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RESEARCH ARTICLE

# Reliable path identifying protocol in VANET

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## Abstract

**Objective:** The objective of this work is to enhance Adhoc On-demand Distance Vector (AODV) routing protocol for better communication through reliable routing scheme. **Methods:** In this paper, a reliable path selection algorithm is proposed to find the Most Reliable Path (MRP) between the source and destination vehicles. Reliable Path Ad-hoc On demand Distance Vector (RP-AODV) is proposed for efficient route discovery in Vehicular Ad-hoc Network (VANET). The algorithm divide network into manageable group and it maintains Cluster Member (CM) updates handling, Cluster Head (CH) re-selection, Cluster merging. The efficient routing decisions would lead to better communication in VANET. It is made by assigning dynamic and static information appropriately to the variables in process. The dataset used is both static and dynamic which is efficient in when compared with existing protocols. **Findings:** The finding of most reliable path in the network of VANET is carried out by the proposed reliable path selection algorithm. The algorithm divides the network as various parts that comprise the information of clustering. The clustering is the mechanism of grouping of nodes into clusters. Clusters possess members and head. The cluster head would be the point of initiation of communication and any node can be re-selected as cluster head. The members of clusters would be updated as per changes in clustering mechanism. The uniqueness of the proposed algorithm revealed through easy identification of vehicles to form a cluster, cluster members maintenance, and fast data communication over the network. The proposed RPAODV adds the extra fields for RouteREQuest (RREQ) and RouteREPly (RREP) messages (CH and CM information). It also works out for static and dynamic topology in good manner by the implementation of modified AODV algorithm. The scalability is also taken care by enhancing topology variant. The performance of the algorithm is measured and analyzed with the existing protocols and posted in graphs. **Novelty:** The simulation results show that the proposed work outperforms 60% than the existing schemes works Cluster-based VANET-oriented Evolving Graph( CVoEG), Leapfrog-Anti-Colony Optimization(LP-ACO) in terms of route reliability (0.11s high), packet delivery ratio (20% high), end to end delay (0.5 s average), and throughput (10 kbps high).

**Keywords:** VANET; Routing Protocol; RPAODV; Clustering; Reliable Routing; and Cluster message

## 1 Introduction

Vehicular Ad-hoc Network (VANET) reduces the death rate due to road accidents through the wireless communication in Intelligent Transportation System (ITS)[1–4]. The communication carried between Vehicular-to-Vehicular (V2V) and Vehicular-to-Infrastructure (V2I) in which infrastructure includes those support traffic services like traffic signal etc.[3].

In ITS, Road Side Units (RSUs) are available for data communication that includes hardware and software equipment[5–7]. It comprises Global Navigation Satellite System (GNSS) receiver, WiMAX, Long Term Evolution (LTE) and so on. Inter-vehicular communication is made through clustering[8]. In data communication, many issues like redundant transmission which causes collision. The message duplication would reduce the network performance. The issues referred as broadcast storm that would be eliminated by efficient protocols.

VANET is skyrocketing technology that needs the research eye on it for obtaining efficient applications in the world of Internet. It excels in various applications in terms of location-based and service-based[9–11]. The node that is the vehicle is considered with the information like their location and the network it communicates. Various research papers identified the problems in the network and also proposed algorithms to overcome to solve to some extent. But the efficient routing algorithms could be proposed comparatively with the previous works. In Paper[12], the clustering of location based and of application based is reviewed with the future directions for cluster based protocol is also revealed.

VANET is the child of Mobile Ad hoc Network (MANET) that works on cluster of vehicles. Broadcast storm is the problem that would occur in communication between nearby vehicles. Being short range communication, the problems could be redundancy in information, rebroadcasting occurrences and collision issues. The scalability is also considered in message transmissions. Selection of clusters also paves way for efficient communication in VANET. The Selective Reliable Communication (SRC) Protocol is the proposed protocol in[13] to overcome the above problems by selecting clusters as "Zone of Interest". And the performance is also revealed with the excellent comparative results with the previous works.

In paper[14–18], new clustering formation technique is proposed to avoid destruction of network links and efficient routing. VANET comprises of wireless network of moving cars and parked or stopped cars. The clustering technique chooses the stopped car as cluster head and gateway node for the data communication over VANET. The optimal routing path is identified and produces good results when compared with Link Reliability-based Clustering Approach (LRCA) and Cluster-based VANET oriented Evolving Graph (CVoEG).

Intelligent Transportation System possesses VANET which is dynamic. The proposed system in[18] is the best performing routing protocol AODV. In the research[15], AODV and Ant Colony Optimization (ACO) technique is applied to reduce congestion in network. It creates the shortest distance path and acquire high network bandwidth. The traffic congestion is reduced in VANET that has a new cluster-based routing protocol combining a modified k-means algorithm with continuous Hope field network and maximum stable set problem(KMRP)[19]. In Paper[20], a novel African Buffalo based Greedy Routing (ABGR) technique is proposed to enhance the utilization of energy and lifetime of nodes in VANET. The blockage is lessen and cluster based communication is improved by the proposed work. The Table 1 reveals the various protocols methodologies, strength, and limitations considered [15,16,18–20].

**Table 1.** Methodologies , strengths, and limitations of various routing protocols [15–19]

| Paper | Methodologies | Strength | Limitations |
|---|---|---|---|
| [15] | Maximum Eigen-centrality score is considered in most reliable routing scheme called CEG-RAODV. | Time complexity is reduced. Scalability is considered good. | Performance metrics is about 30% - 40% only. |
| [16] | Reliable data transmission in the network by using Leapfrog algorithm | The parameters outperform the existing ant colony optimization technique used for routing. | Scalability have to be considered for high number of nodes and performance metrics is to be improved |
| [17] | An Enhanced Hybrid Ant Colony Optimization Routing Protocol (EHACORP) has two phases. In phase 1, the EHACORP relies on a distance calculation method to compute the distance between vehicles. In phase 2, the source-based ant colony optimization is used to guide the ants to build a shorter path with the least number of hops to transmit data. | Improve the efficiency of the routing process using the shortest path | Time Consumption is to be reduced |
| [18] | AODV with Ant Colony Optimization (ACO) | Reduces the congestion of network | Consumption of Network bandwidth is to be decreased |
| [19] | Modified K-Means Clustering Algorithm and Continuous Hopfield Network | Avoids traffic congestion and collision | Reliability of routing should be improvised. |
| [20] | African Buffalo based Greedy Routing (ABGR) technique | Routing overhead reduced and effective infrastructure communucation | Scalability with uniform speed of vehicles should be considered |

Figure 1 represents the various protocols used in VANET. Protocols are the set of rules to define proper data communication. The issues of broadcast storm would be removed by the proper implementation of needed protocol in the communication of vehicles. The proposed work paves the way for efficient protocol for better communication in VANET.

In all of the above related works from various research papers, the communication in VANET is improvised by various protocols. Each of the protocol considers communication to be fast, reliable and efficient. In this study, the reliable path is aimed for the effective communication. The rest of this article comprises the methodology for the proposed reliable path selection for VANET in Section 2, Results and Discussion in section 3, and conclusions in section 4 and section 5 represents references.

## 2 Materials and Methods

The proposed RPAODV protocol focused in reliable path form source to destination. It includes static topology in VANET communication that minimizes time consumption. It also overcomes the problem of scalability. Additionally, the proposed protocol discovers the MRP for efficient journey of data between the source and destination. The proposed RPAODV adds the extra fields for RouteREQuest (RREQ) and RouteREPly (RREP) messages (CH and CM information). First, let us see RPAODV algorithm to find MRP in the Figure 2.

The RPAODV route discovery assumes every vehicle follows reliable algorithm to find the MRP. The route discovery process either follows inter-cluster or intra-cluster route discovery to form clustering. The source vehicle $Src$, if wants to discover a reliable path $RP$ to the destination vehicle$dest$.

To form reliable path clustering the following assumptions are formed. They are

1. Source vehicle($Src$) creates a RREQ and forwards to CH.
2. If a destination ($dest$) is in routing table of CH then intra-cluster communication is processed to reach destination ($dest$) through proposed reliable algorithm.
3. If a destination ($dest$) is not in the routing table of CH then the inter-cluster communication is processed hop by hop until the MRP discovery.
4. Every CM receives the Source ($Src$) vehicle's RREQ message and checks for the destination($dest$).
5. If the destination ($dest$) matches then the discovery process stops and RREP is forwarded backward to reach Source ($Src$).

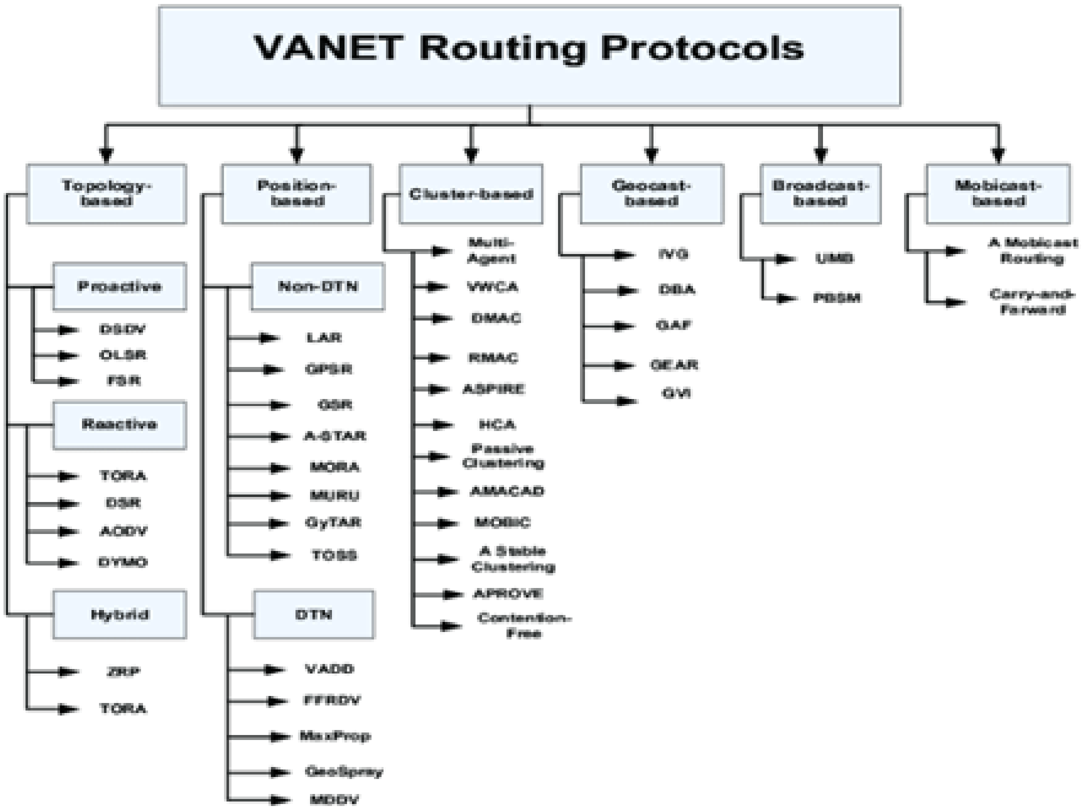


**Fig 1.** Various Protocols in VANET [11]

6. If the RREQ is not find out then RREQ is forwarded to Road Side Unit (RSU) to reach the destination $(dest)$. The RPAODV route discovery is detailed in Figure 3.

## A. Cluster Member Update

The RPAODV cluster member update is a necessary process because of speed or direction change of a vehicle *v*. CH estimates current location of a vehicle *v* based on previous speed and location. Therefore, the CM update is required process to update the CM current speed and location to forward the data without fail. The Figure 4 presents the cluster member update.

## B. CH Re-selection

The CH plays a vital role in initiating the data communication. CH initiates the data communication from the source node. CH should maintain long run time in a cluster; In addition, same vehicle *v* cannot act as CH for a longer period. Therefore, the CH election should be processed faster than the CM election to maintain the rapid cluster formation. The Figure 5 shows the CH Re-selection process in RPAODV.

## C. Cluster Merging

The cluster merging is a better solution to resolve communication management and unnecessary management issues. Sometimes, the CH vehicle may faraway from CM vehicles and then the CM vehicles receive a joining message from nearby CH vehicle to join in the cluster. However, some clusters may merge to form effective cluster formation and effective communication. The Figure 6 presents the cluster merging process in RPAODV.

**Result**: RP set of reliable paths

$RP(Src) \leftarrow 1$

$send.request(Src, CH, dest)$

$send.request(Src, CH, dest)$

$Set\ SltdCH \leftarrow rte(l_{Src}^{CH})$

$if\ dest\ \in\ CH_{tab}\ then$

$\quad while\ Queue\ is\ not\ empty\ do$

$\quad\quad set(u) \leftarrow ExtractMaxi(Queue)$

$\quad\quad Insert\ set(u)\ to\ the\ all\ visited\ vehicles;$

$\quad\quad if\ Travel\big(v, set(u)\big) \in ordered\ pair\ then$

$$Set\ RP(v) \leftarrow (rte(l) \times RP\big(set(u)\big) + SltdCH$$

$\quad\quad else$

$\quad\quad\quad pick\ another\ v$

$\quad\quad end$

$\quad end$

$\quad close\ set(u);$

$Return\ (RP);$

**Fig 2.** Reliable algorithm to find MRP

| | |
|---|---|
| $Send\ (RREQ, Src, CH)$ | $Rte_{Rec} \leftarrow$ v; Remove v; |
| $if\ CH_{tab}(dest) == True\ then$ | end |
| $\quad MRP \leftarrow RouteDiscovery(CH)$ | $while\ RREP\ is\ not\ received\ do$ |
| $else$ | $\quad wait$ |
| $\quad Send(RREQ, CH, RSU)$ | $\quad if\ RREP\_received\ then$ |
| $\quad Send(RREQ, RSU, CH_{dest})$ | $\quad\quad Start\_sending\_packets$ |

**Fig 3.** Route discovery of RPAODV

**Result:** Updated MRPs.

$CH \leftarrow disseminate\ (CM, \Delta V)$

$CH\ estimates\ current\_location\ \ of\ CM$

$Update\ (CM, rte(l))$

**Fig 4.** Cluster member update

**Result:** Updated CH.

$CH \leftarrow disseminate\ (CM, \Delta V)$

$if\ Mean(CH) < Mean(CM)\ then$

$\quad if\ CH_j < Cluster_j\ then$

$\quad\quad new\_CH_j \leftarrow \max\ (Cluster_j)$

**Fig 5.** CH Re-selection process

**Result:** Cluster Merging

$if\ Distance(CH_1, CH_2) < \frac{1}{2}\ distance\ then$

$\quad Start\ Merging$

$\quad\quad |C| \leftarrow CM_1 + CM_2$

**Fig 6.** Cluster merging process

## 3 Simulation performance

The proposed algorithm is evaluated using NS 3.25 and a traffic simulator SUMO [23]. SUMO is an open source microscopic road traffic simulator with General Public License (GPL). SUMO is developed in collaboration between the Centres for Applied Informatics Cologne (ZAIK), Institute of Transportation System (ITS) at German Aerospace Centre (DLR). The simulation and traffic specification are given in Table 2.

Figure 7 shows route reliability between the proposed RPAODV protocol and previous works CVoEG, LP-ACO. Additionally, it shows the route reliability and the proposed RPAODV protocol achieves higher reliability than the existing research works.

The Figure 8 shows packet delivery ratio between the proposed RPAODV protocol and existing works.

The proposed RPAODV protocol maintains higher network lifetime for CM than the existing works. The Figure 9 presents average end-to-end delay between the proposed RPAODV protocol and existing works.

**Table 2.** Simulation and traffic specification

| Parameter | Value |
|---|---|
| Protocol | AODV |
| Connection Type | UDP |
| Packet Sizes | 500 Bytes |
| Number of Connections | 25 % of connections |
| CBR rate | 128 KB/s |
| Number of simulation run | 10 |
| I-5s length L | 10 Km |
| Number of lane | 4 |
| Junctions | 20 |
| Maximum number of vehicles | 1250 |
| Mobility traces duration | 500s |
| Traffic status | Low to high density |
| Road length L | 2 Km |
| Traffic lights | 2 |
| Traffic status | continues arrival |

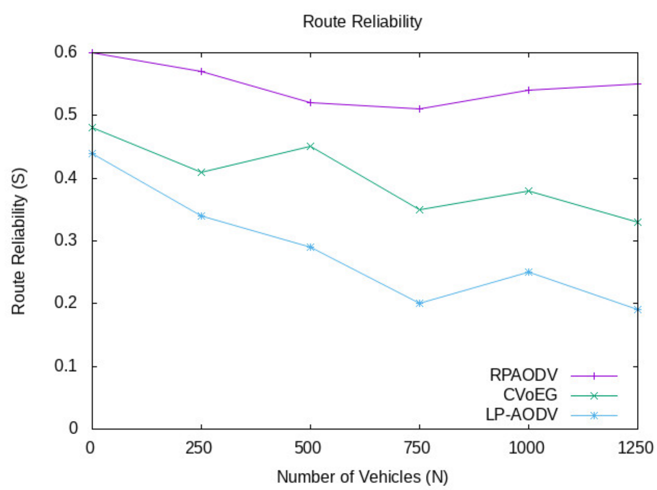


**Fig 7.** Route Reliability

The Figure 10 presents network throughput between the proposed RPAODV protocol and existing works CVoEG, LP-ACO. The proposed RPAODV protocol maintains 60% higher network throughput than the existing works.

The simulation results show the proposed RPAODV protocol compares with previous works i.e., CVoEG, LP-ACO. The proposed protocol works on reliable routing with efficient cluster formation for better communication. The algorithm developed concentrates on clustering for a static and dynamic environment in ITS. The results are compared using the parameters of route reliability (0.11s), packet delivery ratio (20%), end-to-end delay(0.5), and throughput(10 kbps). Thus, proves the proposed RPAODV outperforms the other schemes. The Table 3 gives the comparison of RPAODV with existing protocols CVoEG and LP-ACO.

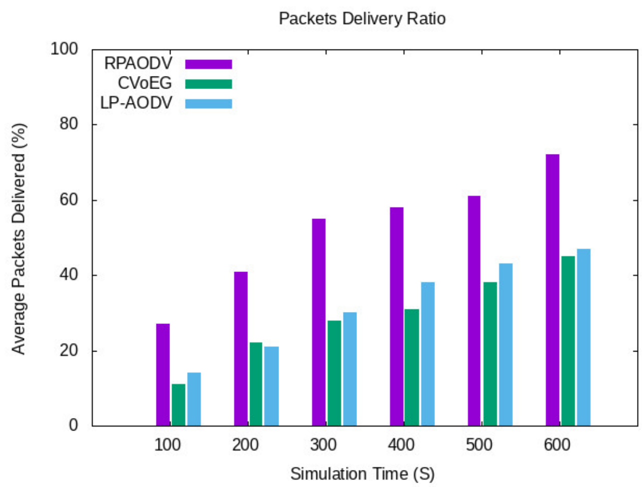


**Fig 8.** Packet Delivery Ratio

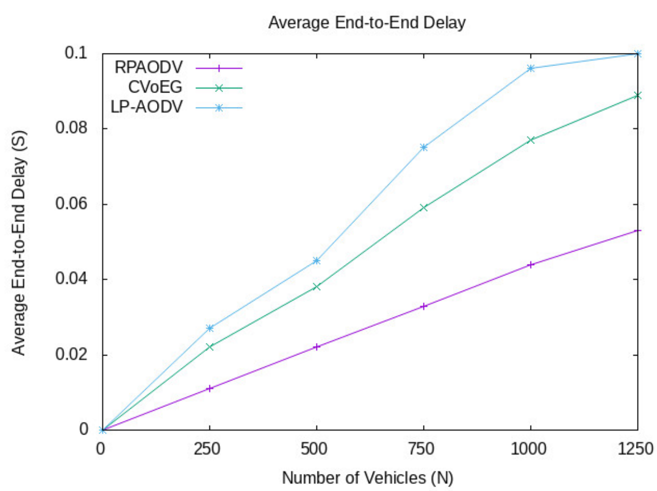


**Fig 9.** Average End-to-End Delay

**Table 3.** Comparison of RPAODV with existing protocols CVoEG and LP-ACO

| Considerations | RPAODV | CVoEG | LP-ACO | Description |
|---|---|---|---|---|
| Route Reliability | High | Medium | Low | Most Reliable Path Selection |
| Packet Delivery Ratio | High | Medium | Low | Dynamic and Static Clustering |
| Average End-to-End Delay | Low | Medium | High | Clustering Maintenance techniques |
| Network Throughput | High | Medium | Low | Optimal Cluster Member Selection |

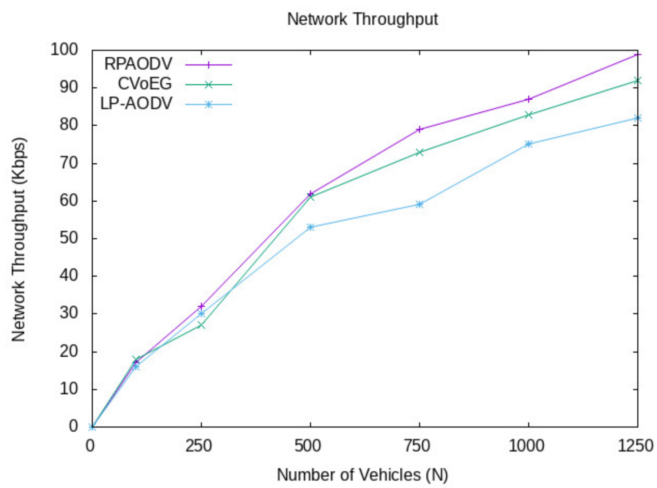


**Fig 10.** Network Throughput

## 4 Conclusions

Communication between vehicles in VANET is made fast, reliable and effective by the RPAODV protocol. The most reliable path is selected and the clustering is done effectively by RPAODV protocol. The cluster head selection is done through messaging and the reliable path selection is selected based on clustering information. Cluster head selection plays a major role as it delivers effective communication over network. In this paper, the most reliable path is identified and clustering mechanism carried out effectively by the proposed algorithm. The protocol in the previous work has its own demerits like time consume, not good for static vehicular topology, and poor in scalability. This proposed protocol overcomes by using modified protocols with enhancing the methodology.

The proposed RPAODV protocol utilise the reliable path that results in 60% of improvements than the other existing schemes. The parameters measured in this work are route reliability, packet delivery ratio, end-to-end delay, and throughput which outperforms excellent compared with previous works.

In future, the parameter metrics can be added such as routing performance, different packet ranges and so on. Additionally, the energy efficient clustering also considered in defining an effective architecture for VANET.

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