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Simulation Study of VANET Routing Protocols on NS-2 and NS-3

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Abstract: ***VANET (Vehicular Ad-hoc Network) is an ad hoc networks technology formed by vehicles mounted with wireless gadgets. Routing plays an important role in forwarding the required data to the nodes or vehicles. There are two types of topology based routing protocols in VANET proactive and reactive. The performance of routing protocols can vary with the various parameters such as speed, pause time, node density and traffic scenarios. The performance of reactive protocols AODV and DSR and proactive protocol DSDV has been analyzed by means of packet delivery ratio & average end-to-end delay with varying pause time and node density under TCP connection using NS-2 simulator and investigate. Similarly, the performance evaluation of reactive routing protocols AODV and DSR and proactive routing protocol such OLSR in urban city traffic scenario and network performance using NS-3 to find an appropriate protocol by using network parameters such as packet delivery ratio, throughput and delay. The performance of AODV is better than other routing protocols in VANET simulation scenarios.***

Key words: VANET, NS-3, AODV, DSR, OLSR, NS-2

1. Introduction

VANET is a form of Mobile ad-hoc network, MANET, to provide communications among vehicles and roadside fixed infrastructure [1]. These roadside units provide geographical information to the vehicles and act as an internet gateway. The most of the important applications is driving assistance. Adjacent vehicles can share road and traffic information with each other (Fig. 1) [5].

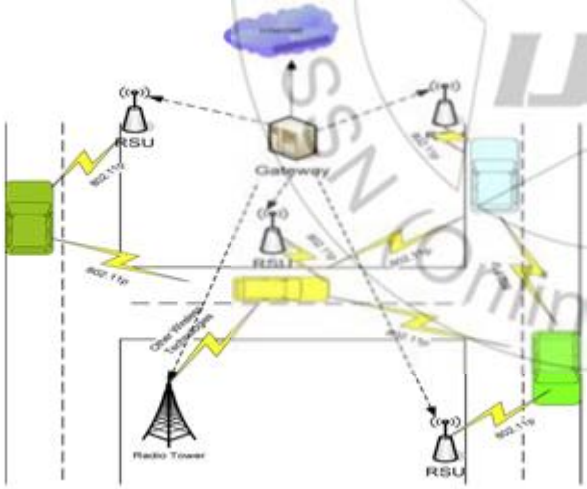

Figure 1: VANET architecture [5]

VANET has faced the big challenges on stability, efficiency, scalability of network since that routing protocols developed for MANET show degraded performance in vehicular scenarios. VANET possesses some characteristics like transporting distance, high mobility, distributed nature of operation, poor link quality and varied channel conditions. Such particular features often make standard networking protocols inefficient or unusable in VANETs.

The technologies like simulators help in representing the real world's real time scenario in computer. It is not easy to implement the scenarios in real in present time. Also, it comes expensive and time consuming too, hence network simulators are the best substitute as for now. There are many types of network simulators on modern world which are differ from their working range. Reproducibility, mode of deployment and scalability are some of the advantageous features of the network simulators. Among many OPNET, VanetMobiSim, OMNeT++, NS-2 and NS-3 are some of the highly used simulators for the researches.

2. Network Simulators

Network simulation is a graphical user interface where a program is made to represent the situation and scenario of the nature of a network for a communication research of communicable devices like computers. A network simulator is software that predicts the behavior of a network of communicable devices. Network simulators are used because the analytical methods of intercommunication networks become too complex and cost consuming. The simulators are designed with several network equipments like nodes, channels, performance parameters to study the performance. Some of the most common network simulators are VanetMobiSim, NS-2, NS-3, QualNet, etc. The paper will discuss about NS-2 and NS-3 briefly.

NS-2 [7] is a network simulator written in object-oriented C++ and OTcl. Ns2 is an open source discrete event network simulator. It simulates many different types of wireless, local area networks and wide area networks specially IP networks. NS-2 includes support for the modules of the models and protocols. The NS-2 simulation environment presents the various characteristics of sensor networks which can be built with almost same set of protocols characterizing the one available in the actual world and evaluating their performances. Energy constraints and node mobility are among the additional support. Also, it provides scalability to the network scenario which is hard to achieve in the practical world. It helps in studying network protocols, network traffic and routing management of protocols like TCP, UDP,

Telnet, FTP, VBR, CBR, etc. It also develops tools for result display and converts topologies to its own format. NS-3 [8] is an open sourced discrete-event network simulator licensed under the GNU GPLv2 license, scripting in Python and coded in C++ and is mostly used in research and development and educational work. and is available for research and development. There is no relationship between NS-3 and NS-2. NS-3 is not an enhancement of NS-2. It was written from the beginning. It has a well organized source code and provides realistic scenario of the real world environment. Its features include modular, documented core, aligned with real-time systems, etc.

3. Classification of the ad hoc routing protocols

MANET routing protocols finds it difficult to define appropriate routing path in VANET. In VANET, the routing protocols can be categorized into five groups. These are Topology based routing protocol, Position based routing protocol, Geo-cast based routing protocol, Cluster based routing protocol, and Broadcast based routing protocol.

Topology based routing protocol use links information which stored in the routing table that exists in the network to forward data packet from sender to receiver. They can be commonly divided into proactive (table driven) routing protocol, reactive (on demand) routing protocol, hybrid routing protocol.

Proactive routing protocols are usually based on the shortest path algorithm to determine which route will be chosen. These protocol use routing table to store routing information and routing table also keep information of all connected nodes and when network topology face any changes every node updates its routing table.

Reactive routing protocols are on demand routing protocol because it starts route discovery only when a node wants communicate with another node. These protocols reduce the burden in the network.

Hybrid routing protocols are combined the properties of both proactive and reactive routing protocol. The aim of hybrid routing protocol is to minimize the control overhead of proactive routing protocol and reduce the delay of route discovery process in reactive routing protocol. In hybrid routing protocol, the network is divided into many zones and it provide more reliability for route discovery and maintenance process.

Destination Sequenced Distance Vector Routing (DSDV) is use to resolving the worriment which is identified with the distance vector routing of wired network. This protocol solves the worriment by using destination sequence number. It uses shortest path algorithm and provides one route to every node from sender to receiver which is loop free. In DSDV each routing table contains information about all nodes which accessible in the network and hops that are needs to reach that node. Each node broadcast its routing table to its neighbor for maintaining the route reliability.

Optimized Link State Routing Protocol (OLSR), is based on the link state approach. OLSR maintains a routing table which accommodates information about all possible routes to network. When the network topology changed, each node must send it updated information to all other some selective nodes and these selective nodes retransmit these updated information to its other selective nodes. But some nodes which are not in the selected list can only read and process the packet. Some researches analyze that OLSR routing protocol has easily done procedure which acquiesce it to build in different operating system. It performs well in the dynamic topology and it also suitable for data transmission applications which required low latency.

Ad Hoc on Demand Distance Vector Routing Protocol (AODV) is on demand routing protocol because in AODV, route is generated when a node wants to send data packet with another one. AODV can be used either unicast or multicast communication. In AODV when a node requested for a route then route discovery process is active. Once route is created the route maintenance procedure maintains the route and route discovery procedure comes to end. In AODV each node maintains the routing table which holds the value of next hope node, sequence number and a hop count. The problem with this protocol is that, a node has to wait for some time to find the route from source to destination so this protocol cannot be suitable for time critical and safety related application.

Dynamic Source Routing Protocol (DSR) is a multi-hop reactive routing protocol. DSR scaled down the network overhead by contracting periodic messages. This protocol applies source routing and maintains active route. DSR protocol subsists of two operations: route discovery and route maintenance that makes DSR protocol to self-configuration and self-organization. It is network type adjustability in which every packet hold complete successful route to the destination to in its cache. But if any failed route occurs, this protocol will replace it by another successful route. But in DSR protocol, the Route Maintenance mechanism does not reconstruct the broken link.

4. Literature Survey

Nitin Sharma, et al.[3], compared the performance of Ad hoc On-Demand Distance Vector Routing (AODV), Destination Sequenced Distance Vector (DSDV) and Dynamic Source Routing (DSR) protocols over different parameters simulated on NS-2. The simulation was performed to analyze and compare the Average Number of Hop Count, Average Jitter Rate, Throughput, and Packet Delivery Ratio of the three protocols. The result of simulation adjudged that the DSR performances better than that of AODV and DSDV. DSR is found suitable for Highway and Freeway traffics, whereas AODV is suitable for urban traffic scenario.

Sanjoy Das et al. [4] analyzed the performance of various protocols such as LAR, AODV, and DSR protocols for vehicular ad hoc networks. Intelligent Driver Model (IDM) based tool VanetMobiSim is used to generate realistic mobility traces and network simulator used is NS-2. The performance of the protocols is examined with the variation node speeds. They have calculated packet delivery ratio for LAR, AODV, and DSR protocols. The result shows that when the network is sparsely populated almost all the

messages are delivered successfully to the destination in LAR protocol which outperforms DSR and AODV in terms of packet delivery ratio.

Tushar Singh Chouhan et al. [6] compared the performance of different routing protocols between the different nodes in the model. An appropriate loss model is chosen for this purpose depending upon the area of the model. The model is simulated in NS-3 which is a simulation tool and models the real world scenario theoretically. The model shows infrastructure nodes that are stationary and the mobile nodes that move in fixed lanes. The model shows communication among the Vehicle nodes, the vehicle nodes and the infrastructure nodes and also amongst the infrastructure nodes. Payload from all the nodes in the model is broadcasted to all the other nodes. The result shows that OLSR proves to be the best in terms of highest PDR and lowest PLR for every node. Also, OLSR has the least overhead, so the buffer size required is less and the communication is faster and more efficient.

5. Simulation with NS-2

For simulation purpose we used random waypoint mobility model. Network Simulator NS-2.3 has been used to measure the performance of AODV, DSR and DSDV. To ensure reliable data transfer a TCP connection is modeled. Table 1 show the various performance metrics which is used to evaluate the performance.

Performance Evaluation Parameters:

- Throughput: throughput is the number of total packets delivered per unit time.
- Packet delivery ratio: it is defined as the ratio of the number of packets successfully delivered to the destination to the number of packets generated by the source.
- End-to-end delay: time taken for a packet to transmitted over the networks from source to destination.
- Routing Overhead: The total number of routing controlled packets generated by routing protocols.
- Average Energy Cost: is the amount of energy (battery power) consumed by the nodes (in joules) while transmitting the node in the network.
- Path optimality: it is the difference between numbers of hops taken by a packet to reach its destination and the size of the existing shortest path.

Table 1: Network Parameters for NS-2 simulation scenario

Parameter	Value
Network Simulator	NS-2.3
Protocols	AODV, DSR, DSDV
Number of Nodes	30, 90, 150
Simulation Area	1000 m x 1000 m
Pause Time	25, 50, 75, 100, 125s
Traffic Type	TCP
Maximum Speed	15 m / s
Mobility Model	Random Waypoint

The performance of AODV, DSR and DSDV has been analyzed with varying pause time 25s to 125s for number of nodes 30, 90, 150 under TCP connection. We measure the packet delivery ratio & average end-to-end delay of AODV, DSR and DSDV. After analysis of AODV, DSR and DSDV the simulated output has shown in the Table 2 and Table 3.

Table 2: Packet Delivery Ratio

	Number of Nodes								
	30			90			150		
Pause Time (ms)	AODV	DSR	DSDV	AODV	DSR	DSDV	AODV	DSR	DSDV
25	96	98.8	97.4	95.8	99	96.6	95.5	98	96
50	96.5	99	97.5	94	97.9	95.9	94.6	98.2	95
75	96.4	99.1	97.3	96	99	97	95	98.8	95.2
100	96	98.9	97.35	94.8	99.2	94.8	94.2	98	95
125	97.5	99.8	97.9	96.9	99	96.9	97	99.4	97.2

5.1 Simulation Result Analysis

The performance of AODV, DSR and DSDV routing protocol shows some differences in low and high node density. In low density with low pause time the packet delivery ratio is high for DSR and average for DSDV. Under the same scenario average end to end delay is low in DSDV, but in AODV it is higher. If the density is low but the pause time is high then the packet delivery ratio for DSR is high and average for AODV & DSR. For the same scenario, DSDV and AODV possess lower performance in comparison to DSR which possess better results with end-to-end delay.

Table 3: End to end delay (ms)

	Number of Nodes								
		30			90			150	
Pause Time (ms)	AODV	DSR	DSDV	AODV	DSR	DSDV	AODV	DSR	DSDV
25	115	300	50	110	360	60	130	0	50
50	85	400	60	150	560	90	110	420	70
75	100	500	60	80	380	40	170	580	100
100	90	225	55	100	600	100	80	610	50
125	85	285	90	170	590	100	70	390	50

In high density with low pause time, DSR possesses better PDR in comparison to both AODV and DSDV. Here, end to end delay is better for AODV than the comparative protocols DSDV and DSR. In high density with high pause time, packet delivery ratio is higher for DSR than AODV and DSDV. DSDV stands low for end to end delay than AODV, where as it is high for DSR.

6. Simulation with NS-3

For the simulation of performance evaluation in VANET routing protocols in urban city Kota Kinabalu UMS map environment. Simulation was performed on NS-3 analyzing the network performance for AODV, DSR and OLSR routing protocols using the various parameters shown in Table 4.

Table 4: Network Parameters for NS-3 simulation scenario

Parameter	*Value*
Network Simulator	NS-3
Map Model	Kota Kinabalu
Number of Vehicles	20,40,60,80.100
Propagation Loss Model	Two ray ground
Routing	AODV, DSR, OLSR
Transport Protocol	UDP
Packet size	512 bytes
Transmission rate	512 kbps (constant)
Simulation time	500s

The simulation result is demonstrated by Table 5, Table 6 and Table 7.

6.1 Simulation Result Analysis

The performance of AODV, DSR and OLSR routing protocols is analyzed in a VANET crossroad scenario using the traffic and network performance analysis by NS-3 is shown in Table 5, Table 6 and Table 7 for packet delivery ratio, throughput and delay respectively.

Table 5: Packet Delivery Ratio (%)

PDR (%)			
	Routing Protocols		
No. of vehicles	AODV	OLSR	DSR
20	80	70	60
40	60	50	60
60	70	70	80
80	80	60	60
100	90	70	65

Table 6: Throughput (in kbps)

Throughput (kbps)			
	Routing Protocols		
No. of vehicles	AODV	OLSR	DSR
20	5000	4000	4000
40	6000	4500	5000
60	5500	4000	4000
80	4500	3500	3000
100	4000	3000	2500

Table 7: Delay (seconds)

Delay (sec)			
	Routing Protocols		
No. of vehicles	AODV	OLSR	DSR
20	0.001	0.001	0.0005
40	0.05	0.01	0.0075
60	0.1	0.05	0.025
80	0.5	0.075	0.05
100	1	0.1	0.05

DSR protocol is high and equivalent to AODV until the vehicle traffic is increased where AODV performs fairly well than comparative protocols. The AODV protocol has a better throughput performance than OLSR and DSR protocols for high vehicle traffic. The AODV performed well than other comparative protocols providing approximately 4Mbps for 100 vehicles.

7. Conclusion

Under varying algorithms and simulation scenarios the routing protocols behaves differently. As per the analysis AODV performs better than comparative routing protocols in packet delivery ratio and delay when executed under random waypoint mobility model in NS-2 whereas DSR outperformed AODV in another scenario simulated by NS-3 with two ray ground propagation model with another algorithm. In other words, AODV performed fairly well in VANET urban city traffic conditions.

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