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Intelligent Routing Scheme for Vehicle-to-Vehicle Communication

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Abstract — Vehicle Ad Hoc Network (VANET) is a type of wireless network composed of vehicles and roadside communication devices. The main goal of VANET is to provide seamless communication for people travelling on the road to collect and relay information from all nearby vehicles in the event of emergency situations such as severe traffic jams, collisions, lane shift, speed limit, hazard or road condition alerts, position alert services and in the event of climatic disasters, etc. Due to high mobility of vehicles data transfer between vehicles in short period requires smart, intelligent routing algorithms. Proposed work aims at design of a intelligent agent (Belief-Desire-Intention) based routing for vehicle-to-vehicle (V2V) communication in VANETs. Intelligent routing scheme operates as follows: gathering of routing parameters, generation of beliefs, development of desires and finalization of route. Presented routing scheme is analyzed and compared with existing routing algorithm for VANETs known as M-AODV+ (Modified AODV+) with respect to packet delivery ratio, network life time and control overhead.

Keywords— Vehicular Ad hoc Network, Vehicle-to-Vehicle Communication, Cognitive agents

I. INTRODUCTION

Wireless network is an integrated part of today's lifestyle to provide ubiquitous connectivity. Ad-hoc network provides connectivity without any fixed infrastructure. The nodes in ad-hoc network are self-organized and self-maintained. MANET and VANET are the two types of ad-hoc networks differing each other basically by the mobility of nodes [1]. Vehicles in VANET engage themselves as both servers and clients to exchange information. As VANET is associated with life critical applications, there is need for understanding each aspect in architecture, features, applications and issues of VANETs before implementing them. This application of Intelligent Transport Systems (ITS) should broadcast safety information to all the nodes with high level security.

The architecture of VANET [2] is as shown in figure 1, where vehicles in VANET communicate with each other or through Road Side Units (RSU) to deliver the messages in time. VANET architecture can be categorized into three types, i) purely ad-hoc based also known as Vehicle-to-Vehicle (V2V), ii) infrastructure based known as Vehicle-to-Infrastructure (V2I), and iii) hybrid (V2V and V2I).

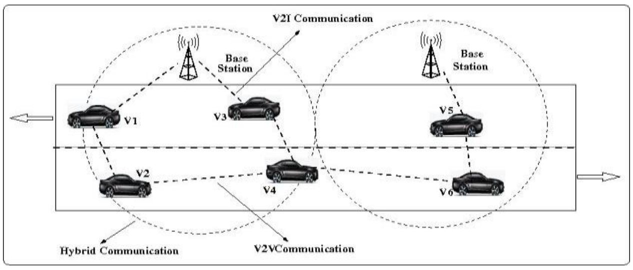

Figure1. VANET Architecture

VANET is supported by Wireless Access in Vehicular Environment (WAVE) technology [3]. WAVE system using Dedicated Short Range Communication (DSRC) is a new technology, designed to enhance and facilitate the data dissemination operation in a vehicular network. IEEE 802.11p (WAVE) is used for wireless access in vehicular domain which enables V2V and V2I communications.

Some of the safety related VANET applications such as commercial, comfort, productive and efficiency etc. to help drivers in vehicles are described in [4] - [6]. Driver and passenger comfortness with infotainment and non-safety applications of VANET are presented in [7] - [8].

Most of the research is going on VANET to come out the key issues related to MAC, Data aggregation, Clustering, Data validation, Data dissemination, Routing and Security [9]. The self decision making makes the technology intelligent which is interdisciplinary. Some of the intelligent techniques include agent technology, artificial intelligence, fuzzy logic, bio inspired computational techniques etc. [10] - [14].

A cognitive agent (CA) is a software entity, works autonomously and continuously in atmosphere. To develop new applications mobile agents are used in VANETs [15]. The cognitive agent works with many models. Belief, Desire and Intention (BDI) are the main components of cognitive agent.. In many 'intelligent' agents these components are present in one or the other form. Belief which is information state, desire which is motivational state and intention is the deliberative state of an agent.

The proposed dynamic routing scheme considers BDI model of cognitive agent which operates in the following sequence: (1) Information gathering such as available bandwidth and end-to-end delay; (2) beliefs creation depending on gathered parameters; (3) develop the desire based on belief; (4) route is selected and intention is executed if desire is attained; (5) if intention is not completed, reselect the route.

Rest part of the paper is organized as follows. The related research works are presented in section II. In section III, network environment and cognitive agent BDI model for dynamic V2V routing scheme is explained. Simulation model of proposed scheme, performance parameters and results of simulation are discussed in section IV. At the end, section V concludes our research work.

II. RELATED WORKS

Some of research related to routing in VANETs using traditional methods and intelligent techniques are explained as follows.

Design, architectures, issues of cognitive agents as well as its applications are discussed in [16]. These agents make smart decision like human psychology in dynamic network environments. The work in [17] presents a cognitive agent based BDI model used to perform a function on behalf of owner. A cognitive agent with BDI routing model is designed in [18] to transmit the data from source to all other vehicles with small delay without losing the information for safe applications in VANET.

Design of routing protocol based on multi agent system for efficient data transmission is proposed in [19] for V2V communication in VANETs. The concept of cognitive agent used to disseminate the intelligent message is proposed in [20]. Regression based critical information aggregation and dissemination in VANETs using cognitive agent approach is presented in [21].

In [22], M-AODV+ (Modified AODV+) which is an extension of AODV+ routing protocol for VANETs is explained, where the reliability of vehicle-to-vehicle communication in VANETs is supported by enabling vehicle-to-infrastructure (V2I) and infrastructure-to-infrastructure (I2I) communications as another communication links within vehicles when single or multi-hop communication is not possible in the mobile network.
A routing protocol for vehicle-to-infrastructure communication using distributed clustering algorithm is proposed in [23]. It uses a coalition game theory to stimulate the vehicles to become the member of a cluster, and uses fuzzy logic to generate stable clusters considering speed of the vehicle, mobility pattern, and quality of the signal between vehicles as fuzzy parameters. The meta-heuristic algorithms (Particle Swarm Optimization (PSO), Differential Evolution (DE), Genetic Algorithm (GA), and Simulated Annealing (SA)) are given in [24] and are applied to Optimized Link State Routing (OLSR) protocol to find optimal path for vehicles. To get solution for selfish behavior of nodes in forwarding the messages, a routing algorithm for VANET using game theory and Multi-Community Evolutionary Game Routing algorithm (MCEGR) are used in [25].

III. METHODOLOGY

This research work proposes the design of a dynamic routing scheme in VANETs using BDI (Belief-Desire-Intention) approach. Every vehicle in network has a static and mobile agents. Network environment, cognitive agency, BDI agent based routing scheme and an example scenario for V2V communication in VANETs are described in this section.

A. Network environment

We consider a network with vehicles (V1-V9) as nodes which communicate each other in their communication range. A single lane highway scenario with purely ad-hoc Vehicle-to-Vehicle (V2V) communication network architecture is as shown in figure 2. All vehicles in the network are considered to be traveling in similar direction and having some safe distance between them. To send the message between vehicles till it reaches the destination, multi hop communication takes place. It is assumed that all vehicles in the network are having inbuilt agent platform, Global Positioning System (GPS), network devices, computing devices, sensors and maps to know the details about road intersections.

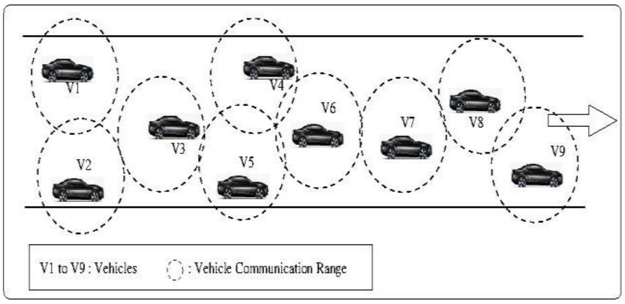

Figure2. V2V Communication in Highway Scenario

B. BDI agent based dynamic routing scheme for V2V communication

The proposed Belief-Desire-Intention (BDI) model based dynamic routing scheme is as shown in figure 3. Each vehicle has a Static Agent (SA) and a mobile Dynamic Routing Agent (DRA). DRA has the capability of migrating from vehicle to vehicle to collect and deliver the information. Once the information sent from source reaches destination it traces back the same path to convey the source that the information is successfully delivered. Knowledge Base (KB) stores and regularly updated by the SA and DRA about the collected information of all the paths.

The proposed dynamic routing scheme works as follows:
(1) collecting the information such as End-to-End delay and available bandwidth; (2) generation of beliefs based on

the collected information; (3) develop the desires based on the belief; (4) select the route if desire is achieved and intention is executed; and (5) reselect the route if intention is not executed.

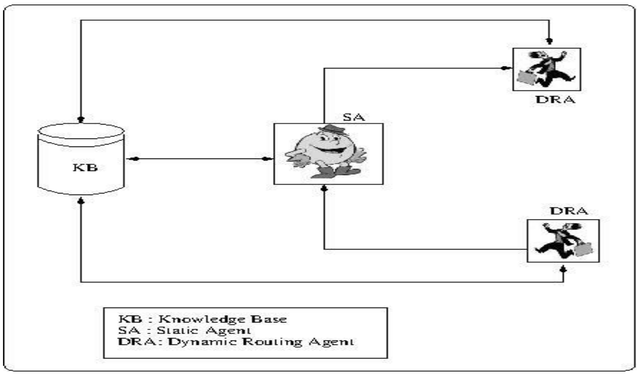

Figure3. BDI routing scheme for V2V communication

1. **Collection of routing parameters:** Initially the source vehicle's static agent triggers dynamic routing agent to collect routing parameters from all vehicles. DRA visits all vehicles till destination is reached and traces back the route with all collected routing parameters. DRA collects the routing parameters and submits the information to source vehicle SA as well as updates knowledge base. All the available paths from source to destination are obtained. The routing information parameters considered here are End-to-End delay and available bandwidth.
   - *Calculation of End-To-End Delay:* A heuristic weighting method is used for calculating the End-to-End delay. It is observed that transmission delay is proportional to the distance between the source and destination. Based on this observation, the weighting metric is calculated as average distance between the source and destination for the whole transmission phase as in equation (1).

   $$w_k = (d_k^0) + \left(1/2\right) |V_D - V_S| T_{data} \quad (1)$$

   where, w_k - Transmission delay, d_k^0 - space between source vehicle and its nearest neighbor, V_D and V_S are speed of destination vehicle and source vehicle respectively, T_{data} is overall data transmission period. For all intermediate nodes *i*, *d* is computed as $\sum w_{ki}$
   - *Computation of available bandwidth* ***(*** A_i ***):*** The available bandwidth in link *i* is calculated by equation (2).

   $$A_i = C_i (1 - u_i) \quad (2)$$

   where A_i always changes with u_i which is utilization of link *i* in time period (0<u_i<1). C_i is constant.
2. ***Beliefs generation:*** Beliefs *B* are developed by RMA depending on the details of collected parameters i.e., $(B_1 = A_{i1}, d_1)$ $(B_2 = A_{i2}, d_2)$, ... $(B_n = A_{in}, d_n)$. Desires are developed based on the set of beliefs $D = B_1, B_2, \dots B_n$.
   Let, *T (θ)* defines set of all preferred beliefs considered to develop the desire.
   $T(\theta) = T_1, T_2$
   where, T_1 is end-to-end delay and T_2 is available bandwidth.
3. ***Desire development based on the Beliefs:*** The Desire *D* is developed based on the available bandwidth A_i and end-to-end delay *d* for all routes. Based on the developed desire the route is decided. From these set of desire, optimal path is taken which is considered as Intention *I*. The operator λ is introduced as accessibility between *B* beliefs $B_1, B_2, \dots B_m$. If any of the belief $B_1, B_2, \dots B_m$ is not accessible, or if any contradiction exists, then λ is indicated as given in equation (3).

   $$\lambda = \mathrm{B}_1, B_2, \dots B_m \quad (3)$$

4. ***Route selection:*** Now an Intention *I* on θ (defined as I = $B_1, B_2, \dots B_k$ where k ∈ D) is executed to choose the optimal path in terms of bandwidth and delay. Finalized route information is disseminated among all vehicles by SRIA.
5. ***Re-selection of the route:*** If the intention is not executed, the whole process is repeated until the optimal path is selected.

C. Algorithm

Proposed routing algorithm works as follows.

Nomenclature: Available bandwidth - A_i , End-to-End delay - *d*, Set of preferred beliefs – *T (θ)*, Minimum bandwidth required - Ab_{min} , Set of beliefs – *B*, Desire - *D*, Intention - *I*, RMA - Routing Manager Agent, RPCA - Routing Parameters Collection Agent, SRIA - Selected Route Information Agent.

Input: Information Collection *T (θ)*, (A_i *and* d by RPCA from all vehicles.

Output: All possible paths and selected optimal path from source and destination vehicle from SRIA.

Begin
RMA collects A_i *and* d of all vehicles from RPCA; //RMA accepts and eliminates duplicates

for (Given source and destination vehicle)
    if ($A_i \geq Ab_{min}$) **then**
    Generate Beliefs *B* and develop the Desire *D*
    else
        Recompute the route
    end if
Obtain Intention *I*
if (Contradiction exists) **then**
    Update Beliefs *B* and revise Intention *I*
    Recompute the route
end if
if (Path fails) **then**
    Repeat the whole process
end if
End

IV. RESULTS AND DISCUSSION

The proposed scheme is simulated using "C"' programming language in Linux platform. In this section, we have discussed network model, simulation inputs, simulation procedure and results of simulation.

A. Simulation model

For simulation we have consider *N* number of vehicles traveling in a road of length *L* and width *W* for simulation. The ID's and positions of the vehicles are randomly chosen. A single lane highway scenario with fixed communication range *C* for all vehicles is assumed for simulation. All vehicles movement direction is considered to be same with uniform speed *M* kmph throughout the simulation. A safety distance between the vehicles is assumed to be *S* meter. Every vehicle has an inbuilt device to know the start time, speed at which they travel, its original position. The simulation inputs are given in table 1.

Table 1. Simulation Inputs

Sl. No.	Input parameters	Specification
1	N	20
2	L	1200 mts
3	W	15 mts
4	C	150-300 mts
5	M	40-80 kmph
6	S	2 mts
7	RTS/CTS packet size	2 Kb
8	Data packet size	1-10 Kb

B. Simulation procedure

In this section the procedure for simulation of the proposed routing scheme is as follows.

1. Consider the road area in terms of length and breadth.
2. Deploy vehicles.
3. Identify the source vehicle and destination vehicle.
4. Compute the available paths.
5. Apply proposed BDI model
6. Identify the optimal path from source vehicle to the destination vehicle.

C. Performance parameters

The evaluate the proposed work, the parameters considered are network lifetime, control overhead and packet delivery ratio.

- **Network lifetime:** It is the time of network in association with vehicles in the specified lane. It is expressed in terms of seconds (s).
- **Packet delivery ratio:** It is the fraction of total data packets received to the total data packets sent at destination and source vehicle respectively. It is expressed in percentage.

D. Result analysis

The above mentioned performance metrics considered are evaluated and analyzed to examine the performance effectiveness of the proposed routing scheme and compared with an extension of AODV+ routing protocol (referred as M-AODV+ in graphs) for supporting vehicle-to-vehicle communication in vehicular ad hoc networks [22].

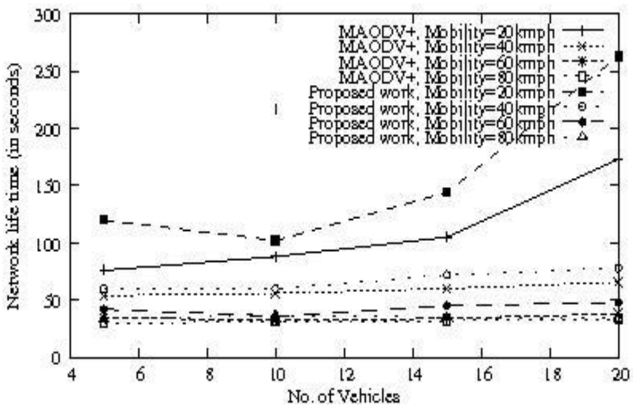

Figure 4. Network lifetime Vs. Number of vehicles

Since the intermediate vehicles between source and destination increases as the number of vehicles are more in the network, the network lifetime increases as the number of vehicles increases which is clearly shown in figure 4. If the vehicle velocity is more, they come out of the considered network area in less time. Hence there is decrease in the network association time of vehicles. If any of the source or destination vehicles come out of the considered area, the simulation stops. Hence there is a lesser network lifetime with high mobility of vehicles. Further it is observed that the network lifetime is more in the proposed scheme as compared to M-A0DV+.

The variation in network lifetime based on communication ange of vehicles by varying the number of vehicles having same speed of 40 kmph is shown in figure 5. The graph clearly reveals that there is increase in network lifetime with increase in number of vehicles. It is again because of the more number of intermediate vehicles. Connectivity among vehicles is more as the range of communication increases which leads to better network lifetime.

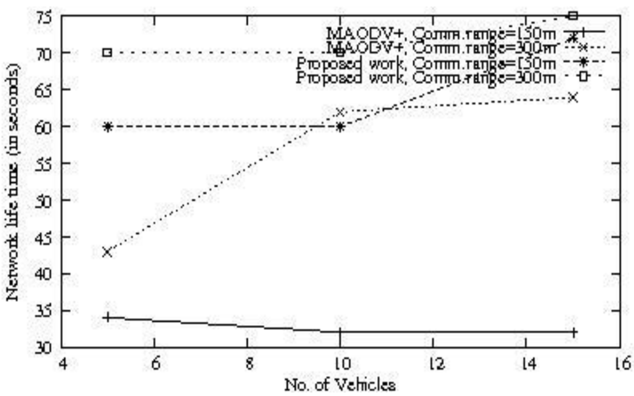

Figure 5. Network lifetime Vs. Number of vehicles (Mobility = 40 kmph)

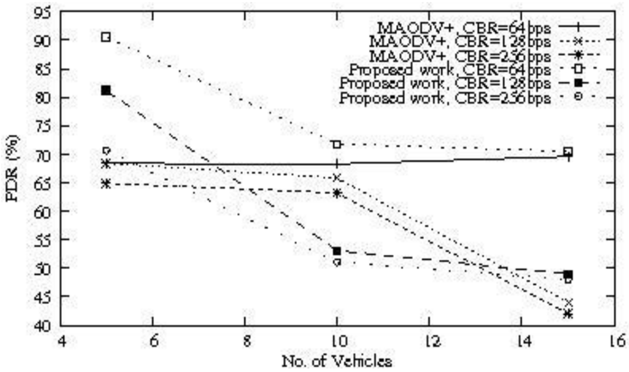

Figure 6. PDR Vs. Number of vehicles (Mobility = 40 kmph)

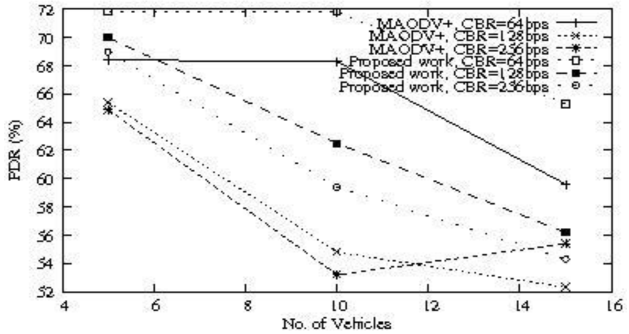

Figure 7. PDR Vs. Number of vehicles (Mobility = 60 kmph)

The results of packet delivery ratio vs. number of vehicles for different Constant Bit Rate (CBR) are given in figures 6 and 7 keeping the steady speed of vehicles (40 kmph, 60 kmph respectively). The packet delivery ratio reduces with increase in number of vehicles due to increase in intermediate vehicles. Congestion rate increases as the number of data packets increases, thus reducing the packet delivery ratio. Compared to M-AODV+, proposed dynamic routing scheme exhibits better packet delivery ratio.

Figures 8 and 9 shows the results of variation in packet delivery ratio by increasing the number of vehicles for different communication range, keeping fixed Constant Bit Rate (CBR) of 64 kbps and 128 kbps respectively. As the communication range increases, there is decrease in packet delivery ratio because the lifetime increases and more vehicles come between source and destination vehicles. Congestion rate increases as the number of data packets increase, hence packet delivery ratio decreases.

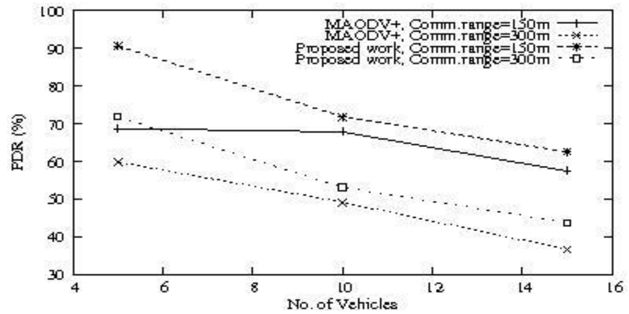

Figure 8. PDR Vs. Number of vehicles (CBR= 64 kbps, Packet Size= 10 kb)

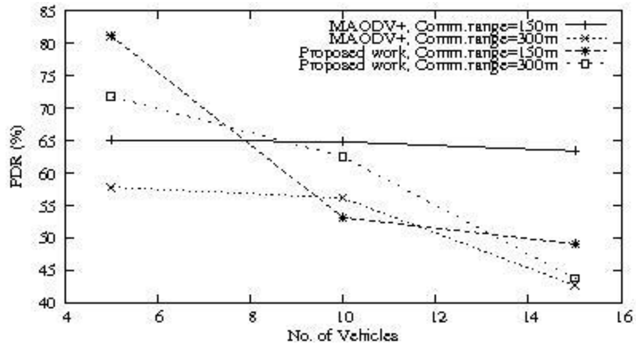

Figure 9. PDR Vs. Number of vehicles (CBR=128kbps, Packet Size = 10kb)

V. CONCLUSION AND FUTURE SCOPE

This paper presents BDI model based dynamic routing for vehicle-to-vehicle communication in VANETs based on available bandwidth in between vehicles and end-to-end elay.

Proposed BDI model helps to select the optimal route from source to destination with less end-to-end delay and high available bandwidth. From the results, we conclude that the proposed scheme performs better than M-AODV+ scheme in terms packet delivery ratio, network life time. Further the work can be extended for more number of lanes and bidirectional movement of vehicles.

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