A Multi-Agent Proactive Routing Protocol for Vehicular Ad-Hoc Networks

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***Abstract*— Vehicular ad hoc network is one of the most promising applications of MANET. However, they have special properties such as high mobility, network portioning and constrained topology which require smaller latency and higher reliability. These vehicles that move along the same road are able to communicate either directly to the destination or by using the intermediate node, such as router. Therefore, designing an efficient routing protocol for all VANETs scenarios is very hard. A lot of researches about routing in VANETs are considering DSDV routing protocol as the most suitable protocol for mobility environment. But DSDV generates a large volume of control packets and takes up a large part of available bandwidth. In this paper, we propose an improving DSDV routing protocol based on multi-agent system approach to solve the performance problems mentioned above. Experimental results show promising results regarding the adoption of the proposed approach.**

Keywords—component; VANET; DSDV routing protocol; agent technology.

I. Introduction

Vehicular Ad-hoc Networks (VANETs) represent a challenging class of mobile ad-hoc networks (MANETs) that enable vehicles to communicate with each other through the road site units (RSUs)[1,2].

The main goal of VANET is to provide safety to vehicles. Applications (like road surroundings warning, collision alert, etc.) are classified under safety-associated applications where the main accent is on timely broadcasting of safety critical alerts to nearby vehicles as shown in figure1.

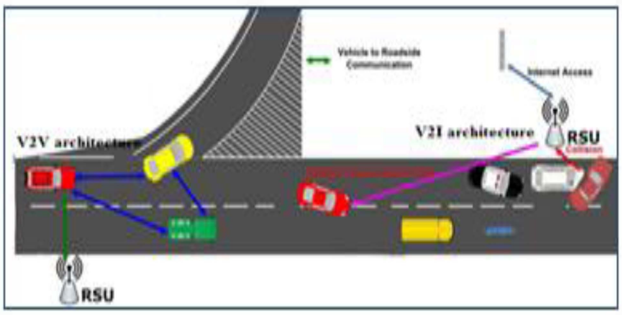

Fig.1. Vehicular ad hoc networks

VANET has some unique characteristics which make it different from MANET as well as challenging for designing VANET applications:

- Frequent disconnected network: This disconnection occurs mostly in sparse network [3].
- Highway topology: The topology of VANET changes because of the movement of vehicles at high speed [4].
- Communication environment: The communication environment between vehicles is not the same in sparse network as it is in dense network [5]. In a dense network, buildings trees and other objects behave as obstacles. In a sparse network like high-way, these things are absent. So the routing approach of a sparse is different from a dense network.
- Mobility modeling: The mobility pattern of vehicles depends on traffic environment, roads structure, the speed of vehicles and driver's driving behavior [6].
- Battery power and storage: The capacity of battery power and storage of each vehicle is unlimited [7]. Thus it has enough computing power which is unavailable in MANET. It is helpful for effective communication & making routing decisions.

The rest of this paper is organized as the follows. Section 2 describes briefly the different routing protocols for VANET. In section 3, we focus more on DSDV routing protocol. Section 4 deals with the motivations that underlie this study. The proposed approach is described in section 5. Section 6 discussed the simulation results. Finally, section 7 concludes the paper with a summary of the presented approach and discusses our future work.

II. Routing in VANETs

Vehicular Ad-hoc Network Communication requires routing protocols for efficient information transmission. To transmit the message from one vehicle to another, the network needs an efficient protocol. The major task of the routing protocol is to identify the position of each vehicle in a VANET [8, 9]. The routing protocol can be classified

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according to the range of communication. For reliable vehicular communication, the performance of the routing protocol used to communicate the message is important.

Different routing protocols are suitable for different VANET characteristics and scenarios, but the main issue is how to select an efficient routing protocol from them. For this purpose proactive protocols namely DSDV are taken into consideration. Lots of mended protocols based on DSDV have been proposed .These improvements include GSR [10], FSR [11], AODV [12], etc. DSDV is a modification of the bellman-ford algorithm, which can solve routing problem in VANETs environment [13, 14, 15 and 16]. Each node, maintains a routing table, which contains the shortest path information to other node. But, in case of link failure, DSDV generates a large volume of control packets and waits for a periodic update or triggered update to get new routing information. As a result, DSDV may take up a large part of available bandwidth [17, 18]. To reduce the number of control packets, the node using DSDV requires cooperation between nodes to transmit information. It must be intelligent to operate normally in case of failure of one or more nodes and to choose the best routes immediately and react autonomously to events that may occur, like changing communication environments causing link breakage of the delivering routes, etc. Given that, the agent technology provides the required characteristics [6] such as intelligence, autonomy, interactivity. We think that, it can be used to significantly reduce the cost of resolving failed links, particularly the elimination of redundancies and unnecessary messages in DSDV.

III. DSDV ROUTING PROTOCOL

In mobile VANETs, the mobility of nodes results in frequent changes of network topology making routing a challenging task. Some studies have been reported in literature to evaluate the performance of the proactive routing protocols [19,20] .

Proactive routing protocol maintains route to all the destinations before the requirement of the route. The most important feature of proactive approach is that every node maintains a route to each other node in the network all the time. In order to maintain correct route information, a node must periodically send control messages. Updates to route table are triggered by certain events which caused the manipulation of other nodes (neighboring) route table. In the proactive approach the main advantage is that the route to each node is instantly found because the table contains all the nodal address. Source needs only to check the routing table and transfer a packet. DSDV is one of the most important routing protocols which is the basis of several routing protocols namely AODV [12].

DSDV protocol is based on classical Bellman-Ford routing algorithm designed for MANETS [21]. Each node maintains a list of all destinations and number of hops to each destination. Each entry is marked with a sequence number. The broadcast of route updates is delayed by settling time. The only improvement made here is the avoidance of routing loops in a mobile network of routers. With this improvement, routing information can always be readily and available. DSDV solves the problem of routing loops and counts to infinity by associating each route entry with a sequence number indicating its freshness.

In DSDV, a sequence number is linked to a destination node (the owner). The only case that a non-owner node updates a sequence number of a route is when it detects a link break on that route. In this case DSDV may take up a large part of available bandwidth and increase the network traffic.

IV. CASE STUDY AND MOTIVATION

In this section we are going to show how the DSDV protocol resolves failed links in VANETs environment.

In figure 2, the node (A) wants to communicate with the node (T).

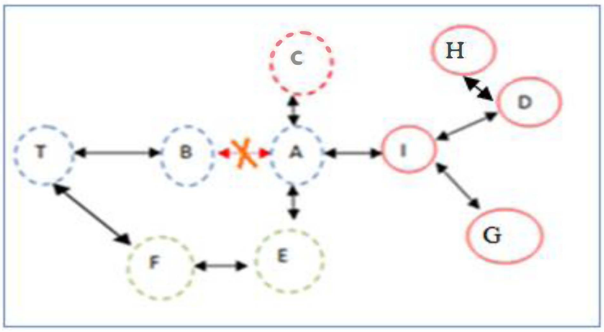

Fig2. Link from A to B breaks

But, it has detected a link failure. To solve this problem and find another way, it broadcasts a route request to all its neighbors as shown in figure 2. Even though I, G and C are not the neighbors of T or B, they have received the route request which can increase the network traffic.

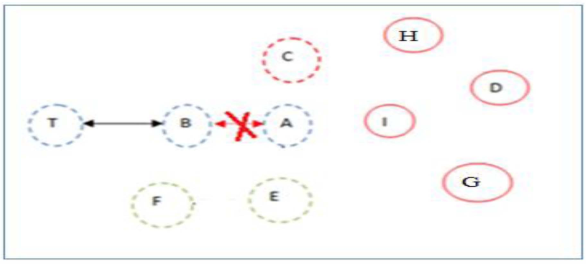

Fig.3.A broadcasts route request to its neighbor

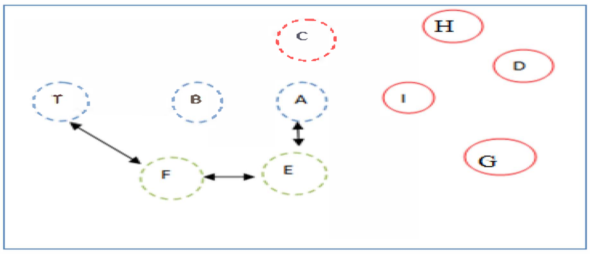

Fig.4.Link established

In order to solve the problem and to decrease the number of control packets, node A requires cooperation between nodes to transmit link breakup information. It must be intelligent to choose the best routes (A-E-F-T) immediately and react autonomously to events. Given that, the agent technology provides the required characteristics [6] such as intelligence, autonomy, interactivity. We think that, it can be used to significantly reduce the cost of resolving failed links, particularly the elimination of redundancies and unnecessary messages in DSDV.

V. PROPOSED APPROACH

Our goal is to reduce the transmission time and reduce bandwidth usage. Therefore, we propose an improved DSDV protocol based on multi-agent system (MAS) which is called MA-DSDV (Multi Agent Destination Sequence Distance Vector).

The main idea of our improvement MA-DSDV is to build a multi-agent system, where each node is replaced by an agent as shown in figure 5.

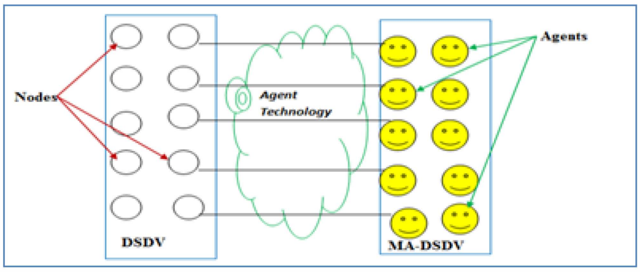

Fig.5. Study of improved DSDV routing protocol

A. Principle of MA- DSDV

MA- DSDV protocol uses the properties of the broadcast to transmit routing information. Indeed, the great advantage of the broadcast is a frame sent by an agent which is heard by all its neighbors. Periodically, it broadcasts its entire routing table that is followed by a number to update routing information. This number is called the sequence number (SN). From the sequence number, it is possible to determine what information is the most recent. The routing table of an agent contains information about each route (destination address, number of hop to join this destination and sequence number of the destination).

Upon receipt of this information, agents update their routing table by following a specific pattern. Any entry of the routing table is updated only if the received information is more recent or if it has the same NS but has a lower number of agents. The MA- DSDV protocol provides for each destination the route that has the lowest number of agents.

In case of link failures, each agent sends periodically its routing information to all its neighbors. If for a certain time, an agent no longer receives routing information from a neighboring agent this means that the latter is no longer part of its neighborhood. A link cut affects all routes using this link. A detecting power agent broadcasts a packet containing all the destinations that can be reached through this link. Any agent receiving such a packet must immediately inform the other about the changing of topology.

B. Agents MA- DSDV

MA- DSDV is composed of a number of agents. Each agent has a knowledge base containing all the information and skills necessary to achieve the task of routing, managing interactions with other agents and with the environment. Each agent has four main components those are:

The identifier of the agent (ID_agent): each agent has a unique identifier used for communication between different agents.

- The program of the agent: each agent has a smart program with which the agent can react autonomously.
- The memory of the agent: each agent contains a set of state variables of system; it also contains information on the status of links between nodes
- The routing table of the agent: Each agent keeps a routing table for each destination that gives access to the network:
    - The neighbor agents : they are used to reach that destination
    - A sequence number sent by the receiving agent
    - The number of hops (intermediate agents) to reach the destination

C. The data for each MA- DSDV agent

The data that must be included in our agents are: Data about itself: Every agent knows its identifier (ID_agent) and has a routing table.

Data about the other: Every agent has data about the other and such data is saved on its routing table.

TABLE1: DATA OF AGENT

Data about itself		**Data about the other**	
ID_agent	**Routing table**	**ID_agent**	**Routing table**

D. Structure of a MA-*DSDV* agent

In MA-DSDV each agent has five main components are:

The identifier of the agent		
The program of the agent		
The memory of the agent.		
The routing table		
Destination address	**Sequence number (SN)**	**Number of Hop**

VI. SIMULATION AND PERFORMANCE ANALYSIS

We tested our approach using the Network Simulator (NS2). Subsequently, we compared MA- DSDV with DSDV. We considered two evaluation criteria:

- **Control packets:** It is the number of packets generated to find the best route
- **Percentage of dropped packets:** It measures the number of packets that are not delivered to their recipients.
- **Transmission Time**: This metric represents the average time between sending a data packet and the time of receipt.

A. The parameters of the simulation

We present in this section the various parameters to be considered in the simulations.

TABLE II: THE PARAMETERS OF THE SIMULATION

Parameters	**Value**
Traffic type	**CBR (UDP)**
Transmission rate	**200 packets/second**
Simulation time	**500 seconds**
Area of the network	**1200m x 1000m**
Routing protocol **Number of nodes**	**DSDV , MA-DSDV** **200 nodes**
Maximum speed of nodes	**Vmax=60m/s**
Transmission range	**250 m**
Simulator	**NS2**
Mobility model	**Manhattan mobility model**

- **Topology:** We consider a vehicular ad hoc network (VANET) that consists of a number of agents ranging from 10 to 200 agents.
- **Traffic model:** Every last n seconds, a number of agents want to exchange data packets such CBR (Constant Bit Rate) simulation. The size of packets exchanged is OC bytes.
- **Data structure**: Each agent maintains a waiting type FIFO (first in, first out) .The size of the queue is set to n packets. The simulated topologies consist of mobile nodes with wireless interfaces that implement the IEEE 802.11 standard.
- **Mobility model:** In order to generate the movement path file and to express the movement pattern of each vehicle and how their speed, location and velocity vary over time as shown in figure 6, we used the Manhattan mobility model [22]. It allows vehicle to make turns at each corner of road. At each intersection, the probability of moving on the same street is 0.5 and the probability of turning right or left is 0.25. Every vehicle is restricted to its lane on the freeway and its velocity is temporally dependent on its previous velocity.

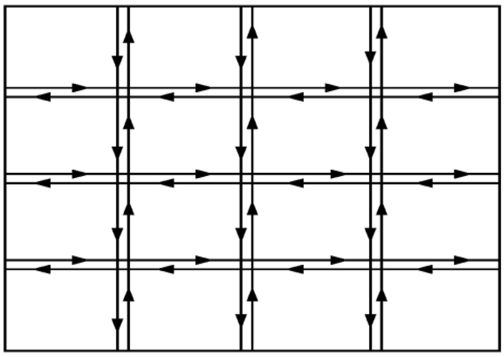

Fig.6: Manhattan mobility model environment

B. Performance analysis *control packets*

- **Control packets:** We aim at minimizing the number of control packets generated by DSDV protocol to solve the failed links and to find the best route. In figure 8, our approach minimizes the number of control packets when the number of nodes increases.

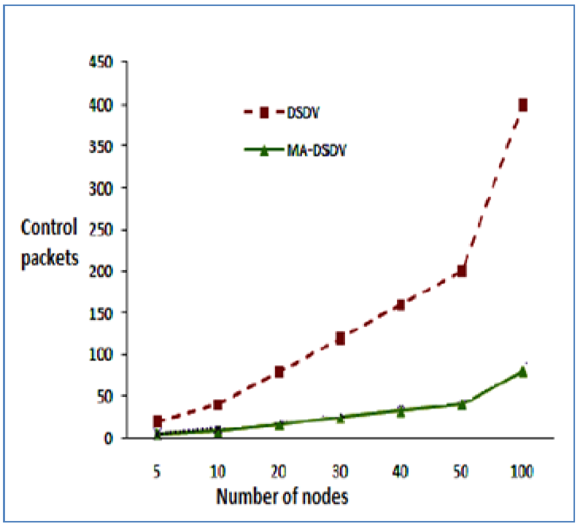

Fig 7. Control packets vs. number of nodes

- **Percentage of dropped packet**

The dropped packet is a critical metric in the evaluation of a routing protocol. To determine which protocol is performing, it is useful to know whether it minimizes the dropped packet. The figure 8 shows the percentage of dropped packet in different mobility scenarios (from 5 m/s to 60m/s). We can notice that our approach loses fewer packets than DSDV when the speed increases. With mobility less than 30 m/s both protocols (MA-DSDV and DSDV) give, nearly the same performance. However, from 30 m/s to 60m/s, the difference between the two protocols is visible. So, we can conclude that in a high mobile environment, MA- DSDV is the most suitable in terms of dropped packet.

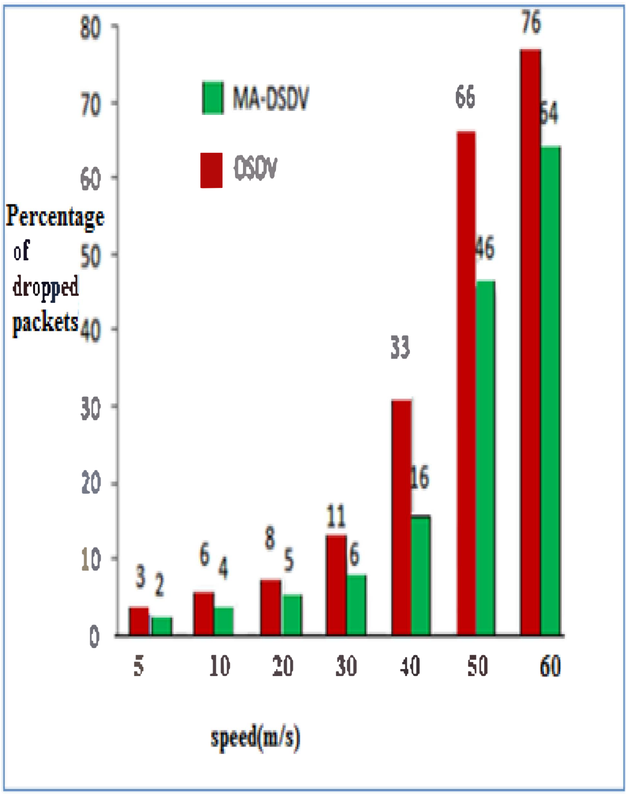

Fig.8. percentage of dropped packets vs. speed

- **Transmission delay**

In this section, we are interested in the study of transmission delay. This delay refers to the period of time that takes for a packet to be sent from a source to a destination. It is equal to the sum of delays on the links that have that path. This period of time takes into account two main steps: the period of time in the queue of nodes along the path and the propagation delay of the packet on the physical medium. The purpose of this section is to calculate the transmission delay of packets in different scenarios density of nodes (ranging from 5 to 200 nodes). As shown in figure 9, MA-DSDV has a transmission delay smaller than DSDV when the network the number of nodes increases.

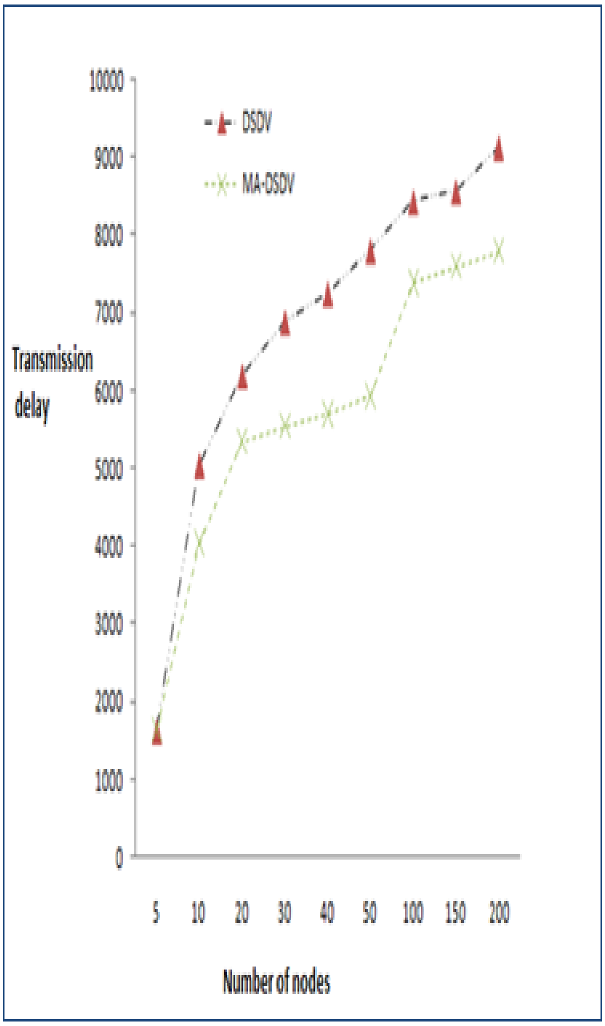

Fig.9. Transmission delay vs. number of nodes

VII. CONCLUSION

VANETs are a collection of mobile vehicles that form a dynamic and high network topology. The most important characteristics of VANET come from node mobility. These features essentially lead to adopt a routing protocol that quickly adapts to nodes mobility. A routing protocol should minimize routing control packet and transmission delay.

In This paper, we have proposed an efficient routing protocol for vehicular communication in highway environment based on a multi-agent system called MA-DSDV. We tested our approach by comparing its performances with DSDV routing protocol. From the results shown in last section, we can observe that our approach performs well in terms of transmission time, control packets and the dropped packets. In our approach, each vehicle is treated as a router to communicate with the neighboring vehicles without using the RSUs (road side units).

In future work, we envision to study the case of vehicles to infrastructure architecture (V2I) related to the presented approach.

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