CONGESTION AVOIDANCE TRAFFIC AWARE ROUTING (CATAR) PROTOCOL IN VANET

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Abstract-

Vehicular Ad Hoc Networks (VANETs) are a special class of Mobile Ad Hoc Networks (MANETs). It is an emerging technology which is gaining attraction of most researchers who are engaged in improving traffic monitoring and driver's safety. Position-based routing protocols are considered best for high dynamic network like VANET. E-GyTAR (Enhanced Greedy Traffic Aware Routing) protocol selects higher density routes for junction selection mechanism, but does not consider the possibility of congestion, which can occur frequently in city area. CATAR proposes a new intersection-based geographical routing protocol based on E-GyTAR which also takes into consideration the traffic lights and the possibility of congestion in city environment. Simulation results exhibit higher packet delivery ratio and reduced end to end delay. Also average throughput, routing overhead and packet dropping is concluded.

Keywords- VANET, E-GyTAR, congestion, V2V,CATAR

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1. Introduction:

VANETs (Vehicle Ad hoc NETworks) are a type of mobile wireless networks In this the vehicle acts as mobile node where vehicles can communicate with each other and with nearby fixed roadside infrastructure. The communication between vehicles is possible using a dedicated short range communication (DSRC) [2]. There are two types of Vehicle to Vehicle communication (V2V): one hop communication (direct vehicle to vehicle communication), and multi hop communication (vehicle relies on other vehicles to retransmit). For vehicle to vehicle (V2V) communication and vehicle to Road Side Units (V2I), vehicles must be equipped with some sort of radio interface or On Board Unit (OBU) that enables short-range wireless ad hoc networks to be formed.

2. Architecture of VANET:

Vehicles in VANET are equipped with wireless communication devices (also known as On-Board Unit (OBU)), GPS, digital maps and vehicle sensors. Vehicles move along roads and exchange information with other vehicles and roadside infrastructure called Road Side Units (RSU) within their radio range. Hence there are two types of communication in VANET: vehicle-to-infrastructure (V2I) communication and vehicle-to-vehicle (V2V) communication. V2I can provide real-time information on road traffic conditions, weather, and basic Internet service via communication with backbone networks. In V2Vcommunication environments, vehicles are wirelessly connected using multi-hop communication without access to any fixed infrastructure [2]. RSU collect the real time traffic information, analyze it and then broadcast it to network so that drivers can select appropriate route. Also virtual traffic lights set their timings based on this collected information to help avoiding congestion. Vehicles can dynamically form infrastructure-free ad hoc and send messages (unicast, multicast, geocast and broadcast) to destination. Following figure shows the architecture of VANET:

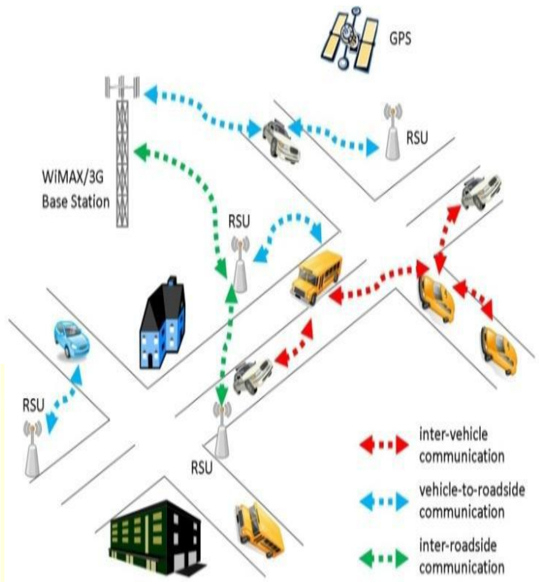

Figure: Architecture of VANET

3. CATAR Protocol:

CATAR (Congestion Avoidance by e-greedy Traffic Aware Routing) protocol is a novel protocol which is able to monitor the real-time traffic status of adjacent roads by considering both road traffics and network traffics simultaneously. Congestion often means stopped or stop-and-go traffic. [9] While the high density road is defined as number of vehicles per lane-kilometer.

Following assumptions are made in this protocol:

i. CATAR assumes that all nodes in the network are equipped with wireless communication devices with the transmission ranges. Any two nodes are able to communicate with each other if they are aware of each other's existence.

ii. Each node is equipped with GPS device, which enable them to acquire its own position.

iii. It also assumes that the source already knows the current position of the destination before transmission by using the location service.

iv. All nodes are aware of the street-level information of the area where they are currently positioned. The street-level information should contain: (1) each road's ID and its length (2) each junction's ID, range and its position (3) the relationship of road connectivity.

3.1 Working of CATAR

- **Collecting neighbor node information**

In CATAR, nodes are required to periodically broadcast "hello" messages to their neighbors in order to update their current information. From the updated information, nodes are able to select the next suitable hop for data transmission. Table2 shows the packet format of the hello message.

Hello Message					
Position (x)	Position (y)	Road ID	At Junction (True /False)	Congestion level	Speed

- Position x and Position y represent the current x and y coordinate of the node.
- Road ID represents the identity of a road or the junction that a node is currently positioned.
- At Junction defines whether the node is in the area of the junction or not.
- Congestion level here represents the level of channel busy time and
- Speed determines the current speed of the node.

3.2 Routing Process in CATAR

In the routing process of CATAR, the junctions are defined as vertices and the roads are described as the edges between two vertices. Each edge has its own score. For given two vertices, it calculates the routing path with the lowest association score. CATAR is a real-time traffic-aware protocol, so the score it uses can be dynamically adjusted according to the real-time traffic status it has monitored. Also it is assumed that the node obtains free channels to broadcast the packet frequently. Each node is initialized and searches for free channel.

When a free channel is obtained, the node broadcasts its "Hello" packet to make aware of its presence to other nodes of the network. The neighbor node information is obtained from neighbor packet from the neighbor information packets through location services. Each source is required to compute the routing path at the beginning of a transmission.

There are two different functions of a node based on its current position:

- Node not at junction
- Node at junction

For the first situation when the node is not at junction:

- When a node on the road receives a packet, it first checks the destination of this packet. If the node itself is not the destination of this packet, it will try to find a suitable next hop according to the determined routing path.
- If there is a suitable next hop to forward this packet, then the task of this node is terminated, otherwise this node will store the packet until a suitable next hop becomes available.

For the second situation when a node is at the junction:

- When a node receives a packet, it also checks the destination of this packet first.
- If the destination of this packet is not designated for this node, it then checks if it is the first time this packet has reached to this junction.

If this is true, the node (called junction node) computes the new routing path for this packet and then finds a suitable next hop according to this new routing path and the calculated score, or else this junction node will try to find a suitable next hop according to the determined routing path. In contrast to nodes on the road, if the junction node cannot find any next hop to forward this packet, it would re-compute the routing path and repeat the process of finding a suitable next hop again. rand() function can be used to get random number generation to reduce the probability of the same countdown time for different nodes. It will utilize T_c seconds to assign each countdown node a countdown time according to its TTLJ (Time To Live Junction). When the countdown timer is expired, the node sends the message to become the new junction leader. They must periodically collect the traffic information from the adjacent roads and disseminate up-to-date score information. If the junction leader leaves the junction, it chooses the successor to inherit its up-to-date score information from (SI table). Its successor is determined by the value of Time to Leave Junction (TTLJ) which is the estimated period of time for a node to stay at the junction. The value of TTLJ can be calculated as:

TTLJ(t)=D(t)/V(t)

where $D(t)$ is the remaining distance for a node to leave the junction and $V(t)$ denotes the current velocity of the node. The higher TTLJ, the longer time the node can stay at the junction. The junction leader thus can choose the successor with the highest TTLJ from its neighbor information table. Thus CATAR can reduce the overhead which is caused by frequent replacement of junction leader.

3.2.1 Junction Leader selection mechanism

A junction leader is a unique node which is selected from among the nodes at each junction. It is the node at the junction which is responsible to periodically collect the up-to-date traffic information from adjacent connected roads.

Mainly there are three functions for the Junction leader:

A. Traffic Information Collection: Collection of the up-to-date traffic information from adjacently connected roads.
B. Determining the road score according to the collected traffic information.
C. Distributing Score

(A) Traffic Information Collection

There are two types of traffic information that CATAR will collect:

- Road traffic density
- Network traffic congestion information

Traffic Information Collection (TIC) Packet		
Junction ID (Source)	Junction ID (Destination)	Timestamp
Segment ID	Number of nodes	Congestion level

Road Density Traffic Information

When the node that is nearest to the central point receives the TIC packet, it will first calculate the number of neighbor nodes(N_i) from Neighbor table information except junction node and includes this value (N_i) into the corresponding field of "Number of Nodes" according to the segment it is currently at.

Network Traffic Congestion Information:

The congestion information is collected by a special mechanism called Polling. Polling is based on a simple idea: decision by majority.

A vehicle will confirm its congestion area with data received from other vehicles in neighbor table information. If the information received is consistent with the congestion, it is said to be in agreement. When the number of vehicles in agreement surpasses those in disagreement by a certain margin, and the congestion reaches a certain size, the congestion is then validated and broadcasted. This will turn on the red signal. This means the node declares itself to be in congested area. This helps other vehicles to take better routing decision and hence avoid congestion.

Nodes on the road must broadcast "hello" messages with the field of "Congestion Level". Once it is detected that the node is in congestion, it determines the congestion level. When a node enters the road, it starts to monitor the channel. Traffic congestion impacts can be measured based on roadway volume to capacity ratios:

$CL_n = (V_n/C_n)$

Where CL_n is the congestion level measured by node n and (V_n/C_n) is the volume to capacity ratio calculated by node n. V_n/C_n ratio less than 0.85 is considered under-capacity, 0.85 to 0.95 is considered near capacity, 0.95 to 1.0 is considered at capacity, and over 1.0 is considered over-capacity. Various factors can affect roadway capacity and therefore congestion costs, including vehicle type, traffic speeds, lane width and intersection design.[9]

3.2.2 Determining Road Score

CATAR calculates the weight of each road can be dynamically adjusted according to the collected traffic information. Once receiving the filled TIC packet, the junction leader determines the score of the road (S_{road}) as follows:

Score = $\alpha * (1 - Dp) + \beta * T + \gamma * C$

Where Dp =distance from candidate junction to destination/current junction to destination

α,β,γ= weighting factors for distance, density & congestion

T=Total number of vehicles between current and next candidate junction in direction of destination

C= congestion level

After determining the score of the road, the junction leader stores this score in its Score Information (SI) table:

Score Information Table				
Junction ID (From)	Junction ID (From)	Score	Time stamp	Signal (Red/ Green)

3.2.3 Packet Forwarding

Once the suitable next route is selected by calculating the score, the packet is allowed to forward between the two selected junctions. The node carrying the score information forwards the packet to next hop.

4. Simulation Setup

The first step for simulation setup is to create Vehicular Ad Hoc Network. We designed city scenarios/network for evaluation of CATAR routing protocol. VANET city scenarios are created by using VanetMobiSim. In this step we designed roads networks by extracting the real map from TIGER data sets of Vanetmobisim. To get the real scenario, Ahmadabad city map is extracted from .osm(open street map) file. This file is then converted to TIGER maps suitable for Vanetmobisim simulator.

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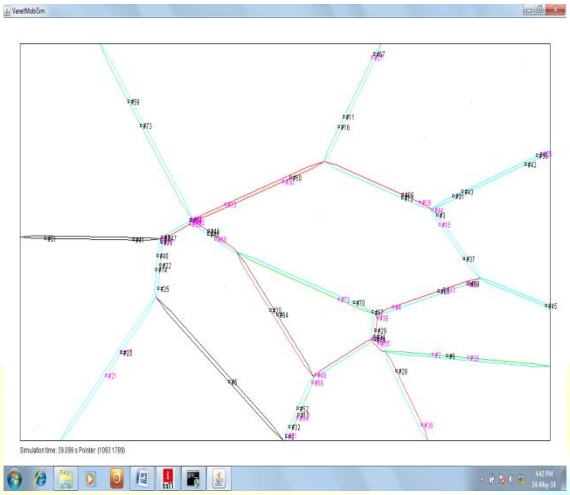

Figure: Simulation area

Each input parameter for the simulation of city scenario is as follows:

Parameters Settings		MAC/Routing	
Simulation Area	2000*2000 m^2	MAC Protocol	802.11
Simulation Time	500 s	Channel Capacity	2 Mbps
Mobility Model	VanetMobisim	Transmission Range	266 meter
No. of nodes	40,75,100,150,200	Traffic Model	15 CBR connection
Vehicles speed	5-60 m/s	Packet sending rate	4.0
No. of roads	16	Packet size	512 bytes

Table: Simulation Setup

5. Results and Analysis

5.1. Packet Delivery Ratio:

Packet Delivery Ratio metric gives the ratio of the data packets successfully received at the destination and total number of data packets generated at source. The following equation is used to calculate the PDR.

PDR = DataR ÷ DataS

DataR = Data packets received by the CBR agent at destination node

DataS = Data packets sent by the CBR agent at source node

If network packet delivery ratio is high it means most of the sent packets to destination has been received, thus this factor reduce delay as packet receive success rate is high.

Comparison of PDR to random speed, 5 m/s, 25 m/s, and 60 m/s shows higher packet delivery ratio in entire simulation time. When node speed is 60 m/s in the highly mobile environment of proposed routing protocol it have slightly higher packet delivery ratio as compare to use low node speed.

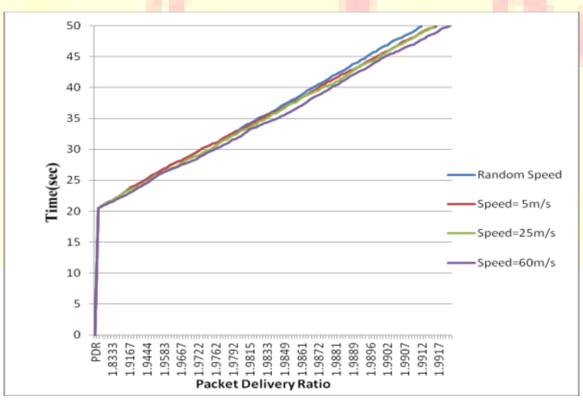

Figure: PDR vs Time for varying speed

Conclusion:

When the node speed is increased in the city scenario then packet delivery ratio is slightly increased. In that case simulation time is constant for all speed scenarios.

5.2 End to End Delay

It is the average time taken by a data packet to arrive at destination. It also includes delay caused by the queue in data packet transmission. The data packets that are successfully delivered to destination are considered.

E2EDelay = ∑ (arrive time – send time)/ ∑ Number of connections

The total number of connections considered is 15. Hence the delay obtained for our scenario is 0.005805489 ms for 75 nodes. Similarly delay for 100,150 and 200 is considered. Hence as the number of nodes is increased the end to end delay is decreased.

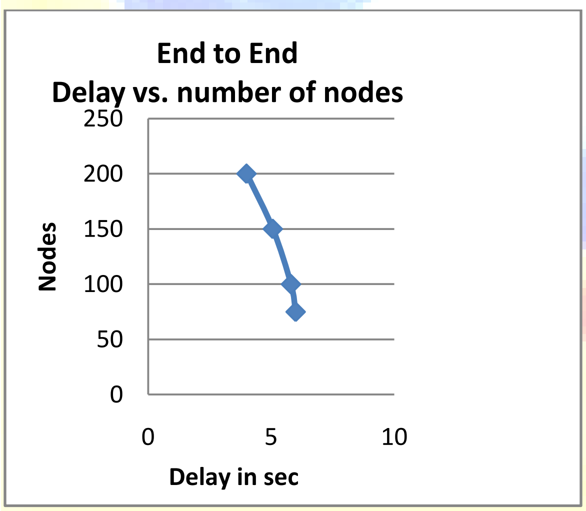

Figure: End to End Delay vs Different no. of nodes

5.3 Average Throughput

Average throughput is the sum of the data rates that are delivered to all terminals in a network. Average throughput of the network obtained is 4.6620 kbps.

6. Conclusion:

In city scenarios CATAR routing protocol is better than Enhanced Greedy Traffic Aware routing in terms of different matrics. This is so because, in the proposed routing protocol congestion factor is considered along with the directional density. While in E-GyTAR routing protocol at some simulation time packet can be dropped that is not in the case of proposed routing protocol. Also the ene to end delay obtained is lower than E-GyTAR.

References:

[1] Kapang Lego, Dr. Themrichon Tuithung, Pranav Kumar Singh, “Simulation based Analysis of Adhoc Routing Protocol in Urban and Highway Scenario of VANET”, International Journal of Computer Applications (0975 – 8887),Volume 12– No.10, January 2011

[2] Kevin C. Lee, UCLA, USA Uichin Lee, UCLA, USA Mario Gerla, “ Survey of Routing Protocols in Vehicular Ad Hoc Networks”, July 2012

[3] Yatendra Mohan Sharma, Saurabh Mukherjee,” A Contemporary Proportional Exploration of Numerous Routing Protocol in VANET”, International Journal of Computer Applications (0975 – 8887) Volume 50– No.21, July 2012

[4]. Moez Jerbi, Sidi-Mohammed Senouci, Yacine Ghamri-Doudane, “Towards Efficient Routing in Vehicular Ad Hoc Networks”,IEEE Transactions on Vehicular Technology 58, 2009, pp. 5048-5059.

[5] Sardar Bilal, Sajjad Madani, and Imran Khan,” Enhanced Junction Selection Mechanism for Routing Protocol in VANETs”, The International Arab Journal of Information Technology, Vol. 8, No. 4, October 2011.

[9] www.vtpi.org, ”Transportation Cost and Benefit Analysis II – Congestion Costs”, Victoria Transport Policy Institute (www.vtpi.org) 28

[10] Aamir Hassan,” VANET Simulation”, Technical report, IDE0948, May 2009