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Cross Layer Based Adaptive Routing Approach for VANET

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Abstract : The modern development in the wireless communication field has enabled Vehicular Ad hoc network (VANET) to be a promising technology for the intelligent transportation system (ITS). This advancement of VANET involves high node density andprodigiousmobility, which makes link breakages and packet drop in the network. So the convergence time for identifying that infeasible path and optimal path has become a crucial one. In order to resolve this issue more efficient and intelligent routing approach has to be designed. Thus this paper proposes a Cross Layer Based Adaptive Routing Approach for the existing Ad hoc Distance Vector (AODV) protocol that is a well-known protocol in VANET. The proposed approach can accelerate the convergence of the feasible route and minimize network overhead by adopting the cross layer design. The cross layer metrics such as signal power, available bandwidth, link residual time, data rate have been used to make the adaptive routing decision in an undesirable situation due to node density and mobility. The simulation are performed using NS2 and the results show that proposed approach performed better than the existing routing protocols of VANET in terms of delay, packet delivery ratio, routing overhead, throughput

Keywords : VANET, cross layer design, AODV, convergence time, adaptive routing, congestion, mobility.

1. INTRODUCTION

Vehicular Ad hoc Network (VANET) enables the communication between vehicle to vehicle and vehicle to road side unit, involves wide range of safety and communication application. Since VANET has been influenced from MANET but it is different from MANET in several ways such as exhibition of dynamic topology changes, considerably limited network diameter and limited redundancy, frequent fragmentation. Since the VANET are highly mobile there exists a rapid change of topology and the occurrence of obstacles makes the link breakage in the network [1]. While selecting the road segments with high node density to discover routing paths can evade from link breakage but it will acquire a huge amount of data traffic on these road segments, leads to severe packet drops because of packet collision. So the convergence time for identifying these types of infeasible path and optimal path has become a crucial one.

Addressing these issues and developing an efficient routing to find an optimal route is the essential concern in the research areas.In view of that, researchers have develops a number of routing protocols with different types of metrics, for example node location, hop count, speed, traffic and so on [2, 3, 4] in order to optimize the flow of packets. Based on the routing update information, the routing protocols have been classified into three categories such as proactive, reactive and hybrid one. In proactive routing protocol, a periodic routing approach has been carried out which adds significant overhead to the network traffic, while the reactive routing approach the route update mechanism carried when the packet exchange is initiated or older routes have been failed. These approaches are generally static and predefined in the protocol rather than being relied upon runtime network condition. Adaptive route update with runtime network condition can be achieved by cross layer design.

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Hence the proposed work considers the reactive protocol “Ad hoc Distance Vector protocol (AODV)” with the cross layer design. In our previous work [5] the mobility pattern and signal quality has been considered to discover the optimal path. The proposed work enhances ourprevious one by addressing the congestion, moreover the road pattern has also been considered like a real time scenario. Hence, the proposed approach can accelerate the convergence of the feasible route and minimize network overhead by adopting the cross layer design. The cross layer metrics such as signal power, available bandwidth, link residual time, data rate have been used to make the adaptive routing decision in an undesirable situation due to node density and mobility.

The rest of the paper is organized as follows: Section 2 discusses the related works. The system model and assumption has been explained in the section 3. The proposed Cross Layer Based Adaptive Routing approach has been explained in section 4. The results and discussion has been provides in the section 5. Finally, section 6 renders the conclusion.

2. RELATED WORK

In [6], the author proposes an enhanced greedy traffic-aware routing (E-GyTAR) for VANET, which is an enhanced version of the greedy-perimeter stateless routing (GPSR). This work considers a real time urban situation with bi-directional roads and multi-lane. The traffic flow has been considered to choose the optimal junction that makes feasible routes. With the two-hop neighbor information, the junction selection and routing mechanism has been processed.

The adaptive route update approach has been proposed in [7] for highly scaled VANET. This approach eliminates the classification of proactive and reactive by classifying them as logical situation to discover and update the route. In [8], proposed a routing algorithm based on the condition of packet delivery rate for VANET in order to build a highly stable. The optimal routes are finding out by using the average delay time and packet delivery rate factors.

The Contention based routing protocol [9] has been enhanced by adding 2 novel techniques that is used to present two new routing protocols for VANET [10]. The duplicate messages has been controlled in this protocol that reduces the routing overhead in the network

A routing protocol namely DR2 [11] aware about the delay and reliability of VANET. A cross layer communication has been processed between the MAC and network layer in DR2. Here the MAC layer examines the delay, velocity vector and signal to noise for all routes of neighboring nodes, after that the network layer chooses the feasible path according to the fuzzy inference system.

In [12], the author designed a system namely machine learning-assisted route selection (MARS) system for VANET. The movement of vehicles has been predicted using the machine learning technique and then the optimal route has been chosen with better transmission capacity. Moreover, the MARS aids to decide the forwarding direction between two road side units based on the estimated location of the destination and computed transmission delays in both forwarding directions.

An interference routing scheme is proposed in [13] for multi-radio vehicular networks. In order to remove the impacts of co-channel interference observed by vehicles, transmission channels are allocated according to the periodical evaluation of average Signal-to-Interference ratio. In [14], the author proposed a connectivity-aware intersection-based routing (CAIR) protocol to choose the feasible route that has great probability of connectivity and minimum convergence time. The data transmission has been processed by geographical forwarding between any two intersections along the feasible path.

In [15], the author introduced a QoS-Aware node Selection Algorithm (QASA) for VANET. The next hop vehicle has been selected by using the bridging approach. The throughput and delay are used as QoS metrics. The probabilistic rebroadcasting scheme is used in this algorithm relied upon different metrics such as inter-vehicle distance, vehicle density and communication range. A geographical routing protocol based on road perception has been proposed in [16] for VANET. To improve the geographical routing the protocol uses the direction, relative distance and midrange forwarder node.

In [17], the author proposed a novel position based routing protocol for VANET. This protocol ensures the connectivity of routes. This protocol is a hybrid one which includes the store-carry-and-forward and greedy forwarding approach. Based on particular assumption, the packet drop rate has been minimized in this protocol.

3. NETWORK MODEL AND ASSUMPTION

This section presents network model and the assumption for the proposed work. Let consider a Vehicular ad hoc network (VANET) which consists of n number of moving vehicle with road side unit. And at each junction are node segment a static node has been presented (*i.e*. traffic signals). The moving and the static nodes are equipped with the On-Board unit (OBU) that involves sensors, memory storage and processing unit. . Figure 1 shows the network model of the proposed approach in a real time VANET scenario.It has been assumed that each node has been fitted out with the short range wireless device and they all have the same transmission range R. The nodes are aware about their current location information with the GPS navigator. Each static node holds the information about the junction radius which indicates the length of the road from it to neighbor static node

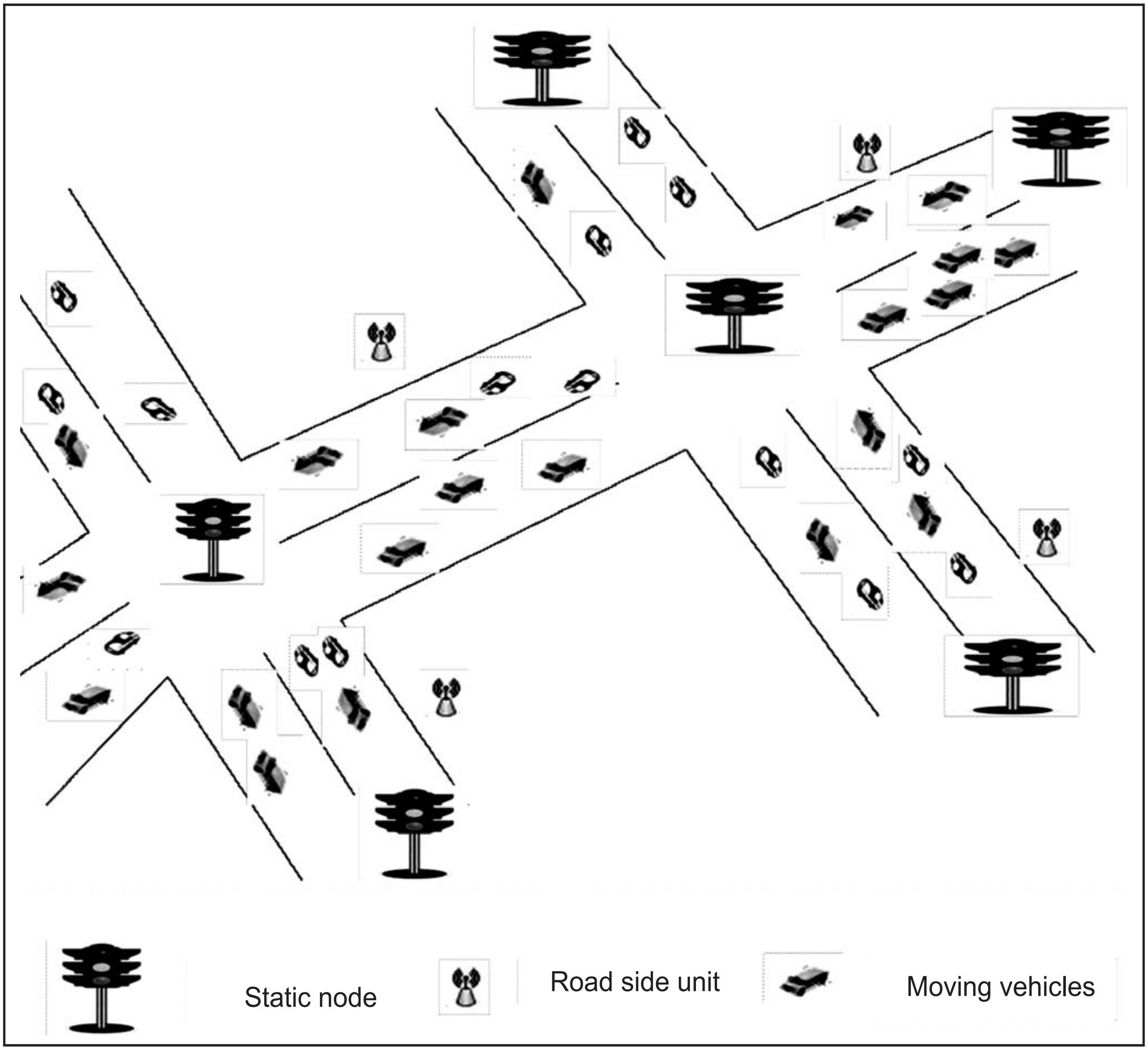

Figure 1: VANET

4. CROSS LAYER BASED ADAPTIVE ROUTING APPROACH

This section present the proposed cross layer based adaptive routing approach for VANET. The routing protocol designed for MANET such as AODV has not appropriate for VANET scenario due to huge node density and high mobility. So, making them to adaptable for these characteristics is crucial one. For that reason, in this paper an adaptive routing scheme has been designed using the cross layer approach.

Figure 2 shows the proposed cross layer framework. The physical layer information such as link residual time and signal quality is used to identify the quality of the link to forward the data. While the MAC layer information such as the bandwidth estimation and the data rate are used to identify the congestion level (MAC overhead) and then adjust the data rate according to the MAC information. The cross layer optimizes these information and aid to the network layer to discover a feasible route and reduce the convergence time significantly. This scheme consists of two modules: (*i*) HELLO Protocol module and (*ii*) Optimal Route Selection algorithm

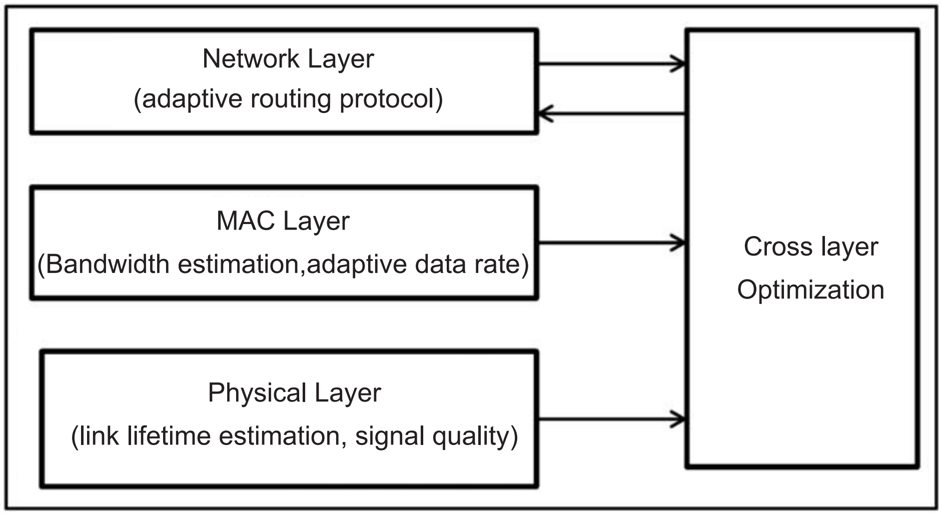

Figure 2: Proposed Cross layer design

4.1. Hello Protocol Module

The HELLO protocol module broadcasts the HELLO periodically in a predefined manner. The Hello message is used to discover on hop neighbors in its communication range. It learnsand updates the information about its one hop neighbors. And the information are link residual time, signal quality, available bandwidth and data generation rate which all estimated using the cross layer design. As previous paper, the link residual time (RT) metric is same which is computed using the free space path loss and the mobility patterns and the equation is given as follows

$$\mathrm{RT} = \frac{d}{v_{sr}} \tag{1}$$

Where d is the distance between two vehicles computed using the free space path loss and v_{sr} indicates the velocity of neighbor node from source to receiver.

The quality of the signal which is known to be Received Signal Strength Indicator (RSSI) at the receiver side can be estimated using signal to noise ratio and the sensitivity of the receiver. In ad hoc network, throughput via the provided route is based on the least possible data rate generation of its whole links. The node with high data rate transmits the packet to a low data rate node will leads to congestion and long queuing delay. So the data rate at each link is computed as follows

$$\text{Data rate} = \frac{\text{Data size}}{\text{Channel delay}} \tag{2}$$

The available bandwidth [18] estimation gains the definite MAC layer overhead details from the MAC layer and it maintains and updates the changes over time. The generation rate of the data from one hop neighbors table has also been used in the estimation of available bandwidth. The equation for estimating the average available bandwidth is given as follows

$$\omega = \left(\rho = \left(\left(\frac{\sum_{\mu=1}^{\theta}(\beta_\mu + \gamma_\mu)}{\theta}\right) + \varphi\right)\right) bps \qquad (3)$$

Where θ indicates the present size of the averaging window φ is the amount of bandwidth assigned to flows, β indicates the total of data rate generation of a node and the nodes within the communication range and the node, and let μ represents the index of the averaging window. indicates the channel rate.

4.2. Optimal Route Selection algorithm

When a source node initiates a route request to transmit a data packet to a destination node, it gets the location information of the destination node and the static node to which the vehicle is travelling towards. The relay nodes will be selected based on the information present in its neighboring table. If the selected relay node comes under the communication range of the static node then it wills forwards the data packet to the static node. Afterwards the static node will selects two road segment based on the location information and forwards the data packet to the moving vehicle in the selected road segment. The road receiver static node may get the redundant RREQ packet from different road segment. According to the packet delivery ratio and the packet delay time, the road segment will be selected for data transmission. The process has been continued until the RREQ packet reaches the destination node. The pseudo code for optimal route selection using the proposed approach has been given in the algorithm 1.

Algorithm 1 Optimal Route Selection using the proposed approach

Inputs: RT (Residual Time), RSSI, ThRSSI, Available bandwidth, data rate, location

Output: Optimal path selection

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Step 1: Begin
Step 2: Do
Step 3: for $i = 0$ to $n$(neighbor node)
Step 4: If static node $\in$ as a neighbor node
Step 5: Select the node as next hop
Step 6: If static node get  redundant RREQ
Step 7: Select the route based on the packet delivery ratio and delay time
Step 6: Select next two road segment
Step 8: Repeat the process from Step 3
Step 9: End if
Step 10: else if destination reached
Step 11: Send RREP packet to the selected route
Step 12: else
Step 13: if ($RT < Th_{RT}$ && $RSSI < Th_{RSSI}$ && $\omega <$ requested bandwidth)
Step 14: Delete the node in the routing table
Step 15: Forward this information to the neighbors
Step 16: else
Step 17: Select the node as next hop
Step 18: End if
Step 19: End if
Step 20: End for
Step 21: End
Step 22: End
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5. RESULTS AND DISCUSSION

The NS2 simulation is used to evaluate the performance of the proposedCross Layer Based Adaptive Routing Approachin AODV protocol ie CL-AAODV. The Simulation setup has been given in the table 1. The proposed protocol is compared with the existing protocols such as AA-AODV [4], DRD [1]. The metric used to evaluate these protocols are throughput, end-end delay, packet delivery ratio and routing overhead.

Table 1
Simulation setup

Parameters	*Values*
Simulation type	NS2
Network size	900×900
Vehicle density	15, 25, 35, 45, 55
Vehicle velocity	3 m/s–30 m/s
Number of lanes	3 lanes
Simulation Time	900s
Speed	40kmph
Physical standard	802.11/802.11p
Transmission range	250 m
Packet size	512 bytes
Data type	CBR

A. Performance Metrics

Packet delivery ratio (PDR)

The packet delivery ratio is the number of packets received correctly at the designated vehicle over the number of originated data packets from the source vehicle.

Routing overheads (RO)

Control packet is the data packet such as hello packet produced by routing protocol. The routing overhead is ratio of control packet produced in the entire data transmission to alldata packets.

Average End to End delay

Average end to end delay is the time interval for the data packet to get through destination. It involves the waiting time in the queue, data processing time, and propagation delay.Usually, these delays acquired during the routing activities and MAC control exchanges.

Throughput

Throughput is the data rate upon that the VANET sends or receives data. It is a measure of the capacity of a channel at a link and connections to the internet is basically rated in terms of how many bits flow per second (bits/s)

B. Discussion

Figure 3 show the packet delivery ratio with respect to vehicle density. The proposed CL-AAODV and the DRD considers both the mobility and network density to select the optimal path, while the AA-AODV considers only the mobility pattern. Since the CL-AAODV performs better than the DRD due to considering the selection of road segment. From the figure 3, it can be observed that the CL-AAODV shows a maximum packet delivery ratio than the AA-AODV and DRD. The packet delivery ratio attained by the CL-AAODV for 55 vehicles is 84%, while DRD, AA-AODV is 77%, 71%. Figure 4 shows the packet delivery ratio with respect to throughput. For different throughputs, the CL-AAODV performs better packet delivery ratio than the DRD, AA-AODV.

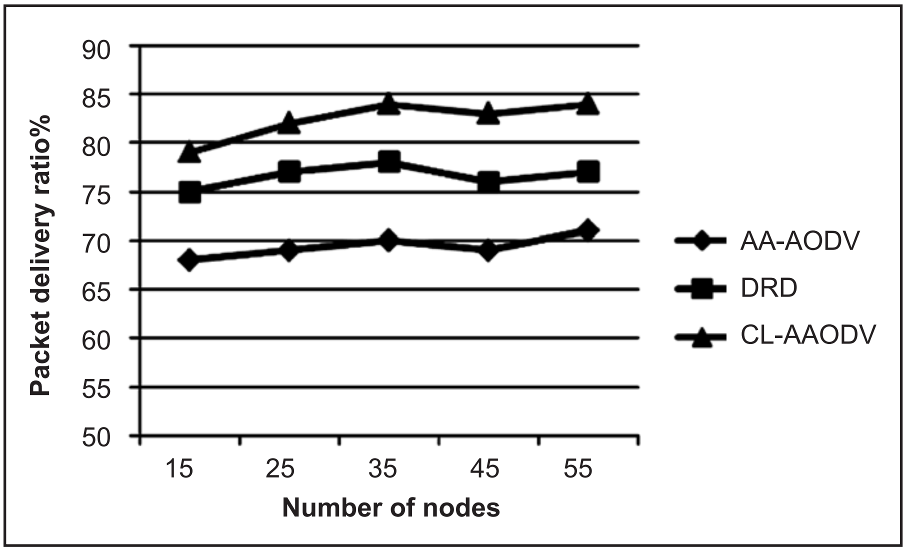

Figure 3: Packet delivery ratio with respect to network size

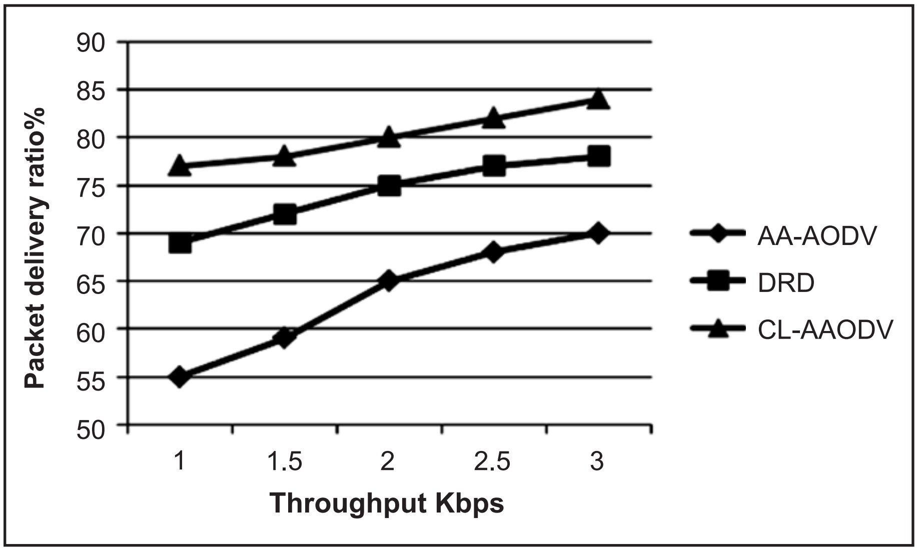

Figure 2: Packet delivery ratio with respect to throughput

As the vehicle density increases in the network, the congestion will be taken place at the data queue or may waiting time of the packet will increase and data rate from the nodes will be minimized. The CL-AAODV select the relay node with minimum congestion, moreover selects the road segment with minimum delay while reaching the static node, so that it makes minimum delay when compared to the DRD and AA-AODV. Figure 3 shows the average end to end delay with respect to vehicle density. The CL-AAODV incurred average delay for 55 vehicles is 0.24ms, while the DRD, AA-AODV is 0.31ms, 0.48ms.

Figure 4 shows the routing overhead with respect to vehicle density 15, 25, 35, 45, and 55. The routing errors due to link breakage and the congestion due to high vehicle density is minimized in the proposed CL-AAODV that makes limited control packet generation in the network when compared to the DRD and AA-AODV. From figure 4, it can be observed that the routing overhead increases significantly when the vehicles density increases. The proposed CL-AAODV performs better than the DRD, AA-AODV. The CL-AAODV incurred 15% of overhead for 55 nodes, while AODV-PNT, AODV incurred 19%, 27%.

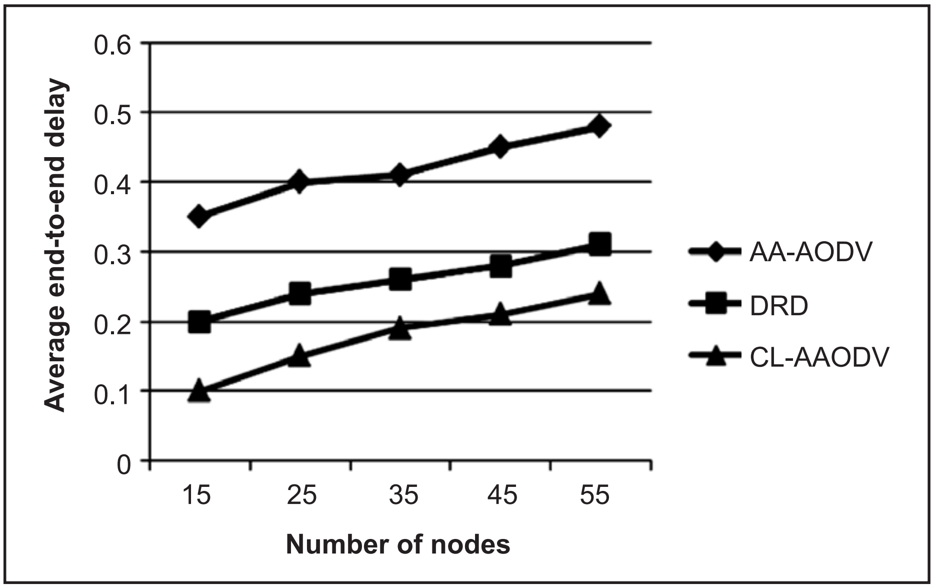

Figure 3: Average end to end delay with respect to network size

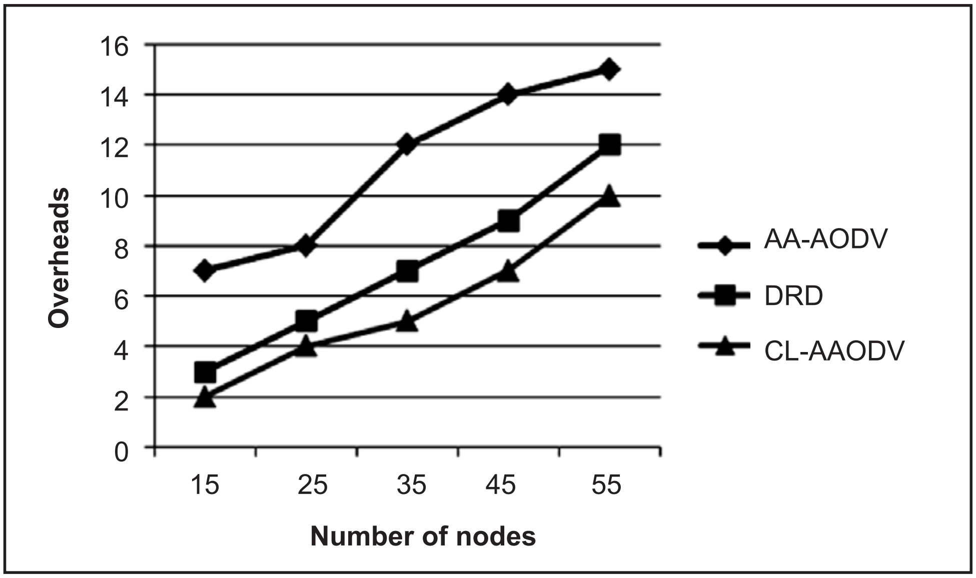

Figure 4: Routing overhead with respect to network size

6. CONCLUSION

The convergence issue due to node mobility and node density has been addressed in this paper related to VANET protocols. A Cross Layer Based Adaptive Routing Approach has been proposed in this paper that can accelerate the convergence of the feasible route and minimize network overhead by adopting the cross layer design. The real time VANET scenario has been considered to make this approach to adapt according to it. The cross layer metrics such as signal power, available bandwidth, link residual time, data rate have been used to make the adaptive routing decision in an undesirable situation due to node density and mobility.The simulation are performed using NS2 and the results show that proposed approach performed better than the existing routing protocols of VANET in terms of throughput, delay, overhead and packet delivery ratio

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