VANET Routing Protocols: Review, Implementation and Analysis

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Abstract. Wireless technology is developing very fast. Most of the researchers are working in
the field of wireless communication. VANET is an evolving technology in the field of wireless
communication and with the advancement it will contribute more to the smart transportation
system in days to come. VANET gives a communication framework that has enhanced the traffic
service and helped in reducing the road accidents. Data sharing in this system is time sensitive
and require quick and vigorous network connection forming. VANET is serving the said
purposes but there are some issues and challenges like efficient handling of fast handovers for
video streaming applications. Therefore, in this paper we have reviewed and discussed several
studies related to the routing protocols to judge which one is the best for video applications in
VANET. Moreover, after studying different systems made by the researchers, we have critically
analyzed them and found advantages and disadvantages for the future works. Also, simulation
is performed to check the delays and throughput comparisons between the routing protocols.
Furthermore, with the experiments we have proven that the AODV performance is better than
the other ad-hoc protocols in VANET environment.

1. Introduction
Vehicular Ad-hoc NETwork (VANET) has become the key research study due to increasing demand
of road safety and management. VANET is a subclass of Mobile Ad-hoc NETwork (MANET) which
belongs to a family of Wireless Ad-hoc NETwork (WANET). Talking of MANET, it is basically a self-
organizing communication system that is not dependent on any infrastructure. Mostly it is used by
the military. But nowadays it is becoming common. In simple way, MANET uses the same basic
communication methodology just like blue tooth adhoc network used for data sharing between the
computers. The basic principle of VANET also is same like MANET. VANET system comprises
of mobile nodes which are the sensors embedded in the vehicle, fixed infrastructure consisting of Road
Side Units (RSU) (Shakyawar and Tiwari 2016). RSU are the permanently installed units that works as
a gateway for connection to the server or internet for getting information. The most vital service
provided by the said network is the driving safety as road accidents are the 9th major cause of deaths.
Moreover, according to the survey, most of the accidents can be avoided if driver gets the warning half
a second before an accident. VANET is serving the said purpose by sharing road safety and traffic
analysis information through internet.

According to Yong et al. (2016), the VANET architecture consist of vehicle and infrastructure
components. Vehicle workings consists of the On Board Unit (OBU) and the application that will be
working for OBU to enable it to communicate. Moreover, infrastructure components consists of RSUs
commonly connected to the internet. Subsequently, Figure 1 is showing a VANET system architecture.

In VANET, there are mainly two kinds of communication such as Vehicle To Vehicle (V2V) and
Vehicle To Infrastructure (V2I) (Vijayakumar et al. 2016). V2V is a wireless communication between
the vehicles where as V2I is the communication between the vehicle and infrastructure. VANET is quite different from other ad-hoc networks in terms of features such as high mobility, abrupt changes of topology, time critical, high computational ability etc. Besides its good features and applications there are some challenges also linked to the said network such as security, scalability, quality of service, power control etc.

Over the years there has been many researches on developing applications and usage models for VANET type of communication. As more people spend time on the road, hence, more requirement of internet connection to communicate with each other, to receive real time news, traffic information and weather reports etc. Moreover, some of the latest applications developed related to VANET are online file sharing, real time video updates and entertainment via connection to the internet through RSUs or V2V type of connections. Moreover, the VANET applications are categorized as safety and comfort applications (Hassan et al. 2016).

![VANET System Architecture](image)

Figure 1: VANET System Architecture

The rest of the paper is organized in a manner that in Section 2, the routing protocols used in VANET are discussed while Section 3 will discuss the related works followed by in Section 4, we talked about video streaming in VANET. In Section 5, we discussed about the OPNET implementation steps. Moreover, Section 6 will show the simulation results and with Section 7, we conclude the paper.

2. Routing Protocols

Due to the high mobility feature of VANET, the use of correct routing protocol is of great concern. The packets in the network are send from vehicle to vehicle that are moving with speed and also the density of vehicles is increasing and decreasing which increases the challenges related to routing protocols. Due to highly challenging nature of VANET, the researcher came out with different types of protocols which will be explained in following sections. Moreover, Figure 2 is showing the classification of routing protocols.

![Classification of Routing Protocols](image)

Figure 2: Classification of Routing Protocols
2.1 Geo Based Protocols

In these protocols, a source will communicate with the destination by using geographical positions as well as with its network address. Load Balancing Routing Protocol (LBRP) calculate as well as configure the route as per information based on the location of nodes. Therefore, there is no such need to build the routing tables. The protocol consists of three components such as beaconing, location and forwarding services. The drawback of this protocol is that it requires the Global Positioning System (GPS) assistance to get the vehicles location. Moreover, the satellite signals get weak when the vehicle goes in the area like tunnel. But as far as highway environment is concerned it gives the best performance. Additionally, its advantages include efficient in high mobility environment. Example of these protocols are Greedy Perimeter Stateless Routing and Distance Routing Effect Algorithm for Mobility (DREAM).

2.2 Broadcast Based Routing Protocols

This protocol floods the data packet to the entire VANET to all the available nodes in the broadcast domain. The said protocol is used whenever the destination node is out of the range of the source node. Mostly these protocols are used with application that are concerned with the safety such as road and weather condition warning, emergency warning messages etc. Example of broadcasting routing protocols includes Distributed Vehicular Broadcast Protocol (DV-CAST), Position Aware Reliable Broadcasting Protocol (POCA) and Density Aware Reliable Broadcasting Protocol (DECA). The positive point of the said protocols is its reliability. But these types of protocols consume more bandwidth and many duplicate packets reaches the node which is not good for the protocol performance.

2.3 Cluster Based Routing Protocols

In this protocol, the vehicle with same characteristics such as the speed, direction etc. are combined in one cluster. Moreover, if a vehicle node needs to communicate with the node within the cluster then the data will follow a direct path as it is considered to be a local communication. Moreover, if the vehicle node needs to communicate the node which is outside the cluster than it requires the help of its cluster head for reaching the destination. The scalability factors make it a good choice for the network designers. But traffic delays is its drawbacks. Clustering for Open Inter Vehicular Communication Network (COIN) is the prime example of this protocol.

2.4 Geo-cast Routing Protocols

Geo cast protocol consists of two main zones i.e. Zone Of Relevance (ZOR) and Zone Of Forwarding (ZOF). ZOR is that area dedicated for the nodes of that region. The main goal of this protocol is to make communication possible between the vehicle present in ZOR. Moreover, if the source vehicle wants to communicate with the vehicle that is not in ZOR of that vehicle than the vehicle will become part of ZOF and any vehicle that comes in ZOF has the responsibility of forwarding the information to other ZORs. Due to the frequent changes in the zones, the connection disconnection can take place regularly and the said point comes in the bracket of drawbacks.

2.5 Topology Based Routing Protocols

The focus of this paper is on topology based protocols. The said type consists of two kinds of protocol such as proactive and reactive. Moreover, the classification of routing protocols used in ad-hoc environment is shown in Figure 3.
2.5.1 Proactive Protocols
The protocols keep on computing the route regularly and therefore, the routing table changes or updates frequently. These protocols use Bellman Ford Algorithm in which all the nodes keep the information related to the next node. The one of the advantage of the said protocol is that the route will be known whenever a packet wants to send a data. Example of these protocol includes Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV) protocol.

OLSR is basically a refined version of link state protocol. The working of link state protocol is such that any change in a topology will be broadcasted to all the nodes in a network which will increase the network overhead. OLSR handles with two kinds of messages like hello and a message to control the topology. Hello messages are used to find the data about the connection status. While topology control message is used to broadcast its own neighbour information with the help of multi point relay (MPR) selected list. Because of the use of MPR, the overload has reduced as it was in the case of pure link state protocol.

DSDV protocol is a modification of Bellman Ford Algorithm. This algorithm resolved the problem of looping in routing by maintaining the sequence number information of each node.

2.5.2 Reactive Protocols
This type of protocols does not possess the information about all the nodes (Zhang and Sun 2016). It only keeps the information of the nodes that comes in the route. The example of reactive protocols is an Ad-hoc On-Demand Distance Vector (AODV), Dynamic Source Control Routing (DSR) and Dynamic Manet on Demand (DYMO) protocol.

AODV is the most commonly used protocol in VANET. It possesses the information of next-hop for the destination nodes. Moreover, each routing table lasts for certain period. If there is no route demand within the specified time than route will get expired and a new route will be defined on demand. As per AODV, whenever a source node wants to send a data to the destination node, it will check the route in its routing table. If the route information exists in the table, then packet will be forwarded to the destination. Otherwise the source node will broadcast the route discovery request to the neighbours. AODV is a mobile ad-hoc protocol that is suitable in a high mobility traffic. The said protocols have reduced the broadcasting overhead. Moreover, route discovery process will be done on demand (Sallam and Mahmoud 2015).

DSR is a productive protocol for routing. It is basically made for multi-hop WANET. It is a self-organizing and configuring protocol that does not require any administration. The two main functions of the said protocol are route discovery and maintenance. The said functions work with each other for node discovery and route maintenance.
DYMO is another on demand protocol designed after AODV. DYMO routing protocol can be implemented as proactive as well as reactive (Spaho et al. 2012). Moreover, route discovery methodology is on demand whenever required.

2.5.3 Hybrid Protocols
Hybrid is a composite of proactive and reactive routing protocols which reduced the overhead and delays occurrence due to the periodic sharing of topology information (Jain and Jeyakumar 2016). With the hybrid approach, the efficiency and scalability feature of network has improved. On the other hand, the drawback of hybrid approach is high latency for navigating new routes. The common protocol based on hybrid approach is Zone Routing Protocol (ZRP).

3. Related Works
With the advancement of wireless communication, there are different kind of networks developed according to the people requirement. The use of wireless devices has increased tremendously. New networks are being introduced and among all VANET is one of them. Moreover, in VANET the packet routing is the main challenge to handle. In view of aforementioned, some works related to VANET routing is discussed in this section.

Prokop (2011) worked on the analysis of routing protocol and proved DYMO protocol to be the best choice. Moreover, Spaho and Ikeda (2014) made a system to analyse the protocols such as DSDV and DYMO and concluded that DYMO outperformed the DSDV as DYMO can work as proactive as well as reactive protocol. Gupta and Chuba (2014), Zhang and Sun (2015) developed an analysis that among all reactive and proactive protocols, AODV gave the best results in the high mobility environment. Kaur and Malhotra (2015) made the performance analysis of AODV, OLSR and ZRP and came out with the result that hybrid protocol works well in VANET environment due its dual nature. Moreover, Sallam and Mahmoud (2015) came out with the conclusion that AODV is far better than OLSR as it gives very good result with high speed vehicles. Another performance evaluation of topology based routing protocol (DSDV, AODV and LSGR) is done by Kumar, Baghel and Mishre (2016) and reported AODV as a good protocol. Lengliz and Slama (2016) worked on the improvement of AODV protocol and came out with the version AODV-RLT in which they enhanced the life time of the route. Another research done on the comparison of protocols such as Q-AODV and GPSR by Mouhib, Ouadghiri and Naanani (2016). As per the study, authors proved that Q-AODV better than its competitor. Subsequently, another study done by Salman et al. (2016) on topological routing protocols by considering the packet drop ratio and end to end delay. The authors came up with an idea that reactive protocols work well in ad-hoc environment. Setiabudi et al. (2016) made the comparative study between GPSR and ZRP. The author concluded that hybrid protocols always work well in ad-hoc environment and specially with high speed nodes. Kumar and Baghel (2016) made an analysis of AODV and LSGR protocols and as per the authors LSGR is more robust for VANET environment.

According to the comparative study done in Table I, it is proved that AODV is the most suitable protocol for use in VANET environment. Moreover, according to the research, new protocol can be designed by combining the features of AODV with ZRP to enhance the performance.
4. Video Streaming in VANET

The challenge other than routing is the provision of good quality video streaming in VANET. In VANET, the nodes move very fast. There are many applications that are running on the VANET. But, the application like video streaming is supposed to be a difficult task in VANET environment as the hand-offs are very fast. So, with such quick changes, maintaining a quality of service for the aforesaid application is a challenging job (Ennaciri et al 2016). In VANET, there is frequent change in the topology which result in link breakages that causes heavy loss of packets.

Some works has been done to resolve the problems in video streaming. Mammeri, Boukerche and Fang (2016) enhanced the existing internet protocol i.e. real-time transport protocol (RTP) used for the live video streaming. RTP basically based on the principle of user datagram protocol (UDP) in which if packet will loss than there will no retransmission of it. Subsequently, Sarakis et al. (2016) explored VANET performance with running the video streaming application. The author performed the tests by using IEEE 802.11 p and ETSI ITS protocol stack with varied size videos and different vehicle speeds. Moreover, they prove that with the use of proper available communication and computational parameters a good performance can be achieved. Joshi et al. 2016 presented an analysis for video streaming in VANET with the use of fast hand off techniques. According to the authors, the rate of packet loss increases with the increase of video streaming bit rate. Layered Cooperative Cache Management Video Content-Centric Network (LCC-VCCN) was proposed by Wei et al. (2016). Moreover, authors proved with the help of simulation results that the proposed caching strategy performed well as compared to the existing strategies.

After studying different work done, we have come up with the conclusion that there is a need to improve the existing protocols that are being used in VANET for video streaming. In our view, instead of using the UDP, different TCP flavours can be embedded in the protocols to reduce the packet loss in video streaming.

Moreover, as per the review conducted by us in section 2, AODV proved to be the best protocol for the VANET. So, in next section we will implement the VANET scenario with the help of simulation software by using AODV and DSR.

**TABLE 1**

| References       | Protocols                    | Performance Results                                                                 |
|------------------|------------------------------|--------------------------------------------------------------------------------------|
| Salman et al. 2016 | Topology Based Routing Protocols | Reactive Protocols works better                                                     |
| Setiabudi et al. 2016 | GPSR and ZRP               | Hybrid Protocol (ZRP) works better                                                  |
| Kumar and Baghal 2016 | AODV and LSGR               | LSGR proved better                                                                  |
| Sallam and Mahmoud 2015 | AODV and OLSR            | AODV is better in more dense and high mobility area                                  |
| Kaur and Malhotra 2015 | AODV, OLSR and ZRP         | ZRP proved to be the best in terms of node density and packet sizes                 |
| Zhang and Sun 2015     | AODV and DSR               | AODV performance is better with high mobility nodes then DSR                          |
| Gupta and Chaba 2014 | AODV, DSR, OLSR and DSDV    | AODV is among the best with high mobility nodes                                      |
| Spaho and Ikeda 2012 | DSDV and DYMO              | DYMO has better performance than DSDV                                                |
| Prokop 2011          | AODV, DSR and DYMO         | DYMO proven best                                                                     |
|                     |                             | AODV can be used as second choice                                                    |
5. OPNET Implementation
To monitor different performance matrices related to AODV and DSR protocols in VANET environment, we have simulated some scenarios with the help of OPNET modeler 14.5. This section will explain in detail the scenarios and parameters used for the simulation.

5.1 Simple VANET Scenario
This scenario consists of two parts having 20 and 40 nodes (mobile stations) respectively and given them the random trajectories for the movement as shown in Figure 4 and 5. Moreover, for the application designation we have included the application config and profile config to set the applications (ftp and http) used by the nodes. Additionally, we have added the mobility config node to set the profile related to mobility of all the nodes. Subsequently, we changed the routing protocol of all the nodes to AODV.

![Figure 4: Simple Scenario with 20 Nodes](image1.png)

![Figure 5: Simple Scenario with 40 Nodes](image2.png)
Moreover, we repeated the same procedure as AODV one except for routing protocol. In this scenario, we used the DSR protocol to monitor the difference of performance as compared to AODV.

5.2 Complex VANET Scenario
In the said scenario, we have added the road side units (RSU) along with 20 nodes. We have used the same applications and settings like previous scenario except that we put four RSUs along the road. Moreover, we have given different BSS identifiers to all RSUs. Additionally, each RSU has designated nodes associated with it and the associated node will have the same BSS identifier as of the RSU which is bound to give the services as shown in Figure 6. Also, we have assumed that there are two different VANET networks and the RSU that are in one network are linked with PPP 28k for their communication. Subsequently, this scenario implemented with the AODV protocol. Similarly, the same scenario is repeated by using the DSR protocol for the comparisons. In Fig. 6, the red blocks are showing different VANETs. Moreover, in every VANET as discussed, all the nodes will have same identifiers related to BSS.

![Figure 6: Complex Scenario](image_url)

5.3 Simulation Parameters and Performance Matrices
For any simulation, there must be some parameters that has to be defined. Same is the case in our simulation. Our simulation parameters are shown in Table II.
6. Simulation Results
This section will present the simulation results achieved from the scenarios described in the previous section for different scenarios.

6.1 Simple VANET Scenario Results
Figure 7 and 8 is showing the throughput and delay comparison respectively between the AODV and DSR with 20 vehicles in simple scenario.

According to the Figure 7 and 8, the performance of AODV in terms of throughput and delay is far better than the DSR protocol.

![Figure 7: Throughput Comparison AODV and DSR with 20 Nodes](image-url)

### TABLE II
Simulation Parameters

| Parameter                | Value               |
|--------------------------|---------------------|
| Maximum Simulation Time  | 1 Hour              |
| Environment Size         | 100 x 100 km        |
| Number of Nodes          | 20, 40              |
| Mobility                 | Random way point    |
| Speed                    | 10 km / hour        |
| Type of Traffic          | FTP and HTTP        |
| Routing Protocol         | AODV and DSR        |
Moreover, Figure 9 and 10 are showing the throughput and delay comparison with 40 nodes. As per the Figure 9 and 10, the AODV is better than DSR in terms of throughput but showing more delay as compared to DSR.
6.2 Complex VANET Scenario Results

In this scenario, we have kept 20 mobile nodes and did comparison by using AODV and DSR routing protocols. According to Figure 11 and 12, like previous scenarios AODV performed good as compared to DSR in terms of throughput as well as delay.
7. Conclusion
In this paper, we have reviewed many studies related to routing protocols. As per the research completed, AODV proved to be the best routing protocol in VANET environment. Moreover, video streaming is another challenging task to achieve in VANET. According to the study, we have concluded that lot of effort is required to get a good quality video streaming in VANET and AODV again is proven to be better for video applications. For the aforesaid we have done simulation using two scenarios that is the simple and complex. In simple we only kept mobile nodes and took the performance results of AODV and DSR. Also, in complex scenario, we added the RSUs to have more comprehensive results. Both the aforementioned situations have shown that AODV performance is far better than the DSR. Moreover, for future works we recommend that a new protocol can be designed by combining some flavors of TCP with UDP.

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