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Performance Study of Various Routing Protocols in VANET Case of Study

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Abstract

Vehicular ad hoc networks or VANET that establishes wireless connections between cars have recently received considerable attention. VANET are used in Intelligent Transportation Systems (ITS) that are designed to offer passengers and vehicles services like warning of accidents, driver assistance, Internet access, etc. The evaluation of VANET routing protocols often involves simulators since management and operation of a large number of real vehicular nodes is expensive. We study the behavior of routing protocols in VANETs by using mobility information obtained from a microscopic vehicular traffic simulator that is based on the real road maps of Tangier in Morocco.

In this paper, we evaluate AODV, DSR and OLSR performance in urban scenarios case study. We study those protocols under varying metrics such as node mobility, vehicle density, and with varying traffic rates. We show that clustering effects created by cars aggregating at intersections have remarkable impacts on evaluation and performance metrics. Our objective is to provide a qualitative assessment of the applicability of the protocols in different vehicular scenarios. The results show that OLSR performs best in most of the simulated traffic situations

Keywords: *Vanet, Routing, Sumo, NS2*

1. Introduction

The increasing demand of wireless communication and the needs of new wireless devices have tend to research on self organizing, self healing networks without the interference of centralized or pre-established infrastructure/authority. The networks with the absence of any centralized or pre-established infrastructure are called Ad hoc networks. Ad hoc Networks are collection of self-governing mobile nodes [1].

Vehicular Ad hoc Networks (VANET) is the subclass of Mobile Ad Hoc Networks (MANETs). VANET is one of the influencing areas for the improvement of Intelligent Transportation System (ITS) in order to provide safety and comfort to the road users. VANET assists vehicle drivers to communicate and to coordinate among themselves in order to avoid any critical situation through Vehicle to Vehicle communication *e.g.*, road side accidents, traffic jams, speed control, free passage of emergency vehicles and unseen obstacles etc. Besides safety applications VANET also provide comfort applications to the road users. For example, weather information, mobile e-commerce, internet access and other multimedia applications [2]. The most well known applications include, "Advance Driver Assistance Systems (ADASE2), Crash Avoidance Matrices Partnership (CAMP),

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CARTALK2000 and Fleet Net" that were developed under collaboration of various governments and major car manufacturers [2].

2. Routing in VANET

2.1 Vehicular ad-hoc networks

VANET is the wireless network in which communication takes place through wireless links mounted on each node (vehicle) [3]. Each node within VANET act as both, the participant and router of the network as the nodes communicates through other intermediate node that lies within their own transmission range. VANET are self organizing network. It does not rely on any fixed network infrastructure. Although some fixed nodes act as the roadside units to facilitate the vehicular networks for serving geographical data or a gateway to internet etc. Higher node mobility, speed and rapid pattern movement are the main characteristics of VANET. This also causes rapid changes in network topology [4].

In VANET, vehicles move on predefined roads, vehicles velocity depends on the speed signs and in addition these vehicles also have to follow traffic signs and traffic signals. There are many challenges in VANET that are needed to be solved in order to provide reliable services. Stable & reliable routing in VANET is one of the major issues [5].

VANET routing protocols history starts with traditional MANET protocols such as AODV (Ad hoc on Demand Distance Vector Routing) and DSR (Dynamic Source Routing)[6]. AODV and DSR have been considered efficient for Multi hop wireless ad hoc networks [7].

2.2 Ad Hoc On Demand Distance Vector Routing- AODV

Ad Hoc On Demand Distance Vector Routing (AODV). AODV belongs to multihop type of reactive routing. AODV routing protocol works purely on demand basis when it is required by network, which is fulfilled by nodes within the network. Route discovery and route maintenance is also carried out on demand basis even if only two nodes need to communicate with each other [8]. AODV cuts down the need of nodes in order to always remain active and to continuously update routing information at each node. In other words, AODV maintains and discovers routes only when there is a need of communication among different nodes.

AODV uses an efficient method of routing that reduces network load by broadcasting route discovery mechanism and by dynamically updating routing information at each intermediate node. Change in topology and loop free routing is maintained by using most recent routing information lying among the intermediate node by utilizing Destination Sequence Numbers of DSDV [9].

2.3 Dynamic Source Routing DSR

The Dynamic Source Routing protocol (DSR) [Johnson 1994, Johnson 1996a, Broch 1999a] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. Using DSR, the network is completely self-organizing and self-configuring, requiring no existing network infrastructure or administration. Network nodes (computers) cooperate to forward packets for each other to allow communication over multiple "hops" between nodes not directly within wireless transmission range of one another. As nodes in the network move about or join or leave the network, and as wireless transmission conditions such as sources of interference change, all routing is automatically determined and maintained by the DSR routing protocol. Since the number or sequence of intermediate hops needed to reach any destination may change at any time, the resulting network topology may be quite rich and rapidly changing. The DSR protocol allows nodes to dynamically discover a source route across multiple network hops any destination in the ad hoc network. Each data packet sent then carries in its header the complete, ordered list of nodes through which the packet must pass, allowing packet routing to be trivially loop-free and avoiding the need for up-to-date routing information in the intermediate nodes through which the packet is forwarded. By including this source route in the header of each data packet, other nodes forwarding over hearing any of these packets may also easily cache this routing information for future use [10]. DSR is composed of two mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network:

- ✓ Route Discovery is the mechanism by which a node S wishing to send a packet to a destination node D obtains a source route to D. Route Discovery is used only when S attempts to send a packet to D and does not already know a route to D.
- ✓ Route Maintenance is the mechanism by which node S is able to detect, while using a source route to D, if the network topology has changed such that it can no longer use its route to D because a link along the route no longer works. When Route Maintenance indicates a source route is broken, S can attempt to use any other route it happens to know to D, or can invoke Route Discovery again to find a new route. Route Maintenance is used only when S is actually sending packets to D.

2.4 Optimized Link State Routing Protocol OLSR

OLSR is a proactive routing protocol for mobile ad hoc networks. The protocol inherits the stability of a link state algorithm and has the advantage of having routes immediately available when needed due to its proactive nature [11]. OLSR is an optimization over the classical link state protocol, tailored for mobile ad hoc networks. OLSR minimizes the overhead from flooding of control traffic by using only selected nodes, called MPRs, to retransmit control messages. This technique significantly reduces the number of retransmissions required to flood a message to all nodes in the network. Secondly, OLSR requires only partial link state to be flooded in order to provide shortest path routes. The minimal set of link state information required is, that all nodes, selected as MPRs, must declare the links to their MPR selectors. Additional topological information, if present, may be utilized *e.g.*, for redundancy purposes. OLSR may optimize the reactivity to topological changes by reducing the maximum time interval for periodic control message transmission. Furthermore, as OLSR continuously maintains routes to all destinations in the network, the protocol is beneficial for traffic patterns where a large subset of nodes are communicating with another large subset of nodes, and where the [source, destination] pairs are changing over time. The protocol is particularly suited for large and dense networks, as the optimization done using MPRs works well in this context. The larger and more dense a network, the more optimization can be achieved as compared to the classic link state algorithm. OLSR is designed to work in a completely distributed manner and does not depend on any central entity. The protocol does not require reliable transmission of control messages: each node sends control messages periodically, and can therefore sustain a reasonable loss of some such messages. Such losses occur frequently in radio networks due to collisions or other transmission problems. OLSR does not require sequenced delivery of messages [12]. Each control message contains a sequence number which is incremented for each message. Thus the recipient of a control message can, if required, easily identify which information is more recent - even if messages have been re-ordered while in transmission. Moreover, OLSR provides support for protocol extensions such as sleep mode operation, multicast-routing *etc*. Such extensions may be introduced as additions to the protocol without breaking backwards compatibility with earlier versions. OLSR does not require any changes to the format of IP packets. Thus any existing IP stack can be used as is: the protocol only interacts with routing table management [13].

3. Simulations

The main goal of our work is the comparison between the three routing protocols AODV, DSR and OLSR, by measuring their performance parameters and adjusting certain properties of the network such as mobility, density, and end to end delay.

3.1 Performance Metrics

The delay: is the time that elapses between the sending and receiving node of the message. During the transition packages, delayed delivery to the destination can occur because of the queues, delays retransmission of the MAC layer, propagation and transfer time, etc. For each packet sent, the average time from start to finish will be the difference between the emission time and the time of receipt of the package by the total time delivery of all packages. The average of the lowest end-to-end shows the best performance of the routing protocol.

Average time end-to-end (s) = Σ (reception time - transmission time) / Σ well received packets

Throughput: is the data transmission capacity in a time interval. It represents the maximum rate of data transfer between two terminal nodes in a network. The highest rate identifies best performance of the routing protocol.

Throughput (kbps) = Σ Size of Received Packets / (simulation start time - simulation end time)

Delivery Rate (%): is the ratio between the number of received packets and the number of packets sent. The delivery rate is a parameter for measuring the capacity and reliability of packet delivery to a routing protocol. A high rate identifies improved reliability of a protocol. It is calculated as follows:

Delivery Rate (%) = received packets number / sent packets number.

3.2 Simulation Tools

In this paper, the simulation tool used for analysis is NS-2 which is highly preferred by research communities. The performance analysis is done under Ubuntu 10.04 Operating System and Ns –allinone-2.34 was installed among SUMO-0.0.12.3 for the road traffic simulation, the tool MOVE-2.92 was used for the mobility model for VANET.

3.3 Simulation Scenarios

3.3.1 Network Schema Used

Under practical manipulation MOVE and SUMO, we used two types of network schema: a manually drawn schema, and reel schema imported from opens tree map. MOVE tool has allowed us to create through the following VANET network schema:

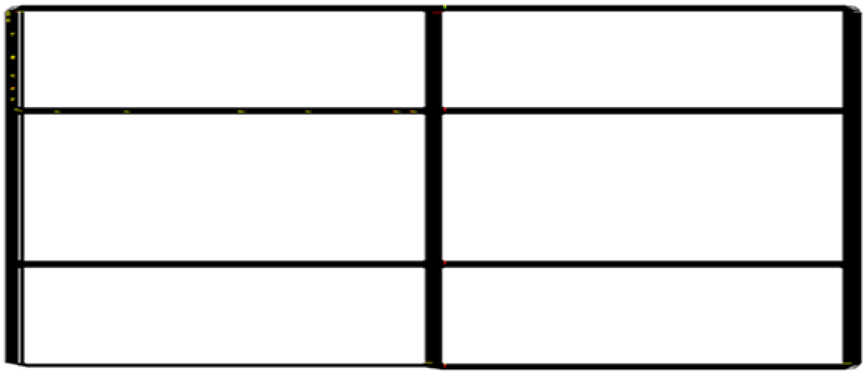


Figure 1. Manual Schema

Figure 2. Road portion Tangier Region Iberia

3.3.2 Simulation Parameters

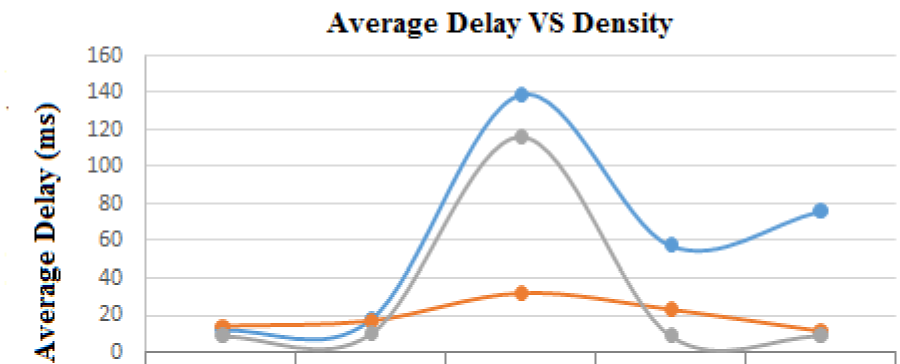
Table 1. Simulation Parameter

Parameter	Value
Protocol	AODV/ DSR/ OLSR
Simulation time	100, 150, 200
Pause time	10, 20, 30, 40, 60
Number of nodes	20, 40, 60, 80, 100
Area simulation size	500m*500m
Velocity (m/s)	20, 30, 40
Type of traffic	CBR/UDP
Packet size	512 Bytes

4. Simulation and Results

4.1 Scenario 1: varying the nodes number (density)

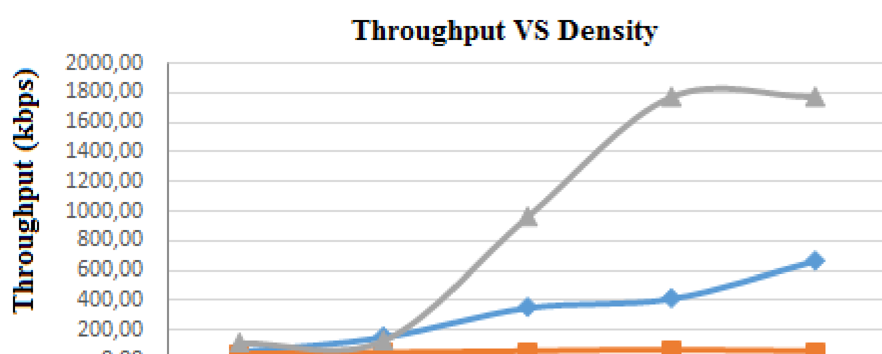
We studied the impact of density on the performance of OLSR, AODV and DSR. The pause time is 30 seconds, the simulation time set to 150 seconds and the maximum speed of vehicles is 20 m / s.



	20	40	60	80	100
AODV	12,11	17,778	138,913	57,5241	76,2044
DSR	14,0373	16,9006	32,4657	23,3563	11,1483
OLSR	9,15745	10,2815	116,533	9,28173	9,28173

Figure 3. Effect of Varying the Nodes Density on the End-To-End Average

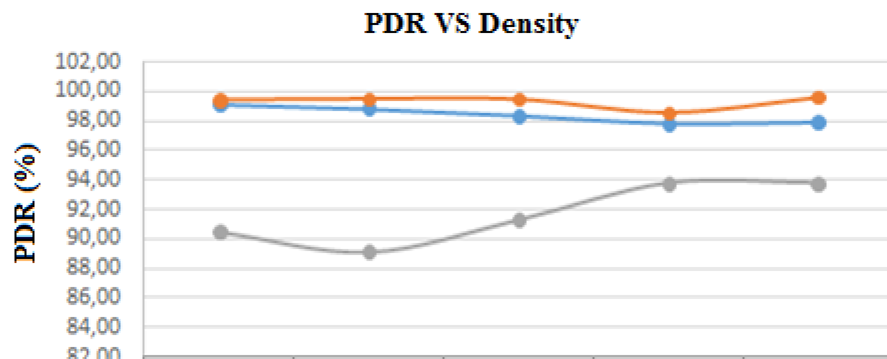
Figure 3 shows that OLSR act well in low and high density network compared with AODV and DSR, both in networks with low or high density. In other hand, DSR provides a lower limit than AODV protocol.



	20	40	60	80	100
ADOV	63,71	158,41	356,28	415,90	665,67
DSR	41,35	50,12	59,25	67,41	58,43
OLSR	117,99	133,75	965,61	1774,77	1774,77

Figure 4. Effect of Varying the Nodes Density on the Throughput

By varying the density, the results show that OLSR performs well by increasing the density network, thus OLSR is more efficient in high density rate, compared with AODV and DSR. However, the AODV protocol outperforms the DSR protocol.



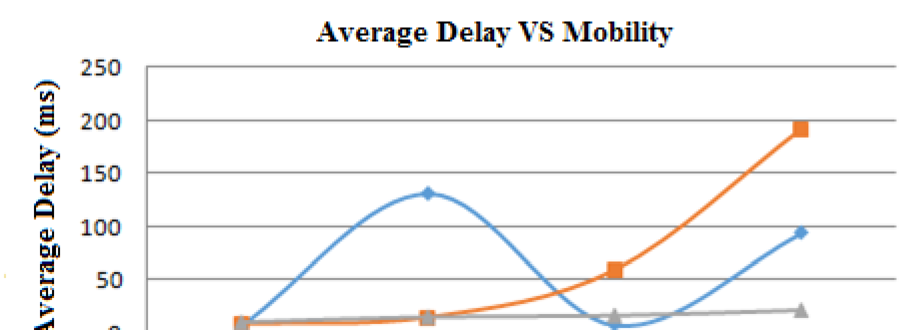
	20	40	60	80	100
AODV	99,06	98,74	98,30	97,78	97,87
DSR	99,42	99,49	99,46	98,52	99,58
OLSR	90,47	89,12	91,29	93,77	93,77

Figure 5. Effect of Varying the Nodes Density on the Delivery Rate (%)

In Figure 5, the obtained results show that DSR protocol relies on the destination more than 99% of the packets regardless of the network density. Then again, the protocol AODV and DSR are well above the "rate of packets delivered" provided by OLSR.

4.2 Scenario 3: Varying the vehicles speed (Mobility)

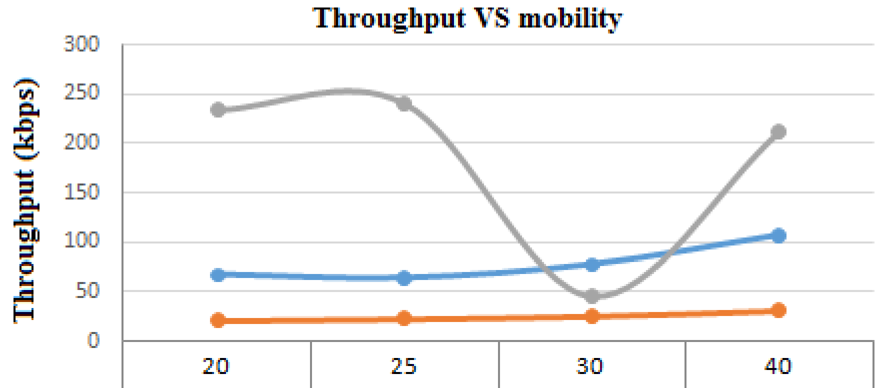
In this scenario, we investigated the impact of mobility on the performance of OLSR, AODV and DSR. The pause time is set to 0, the simulation time is 100 seconds and the number of nodes is 30.



	20	25	30	40
AODV	7,80796	131,291	7,90291	94,4582
DSR	9,09179	15,2448	60,0407	192,492
OLSR	10,485	15,2648	16,6007	21,3905

Figure 6. Effect of Varying the Nodes Velocity on the End-To-End Average

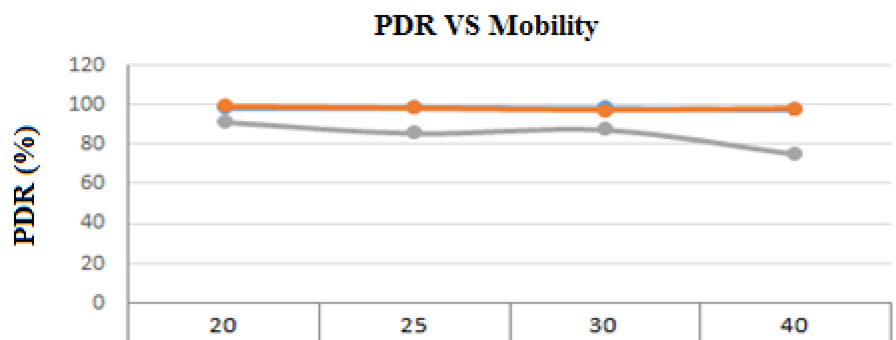
Here, the results show that OLSR provides low delay compared to DSR and AODV protocols, whether for networks with high or low mobility. The AODV protocol provides a lower DSR, especially in networks with high mobility period.



	20	25	30	40
AODV	68,14648438	64,65039063	78,11621094	107,3291016
DSR	21,28808594	23,05957031	25,83984375	31,26953125
OLSR	234,234375	240,71875	46,484375	212,2441406

Figure 7. Effect of Varying the Nodes Velocity on the Throughput

In the Figure 7, the results show that OLSR works with high throughput and is more efficient compared to DSR and AODV protocols, either in networks with low and high mobility vehicles. Moreover, The AODV protocol outperforms the DSR protocol in all case of mobility vehicle context.



	20	25	30	40
AODV	98,9101	98,8139	98,5494	97,9286
DSR	99,9097	98,8309	97,4978	98,5507
OLSR	91,8312	85,9855	87,8114	75,0668

Figure 8. Effect of Varying the Nodes Velocity on the Delivery Rate (%)

In the last figure, (Figure 8), it's clear that PDR delivered by AODV and DSR are higher than OLSR's one. Furthermore, DSR and AODV protocols proceed almost in the same way in this case of simulation.

5. Conclusion

Nowadays, VANET are getting remarkable attention from the networking research community due to their flexibility and their easy deployment like a sub class of MANET (Mobile Ad hoc Networks). The performance of the routing protocol, considered as a key that provide communication between nodes, is strongly related to the cases of study, scenarios, environment of deployment and simulators also. In this paper we have presented a performance study of the AODV, DSR and OLSR protocols in a VANET environment, it can be concluded that the results of these protocols depend on a set of variables that make up the simulation environment such as mobility, density, pause time, network size etc. ... .Knowing that the simulation environment does not reflect properly a real case, we tried to approach the maximum possible to a real scenario. Currently, there is no protocol that is the best and most efficient for all environments and for all possible constraints. In our simulations, OLSR, is in most studied cases, the best choice and outperforms both AODV and DSR.

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