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Co-operative Cluster based Multi-Agent Approach for Efficient Traffic Forecasting and Management in VANET

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Abstract*: *Vehicular Adhoc Network (VANET) is a kind of advanced MANET specially designed for vehicular communication. Routing in dynamic environment is difficult therefore Multi agent based cooperative routing in dynamic vehicular technology is proposed. The objective of this work is to determine effective routing by utilizing the information provided by the intelligent multi agent systems. A Co-operative Cluster based Multi-Agent Approach (CCMAA) for intelligent routing protocol is proposed for better results since implementing traffic forecasting and efficient routing in dynamically changing environment is a challenging task. The multi agent system includes mobile agent, static agent, service agent and this agent are used for optimal communication and reduces network traffic. The performance evaluation is done using the simulation tool Network Simulator (NS2) tool. Packet delivery rate, delay and throughput are the performance metrics used to evaluate the proposed protocol.

Index Terms*: *Intelligent vehicles, Multi Agent technique, Co-operative routing, Traffic forecasting.

I. INTRODUCTION

VANET is a promising technology being developed efficiently for traffic monitoring and control, accident prevention, road safety, direction planning etc., here the vehicles are considered to be moving nodes. VANET is a decentralized and infrastructure-less network since the nodes move freely in any direction with high speed and communicate with other nodes through the communication link. This vehicular network includes vehicle to vehicle and vehicle to infrastructure communication based on their communication range. Using different multiple agents considered in the scenario the traffic forecasting for interruption less communication is determined. Agent technology provides a suitable contribution to traffic management since the hypothetical awareness used in the agent and multiple agent systems straightforwardly interpret the traffic executive domain. In order to identify the more reliable routes and intelligent traffic forecasting system it is necessary to make the agents

Communication between vehicles and road side infrastructure plays an important role for the safety services. Traffic lights or road signs could be equipped with a communication device to actively inform vehicles in the vicinity. Hence, drivers can receive information on traffic flow, road conditions or construction sites directly from the respective road side infrastructure. In addition, static hazard areas, e.g. construction sites, could be equipped with a road side infrastructure to warn surrounding vehicles.

The main application of VANET is to endow with safety and comfort for passengers helping drivers on the roads by anticipating hazardous control of traffic flows, blind crossing and collision prevention, allow them to communicate with other vehicles and with internet hosts so the passenger can download music, send emails, watch online movies and can chat online.

II. RELATED WORKS

Many of the related works are reported in the literature that indenture with the ad-hoc networks and their adaptability with vehicular network environment. VANETS are a extraordinary case of MANET in which vehicles takes part as a mobile nodes in order to improve road safety, prevent high traffic, reduce congestion and so on. There are several issues raised by VANET's such as Network congestion, Data aggregation and Mobility supervision, Data Validation, Routing, Privacy and Security.

Multi agent based congestion control method [1] was proposed for getting the neighbor nodes information intelligently and promotes congestion free path for data transmission. This scheme possess better bandwidth usage as well as reduces the latency occurs in the network. A dynamic probabilistic approach [2] was proposed for reducing the number of unnecessary repetitive transmissions of control packets. The objective of this protocol is to achieve higher saved rebroadcast, low collision rate and to keep low number of relay or hop count. This mechanism greatly reduces the 'broadcast storm problems'. An infrared inter-vehicle and V2I communication are taken for consideration [3]; here Direct Sequence Spread Spectrum (DS-SS) is used to achieve the robustness against interference. The infrared DS-SS ranging and communication performance are evaluated with multipath rate and multipath interference. By using optical orthogonal code the interference from other users can be reduced using prime code, an extended prime code and modified m-sequences.

A decentralized algorithm [4] for a group of autonomous vehicles was proposed to minimize the expected waiting time for the service targeted. M-vehicle dynamic travelling repair person [5] is the general problem raised

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during the autonomous vehicles and to overcome this problem a new class of control algorithm (prior task assignment) is presented that is adaptive to changes of network conditions, locally optimal to the light load case.

Automobile traffic congestion became major issue in transportation; therefore providing information about road conditions will help drivers to take most effective route. Tree based counting algorithm [6] is used to calculate the total number of nodes in congestion and the congestion is observed by discovering the neighbor beacons. However this proposed scheme only gives the total number of vehicles which undergoes the congesting features. Congestion control [7] must be considered since the VANET have high mobility resulting in high dynamic network topology. For each node the average utility value is calculated based on utility of its data that shared by the other nodes. The loss of packets can be reduced by using this decentralized Utility-Based Packet or Data Forwarding and Congestion Control (UBFCC). Self-Organized Traffic Information System (SOTIS) [8] is a decentralized information system that uses a technique called Segment-Oriented Data Abstraction and Dissemination to overcome the issues caused by V2V communication. This protocol requires a large ratio of equipped vehicles with significant benefits.

Delegate Multi-agent Systems (DMS) [14] proposed using environmental co-ordination mechanism like bio-inspired organisms like ant agents. Decentralized Approach for Anticipatory Vehicle Routing Using DMS follow antlike agent for identifying the route and forwarding the data. This protocol developed based on ant behaviour such that the ant co-ordinates with other ants by dropping their pheromone substrate so that other ant follow the information, in similar way the moving nodes drops the information in the Information and Communication Technology (ICT) infrastructure.

Dynamic clustering [13] forms a group of vehicles and the cluster head selected based upon the connectivity degree, average speed, and time to live. Based on the mobility patterns the cluster head predicts the future association of group members. The multi agent comprises of heavy-weight immobile agents and light-weight mobile agents. Dynamic cluster was formed and maintained by Cluster Information Dissemination Agent (CIDA). Cluster Information Collection Agent (CICA) is cyclically generated and collects the information regarding speed and location with the use of knowledge base. Identifying relative speed is the primary component since neighbouring vehicles speed follows normal distribution operation.

III. PROBLEM FORMULATION AND CONTRIBUTION

A single agent in the network cannot handle and control the entire network operations. Hence it is necessary to implement multiple agents to carry out different operations by monitoring the network and to cooperatively incorporate the collected information for efficient communication. Routing strategy for preventative vehicle routing using delegate multi-agents was designed. The approach is based on an environment-centric coordination mechanism inspired by ant behavior. Antlike agents explore the environment on behalf of vehicles and detect a congestion factor that allows vehicles to reroute. Re-route consumes more energy therefore to prevent reroute Service Agent is placed in order to broadcast critical information that minimizes congestion in data traffic. Clustering the nodes becomes energy efficient and reduces data redundancy. Routing information in VANET scenario is in fact a difficult task as vehicles moves in high speed; therefore providing efficient routing is essential.

IV. PROPOSED MECHANISM

Cooperative Cluster based Multi-agent proactive source routing for congestion avoidance and traffic forecasting is proposed by utilizing traffic control algorithm since forecasting the vehicles movement and congested area in dynamic environment is a critical task. The proposed work is divided into four parts; here each task is carried out by different agent allotted for the particular task. Then the agents are cooperatively interacted to form a reliable network structure. Road Side Units (RSU's) are placed in the infrastructure and On Board Units (OBU's) are placed in the vehicles and the communication takes place with the help of this devices. Routing the packets efficiently with the help of cooperative multi-agent mechanism greatly improves the network throughput. The figure 1 shows the system model of the proposed CCMAA protocol.

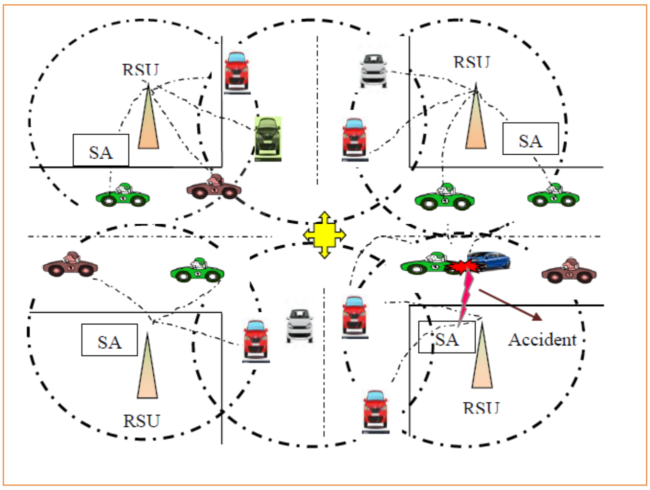

Figure-1. System Model for CCMAA

A. Agents Classification

Agents are employed to collect and control the information intelligently in a cooperative manner. Each and every agent employed in the network has its own operations to perform and the collected data is exchanged among them through proper routing.

Here the agents are classified in two ways such as static agents and mobile agents. The static agents are categorised under RSU's and the mobile agents are categorised under OBU's which are placed in the vehicles for communication purpose. Each agent has a unique identifier so that the data can be identified from which it has generated. Service Agent (SA) is placed near RSU's to route data with traffic. Emergency information's are passed over SA V2V communication takes place if the vehicles lie in the same communication range. Routing in this case

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is not so difficult one but there might be data loss due to bandwidth constraints and delay in delivering the timely information like warnings to the driver. Finding the moving nodes with largest buffer size, reliable bandwidth and cache memory is mandate to transfer the data reliably. Each vehicle is equipped with GPS, DSRC, Control Unit and OBU.

B. Traffic Forecasting

Every agent employed in the network monitors the environment and collects the environmental factors or information. Then the collected information's are cooperatively shared among the neighbor agents if the vehicles are not in the communication range. By using this collective information the congestion amount and the vehicular traffic information is forecasted for the future prediction of the vehicle movement. Table 2 describes multi-agent components. Cooperative Multi Agent Proactive Source Routing (CMA-PSR) protocol consists of Agent ID, Data ID, Program and Memory of the agent, Hop count and routing table.

Static Agents (Contains self-information)		Mobile Agents (Contains event-time driven information)	
Agent ID	Data ID	Agent ID	Data ID
Program of the Agent		Program of the Agent	
Memory of the Agent		Memory of the Agent	
Hop_Count		Hop_Count	
Routing Table			

Table-1. Multi-agent Components

C. Multi-Agent Traffic Control Algorithm

The mobile agent consists of moving nodes that gathers information and brings towards the static agents. Multi-agent based distributed algorithm for traffic monitoring is implemented. Data are consecutively routed to the SA for reducing the data traffic This method includes link estimation phase and bandwidth estimation phase before routing the data. The metrics link instinct and bandwidth are estimated to select the reliable routes available between the vehicles as well as static agents.

V. RELIABLE ROUTING THROUGH AGENTS

The routing in vehicular networks involves four steps: Neighbor discovery, Context-information, path discovery, routing. Amount of control packets are generated to determine active nearby nodes that are present in the same transmission range. This process is said to be neighbor node discovery. Once the neighbor node is discovered then the environmental factors and their information's are collected effectively through context information process. By using this context information the routes are established among the neighbor nodes. Routing is done using two phase namely bandwidth estimation phase and link instinct phase. Each node evaluates its position 'p' and velocity 'v' so that the Link Instinct (LI) can be identified. LI between nodes is calculated based on the previous route updates.

$$L_I = \frac{\sum \forall nodes\_pairs\,(\mathrm{i,j}) \rightarrow L_I^{(\mathrm{i,j})}}{N(\mathrm{N}-1)} \qquad (1)$$

Link Instinct is calculated between all pairs of nodes (vehicles) present in the network. The average LI (avg LI) is calculated and compared with LI. If avg LI is greater than the obtained LI then the link gets disconnected soon. The average link convergence is determined for all nodes as well as agents in the network and thus defined as

$$avg\ L_I = \frac{\sum \forall nodes\_agents\,(\mathrm{L_I}^{(\mathrm{i,j})})}{N} \qquad (2)$$

Then the packets are routed from one node to the other through a wireless radio link that satisfies the QoS requirements. Communication between vehicles takes place four methods (i).V2V (ii).V2I (iii).Cluster to cluster and (iv).Cluster to Regional Transport BS (RTBS).

Bandwidth estimation phase involves identifying the bandwidth consumed by the hello message from the total available channel bandwidth. The available bandwidth is calculated using the equation (1),

$$B_A = (I_{bw} - C_{bw}) / M_f \qquad (3)$$

The bandwidth consumption is calculated using residual bandwidth (Rbw) and the bandwidth consumed by the current source node (ibw) times of Mf. The critical information is passed with higher priority by finding more bandwidth nodes.

$$C_{bw} = (R_{bw} - i_{bw}) * M_f \qquad (4)$$

Bandwidth threshold (Bw_Thresh) is calculated and set using average bandwidth consumption. The high bandwidth route is selected for data transmission.

$$Avg\left(B_A\right) = (Max\_Data\,rate)_{\mathrm{n}}\ / time \qquad (5)$$

$$B_{w\_Thresh} = Avg(\mathrm{B_A}) / Hop\_Count \qquad (6)$$

Therefore by estimating the link instinct between nodes and bandwidth availability, the reliable path is selected based on higher link instinct with high bandwidth nodes.

A. Mobile agent to Mobile agent (V2V)

This vehicle to vehicle communication resembles peer to peer network architecture. The vehicles are the mobile agent that moves around the network and information between the vehicles are passed within their transmission range. The routing between the vehicles is done using PSR protocol based on the life span of the link. If the link fails at a certain time period but the node has information to send through the link then a new route request is generated for the

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path establishment. The information consists of agent ID, source address, destination address, sequence number, hop-count, TTL.

Algorithm for V2V

Begin
Initialize Src agent → S
Set Destination → D
Check for data availability
While S != D;
Get neighbour
For all nodes 'n'
{
Check for 'L_I'
If {
L_I > avg L_I
Link exists
Generate M_f
Create link
Revert M_f
Calculate B_A
Measure R_{bw}
Set B_{w_Thresh}
Pick route with high L_I & B_w
Send data → S
}
Else {
Reselect the route
}
End

B. Mobile Agent to Static Agent (V2I)

A fixed infrastructure consists of RSU which are placed in the road side environment (highways) facilitates in uploading/downloading the information from or to the vehicles passed by. Each RSU covers the group of vehicles termed as clusters. The vehicles enter into the cluster and leaves at some particular instant. The RSU has particular knowledge base includes road conditions, visited vehicles, traffic density, cluster services, weather condition, etc. Service Agent (SA) is placed in the cluster to collect the information, and then the collected information is sent to the RSU agent. RSU broadcasts the information to all the vehicles and vehicles thereby pass the information in V2V manner. Based on the link instinct 'L_I' the information is passed to all the vehicles but passing same information to the same vehicle with different node ID and different sequence number creates unnecessary overheads. This causes unnecessary delay and congestion in routing. The algorithm for V2I communication is depicted. Figure 2 describes data routing between vehicles and RSU's through SA.

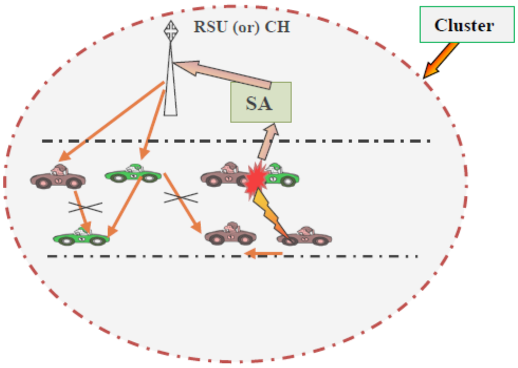

Figure-2. V2I Data Communication through SA

Algorithm for V2I

Begin
Mobile Agents 'A' & 'B' → Accident
SA → Send Information to RSU
RSU broadcasts information to all vehicles
Generate RReq
Check Data ID
If {
Data exists already
Neglect RReq
} else {
Pick route with high L_I & B_w
Revert RRep
Send data
}
Else {
Re_Generate RReq
}
End

C. CA to CA (or) RSU to RSU

The groups of self-managing vehicles are formed as clusters in the network. The network topology changes dynamically and the clusters adapt to the changes by themselves and forms new configurations. Road side units are acts as cluster head nodes that communicate information to other cluster head or RSU's. These RSU shares the obtained information to their cluster members as well as to the RTBS.

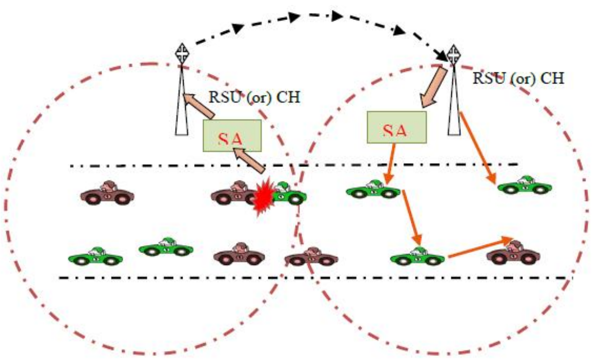

Figure-3. Communication between RSU to RSU

D. CA to RTBS

RTBS is dumped with complete information about transportation infrastructure that collects various clusters

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information and stores in the knowledge base. The RTBS collects overall information such as road conditions, traffic density prediction, critical events like road accidents, etc. The collected information is routed from RSU's to the RTBS in a timely manner.

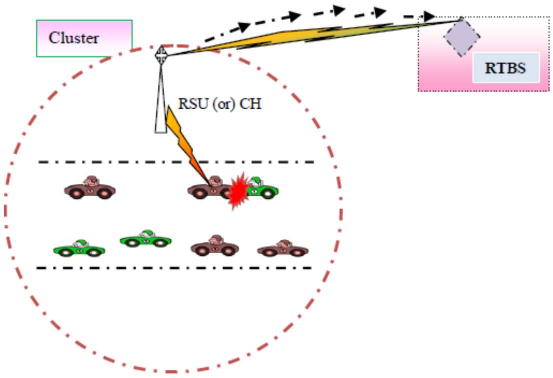

Figure-4. CA to RTBS

VI. SIMULATION RESULTS

The Co-operative cluster based multi-agent approach for efficient traffic forecasting is simulated using the simulation tool Network-Simulator-2. Vehicles are placed and random way point mobility model is applied to the vehicles. The vehicles enters in the RSU shares the information and if more number of vehicles present on the same lane at the same time, then this information is forwarded to the other RSU in order to forecast the information to the vehicles present in the other RSU. SA is placed to pass the emergency information's like road accidents, traffic congestion with high vehicle density etc., So that the vehicles can take alternative path.

The simulation parameters are given in the table 2. The channel and data model used between the vehicles is data congestion traffic model. For accessing media type vehicles use CSMA/CA. Based on link and bandwidth estimation the reliable routes between the vehicles are identified. The parameters like Packet Delivery Rate (PDR), Packet Loss Rate (PLR), Throughput and average delay are shown for the proposed model efficiency. The proposed model CCMAA is compared with the existing DMS and MADC protocols.

Parameter	Value
Channel Type	Wireless Channel
Simulation Time	100 sec
MAC type	802.11
Traffic model	CBR
Data Rate	11Mbps
Transmission range	250m
Network interface Type	WirelessPhy
Mobility Model	Random Way Point

Table-2. Simulation Parameters

Performance Evaluation

The simulation of the proposed CCMAA method is achieved using NS2. The most important advantage of using NS2 to validate this model is the simple scalability factor using the front end Object Oriented Tool Command Language (OTCL) when compared to the back end C++ programming. The metrics PDR, PLR, delay and throughput are evaluated to perform the comparison using the equations (7), (8). (9) and (10).

- **Packet Delivery Ratio**

PDR is computed using the formula,

$$PDR = \frac{\sum_0^n PktRcv(n)}{\sum_0^n PktRcv(n) + \sum_0^n PktLost(n)} \quad (7)$$

- **Packet Loss Ratio**

PLR is computed using the formula

$$PLR = \frac{\sum_0^n PktLost(n)}{\sum_0^n PktRcv(n) + \sum_0^n PktLost(n)} \quad (8)$$

- **Average Delay per node**

Delay per node is measured using

$$Avg.Delay = \frac{1}{n}\left(\sum_0^n PktSent_{TIME}(n) - PktRcv_{TIME}(n)\right) \quad (9)$$

- **Throughput**

Throughput of the network can be calculated using

$$Throughput = \frac{\sum_0^n PktsReceived(n) * PktSize}{1000} \quad (10)$$

The PDR and PLR comparison for the proposed and existing scheme is shown in the figure (5) and (6). The delivery rate for the proposed method is better than the existing methods. The loss rate is comparatively low compared to DMS and MADC protocols.

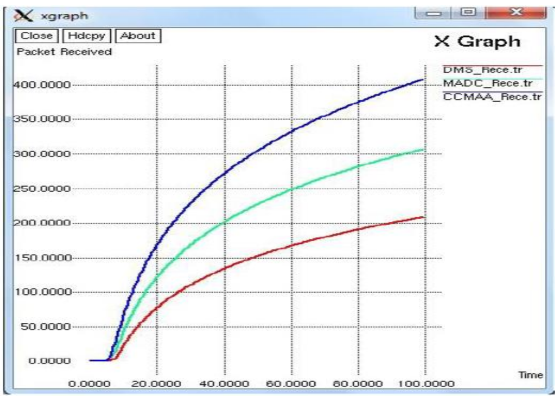

Figure-5. PDR

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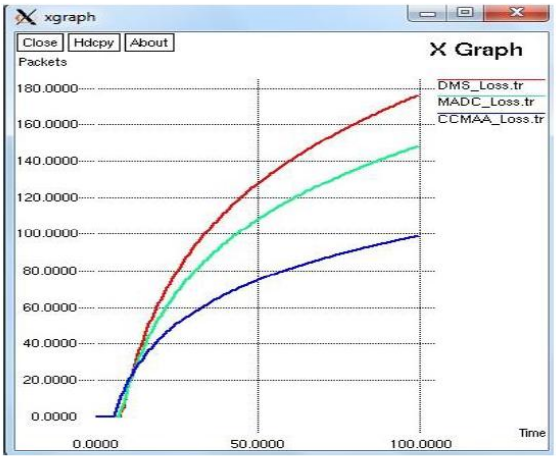

Figure-6. PLR

The average delay taken for the packets to receive by the sink is given in the figure 7. The delay of the proposed scheme is comparatively better when compared to the existing models.

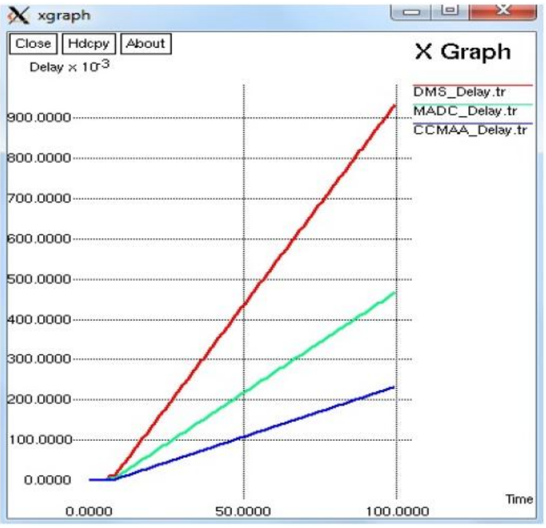

Figure-7. Average Delay

The throughput of the network is determined using the successful packet delivery rate with respect to the packet size. The figure 8 shows the throughput of both existing and proposed model. The achieved throughput is better for the proposed model.

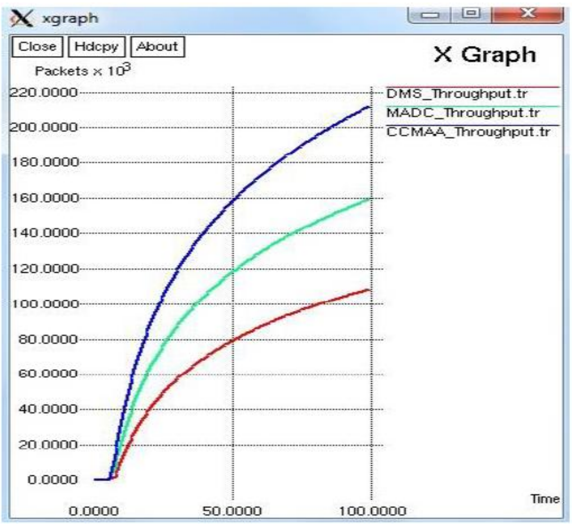

Figure-8. Throughput

VII. CONCLUSION

Cluster based Multi-Agent Approach (CCMAA) for intelligent routing protocol is proposed here. By using the intelligent multi agent systems an effective routing is implemented that reduces network traffic while transmitting information's among the vehicles. Service Agent plays a vital role for transmitting the critical information in prior to the other vehicles and RSU's in cluster basis. Link Instinct and bandwidth estimation provides selection of reliable routes for transmitting the data among agents. Therefore the proposed scheme achieves better network throughput compared to the existing protocols. The simulation analysis is done and the metrics are evaluated. The proposed protocol is 0.33% better comparing to the existing in terms of achieved data delivery rate.

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