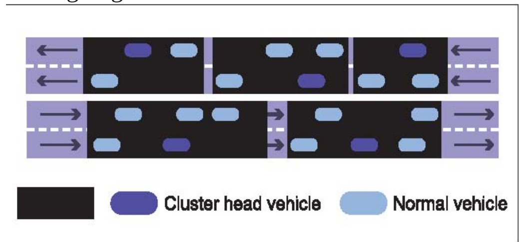

FIGURE 1 Vehicles form multiple clusters in cluster-based routing.

VANETs called LORA_CBF. Each node can be the cluster-head, gateway or cluster member. Each cluster has exactly one cluster-head. If a node is connected to more than one cluster, it is called a gateway. The cluster-head maintains information about its members and gateways. Packets are forwarded from a source to the destination by protocol similar to greedy routing. If the location of the destination is not available, the source will send out the *location request* (LREQ) packets. This phase is similar to the route discovery phase of AODV, but only the cluster-heads and gateways will disseminate the LREQ and LREP (*Location Reply*) messages. The performances of LORA_CBF, AODV and DSR are evaluated in typical urban and highway traffic scenarios. Simulation results demonstrate that network mobility and size affect the performance of AODV and DSR more significantly than LORA_CBF. Cluster-based method has also been used in data dissemination and information propagation for VANETs, such as in [24] the authors described a cluster-based message dissemination method using opportunistic forwarding.

In summary, 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.

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. 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.

Durresi *et al*. [25] presented an emergency broadcast protocol, BROADCOMM, based on a hierarchical structure for a highway network. In BROADCOMM, 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. 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

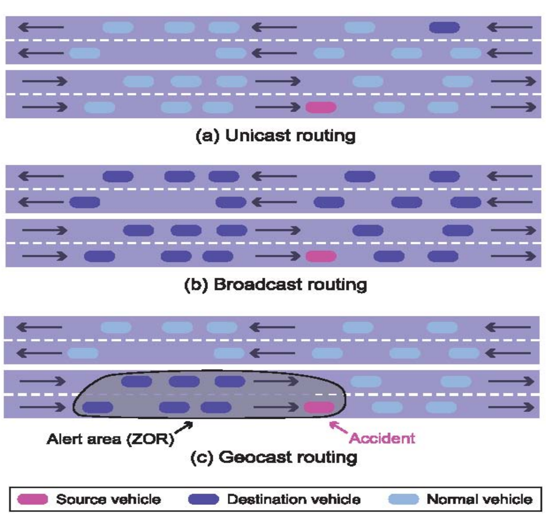

FIGURE2- Different communication scenarios in VANETs.

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.

Urban Multi-Hop Broadcast protocol (UMB) [26] is designed to overcome interference, packet collisions, and hidden nodes problems during message dissemination in multihop broadcast. In UMB, the sender nodes try to select the furthest node in the broadcast direction to assign the duty of forwarding and acknowledging the packet without any a priori topology information. At the intersection, repeaters are installed to forward the packets to all road segments. UMB protocol has much higher success percentage at high packet loads and vehicle traffic densities than 802.11-distance and 802.11-random protocols, which are flooding based modified IEEE 802.11 standards to avoid collisions among rebroadcast packets by forcing vehicles to wait before forwarding the packets.

Vector-based TRAcking DEtection (V-TRADE) and *History-enhanced* V-TRADE (HV-TRADE) [27] are GPS based message broadcasting protocols. The basic idea is similar to the unicast routing protocol *Zone Routing Protocol* (ZRP) [28]. Based on position and movement information, their methods classify the neighbors into different forwarding groups. For each group, only a small subset of vehicles (called border vehicles) is selected to rebroadcast the message. They show significant improvement of bandwidth utilization with slightly loss of reachability, because the new protocols pick fewer vehicles to re-broadcast the messages. But they still have routing overhead as long as the forwarding nodes are selected in every hop.

Geocast Routing

Geocast routing [29] 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 2 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.

In [14], a simple geocast scheme is proposed to avoid packet collisions and reduce the number of rebroadcasts. 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. The scheme also uses a maximal-hop-number threshold to limit the scope of the flooding. Bachir and Benslimane [30] proposed a *Inter-Vehicles Geocast* protocol, called IVG, to broadcast an alarm message to all the vehicles being in risk area based on defer time algorithm in a high way. The main idea is very similar to [14].

Maihöfer and Eberhardt [31] concerned with cache scheme and distance aware neighborhood selection scheme to deal with the situation of high velocities in VANET compared to regular geocast protocols. The main idea of their cached greedy geocast inside the ZOR is to add a small cache to the routing layer that holds those packets that a node cannot forward instantly due to a local minimum. When a new neighbor comes into reach or known neighbors change their positions, the cached message can be possibly forwarded to the newly discovered node. Their distance aware neighborhood strategy takes frequent neighborhood changes into account. It chooses the closest node to destination which is inside the range *r* (smaller than the transmission range) instead of the node transmission range in the general greedy routing mode. Notice that in greedy routing, the intermediate node always select next hop node that lies close to the relaying nodes' transmission range border, so the selected next hop node has high possibility to leave the transmission range because of the high speed node movement. Simulation results show that a cache for presently unforwardable messages caused by network partitioning or unfavorable neighbors can significantly improve the geocast delivery success ratio. The improved neighborhood selection taking frequent neighborhood changes into account significantly decreases network load and decreased end-to-end delivery delay.

Beside of the classical geocast routing, recently, Maihöfer *et al*. [32] also studied a special geocast, called abiding geocast, where the packets need to delivered to all nodes that are sometime during the geocast lifetime (a certain period of time) inside the geocast destination region. Services and applications like position-based advertising, publish-and-subscribe, and many others profits from abiding geocast. In [32], the authors provided three solutions:

(1)a server is used to store the geocast messages; (2) an elected node inside the geocast region stores the messages; (3) each node stores all geocast packets destined for its location and keeps the neighbor information.

Table 1: Summary of routing protocol performance in VANET

PROTO-COL	**PROTOCOL EXAMPLES**	**ADVAN-TEGES**	**DISADVANTAGES**
Connectivity	AODV, DSR ,DSDV	simple	Overhead,broadcasting strom
Mobility distance, speed.)	PBR	Reliable , accurate	Overhead,not workingin sparse/ /congested area
Infrastructure	DRR, SARC	Reliable , accurate	Expensive in rural Area.
Location (Geocast)	CarNet, Zone Greedy, ROVER, LORA-DCBF	Simple , direct	Overhead,not optimal
Probability	REAR,CAR,NiuDe, GVGrid, Yan	efficient	Not optimal,only work for certain traffic.

IV. PERFORMANCE COMPARISION OF ROUTING PROTOCOL

4.1 Implementation of routing protocol:

In this section we apply the algorithm of the classical reactive routing protocol AODV [1]. Our Proposal can further improve the quality Of this protocol when used for vehicular networks and V2VC.Generally speaking, AODV Will build the route to the destination adding one intermediate node after the other, by applying the "Route Request (RREQ)-Route Reply (RREP)" procedure. The source broadcasts labeled RREQs and when the destination is reached by one of the RREQ packets it replies via the route constructed by the RREQ (each intermediate node adds in its routing table the node ID from where the RREQ came), confirming the route itself is the chosen one. If the destination gets multiple RREQs with the same label, AODV will choose the route with the smaller number of intermediate nodes ops). An extension to the basic AODV scheme is he one of maintaining multiple routes as proposed in [3] and [5].

Because of the particular scenarios of our work (Roads), the nodes are moving following specific directions and are constrained by limited lateral movements, so the basic AODV operation is slightly modified so that an intermediate node who receives multiple RREQs with same source and same route ID (and possibly with same previous-hop) will check if all previous hops in the received RREQs are identical well an anti-loop check in those modifications.. Doing this way, the destination vehicle will possibly receive multiple RREQs, which can even come from the same previous hop, and it will send then send RREPs to all of them. This process may increase the used signaling bandwidth, but the benefits for short and medium message transmission (like warnings) will then come from the better route selection procedure. Additionally, we avoid recurrent link failures occurring the basic AODV which generates lot of RERR/RREQ/RREP AODV messages to look for a new path to the destination.

4.2 Simulation results

To evaluate the performance of our algorithm, we compare the simulation results of the basic AODV and of the combination of our modified AODV which has been implemented in NS-2 v2.28 network simulator [4]. We term our algorithm m-AODV. As an example, when 120 nodes (vehicles) are simulated, Nodes are placed over 3 crossing ways each with 4 parallel roads with alternating driving directions are 10 vehicles per road with initial position randomly chosen along The horizontal way was 10 m long and 400 m large (100 m per road), while vertical ones have the same width, but they are 1500 m long. When other vehicles are added to the simulations, they are placed always along the main horizontal way; for example, when 160 nodes are simulated, 80 are running along the main horizontal way (Figure 4). Radio propagation range was set to 250 m and channel capacity to 1 Mb/s. The vehicle mobility constrained along the roads with a fixed direction and fixed speed randomly chosen within ranges of 30 km/h starting from [30160] km/h until [150.180] km/h (Figure 3).

We used the classical 802.11MAC functionalities, i.e. Distributed Coordination function DCF , Carrier Sense Multiple Access with acknowledgements (CSMA/CA with ACK) and Request-To-Send Clear-To-Send (RTS/CTS), fragmentation, even if we suppose the messages enough small. Traffic type was CBR, and the only transmitting source and destination were selected along the road.

4.3 Results and Analysis

Further investigation and simulations are needed to prove the performance of m-AODV, but Figure 3 shows the percentage of link failure detected for m-AODV and for the basic AODV over 1000 runs. We set the time T needed to transfer some data from the source to the destination change to 5 seconds. Note that this parameter T does not correspond to a fixed data size to be sent, but to the period between the times when the source starts the transmission until the moment the destination gets all data which can be formed by many small packets. this means that if two vehicles have 100 km/h as difference in speed, the distance between them after 5 seconds will augment of around 139 meters, which is still less than the radio coverage of a node and so they are still reachable from each other.

We can notice here how m-AODV is always detecting less link failures than basic AODV; in general 3% to 5% less link failures. The trend, anyway, seems to be that the m-AODV algorithm is almost constant with respect to classic AODV, which selects shortest available route.

In the second simulation the topology is the same, In the second simulation the topology is the same, but we fixed the vehicle speed range between 60Km/h and 90Km/h. Initially there are 40 vehicles, and at each time we add 20 vehicles until we reach 120 vehicles, i.e. 220 vehicles on all networks. The results (percentage of detected link failure) obtained over 1000 .runs for each point is presented in the figure 4. We notice that the gain of m-AODV is again almost stable and around 7% with respect to AODV. The density of vehicles in the network plays here an important role in decreasing the number of link failures.

A first analysis of the increased bandwidth used by m-AODV with respect to AODV shows that around 20% more bandwidth is used to manage m-AODV routing, due to multiple RREPs sent by the destination node, each one increasing its size at intermediate nodes. This figure must be confirmed by other extensive simulations, but authors think that it can be even smaller because AODV must restart the RREQ procedure when a link failure is detected, and this is not taken into account in the analysis.

V. CONCLUSION

In this paper, we discuss briefly ad hoc network characteristics and the challenges of designing routing protocols in VANETs and survey several routing protocols recently proposed for VANETs. Table 1 summarizes the performance characteristics of these routing protocols.

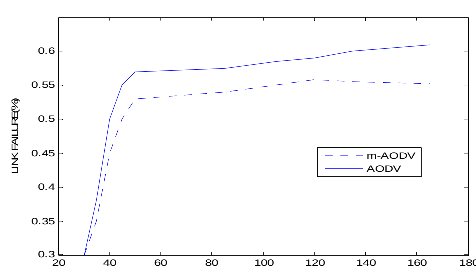

Fig 3 - effect of vehicle speed on link failure (%)

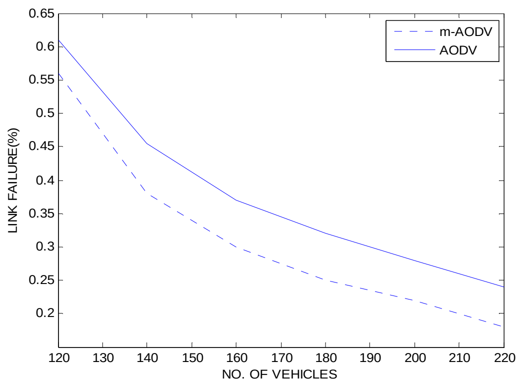

Fig 4 - Effect of no. of vehicles on link failure (%)

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. Therefore, having a universal routing solution for all VANETs application scenarios or a standard evaluation criterion for routing protocols in VANETs is extremely hard. In other words, for certain VANETs application, we need to design specific routing protocol and mobility model to fulfill its requirements.

Because of the fast moving characteristics of vehicles and the difficulty to predict the traffic variations, it is very hard to efficiently cope with these problems while deploying methods for data routing in vehicular networks. In this paper, we presented a part of our work that focused on designing an algorithm that allows routing protocols to avoid links potentially broken by the node mobility during data transmission, therefore to avoid data loss and network overload caused by re-transmissions. Basically, the proposed algorithm uses the moving information of vehicles to choose the best routing route. Furthermore, we applied our ideas to me of the classical on-demand reactive routing protocol, AODV. Future works include the development of a complete cross-layer architecture including not only information about vehicles speed and direction but also channel quality.

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