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Performance Evaluation of MANET's Reactive & Proactive Routing Protocols in High Speed VANETs

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Abstract— **Vehicular Ad hoc Networks (VANET) are a kind of mobile ad-hoc networks that were primarily developed for applications pertaining to traffic safety and management. Contrasting to MANETs, VANETs are characterized by high speed mobility, open group of nodes with heterogeneous densities, little or no constraints on storage and energy, and difficult communication environment with very unpredictable link lifetime. In this study we have evaluated the performance of two important MANET routing protocols, -viz. AODV and DSDV, when deployed in high mobility VANETs and put into stress to transfer generic type of data between running vehicles. A scenario was created consisting of ambulances rushing on a highway (together with other vehicular traffic) and intercommunicating with each other with emergency voice messages. We considered four QoS parameters -viz. Packets Delivery Ratio, Network Throughput, End-to-End Delay and Normalized Routing Load as benchmark for the performance while varying three network parameters -viz. Density of the network, Speed of the vehicles and the Data traffic load. It was observed that AODV performed very well in all the stress conditions compared to DSDV which remained embarrassingly low in even un-stressed conditions.**

Index Terms— **AODV, DSDV, MANET, Performance evaluation, VANET.**

I. Introduction

Vehicle driving is becoming more and more challenging as the number of vehicles is increasing on the roads[1]. Wireless communication between vehicles has great potential to improve traffic safety and has therefore attracted substantial attention from government, industry and academic communities [3]. Intelligent Transportation System (ITS) is a division of US Department of Transportation that is leading the research and setting standards to make technology provide safety and comfort to the road users [2]. During the last few years several research projects have been initiated by automobile industry [4]. These projects include Car to Car Communication Consortium (C2C–CC) and Car Talk 2000 and many more [5].

Vehicular Ad hoc Networks (VANET) are a kind of mobile ad-hoc networks (MANET) that were primarily developed for applications pertaining to traffic safety and management. They can assist vehicles to communicate and coordinate among themselves in order to help drivers to take timely decisions and avoid any critical situations like accidents and traffic jams. Some other safety applications may include intelligent traffic lights, speed control and automatic braking, free passage for ambulances and other emergency vehicles. Besides safety applications, a significant portion of research is also devoted to study how VANETs may be used as a means for gereric data communication including voice calling and video streaming [6]. Contrasting to MANETs, VANETs are characterized by high speed mobility, open group of nodes with heterogeneous density, little or no constraints on storage and energy, and difficult communication environment with very unpredictable link lifetime [1]. Because of these notable differences, it is very important to study how MANET routing protocols will behave in VANETs and to identify any inherent issues present in the protocols that may help suggest some improvements [7].

In this paper we have evaluated the performance of two important MANET routing protocols, -viz. AODV and DSDV, when deployed in high mobility VANETs and put into stress to transfer generic type of data between running vehicles.

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II. Applications of VANET

A. Safety Applications

Safety applications include Real-time traffic information, Co-operative Message Transfer, Slow/Stopped Vehicle Advisor (SVA), Congested Road Notification (CRN), Post Crash Notification, Road Hazard Control Notification, Traffic Vigilance and Intelligent Traffic Lights.

B. Commercial Applications

Commercial applications will provide the driver with the entertainment and services as web access, streaming audio and video. The Commercial applications may include Remote Vehicle Personalization, Remote Vehicle Diagnostics, Announcement of services available in the locality, Value-added advertisement, Internet access, Digital map downloading, Real Time Video Relay (eg: TV multicasting).

C. Convenience Applications

Convenience application mainly deals in traffic management with a goal to enhance traffic efficiency by boosting the degree of convenience for drivers. The Convenience applications may include Electronic Toll Collection, Parking Availability and Active Prediction etc.

D. Statistics Applications

These type of applications may include statistical data collection about environmental factors, number and type of vehicles running, time of road utilization etc.

III. Routing Protocols

The routing protocols are used to find a path from source to target destination. Essentially these protocols have been classified into three categories. (1) (Proactive) routing protocols, [14], [15] (2) (Reactive) routing protocols and (3) Hybrid routing protocols (Proactive + Reactive). Figure 1 shows a classification of MANET routing protocols such as Destination Sequence Distance Vector (DSDV), Zone Routing Protocol (ZRP), and Ad-Hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Reverse Ad-Hoc on Demand Distance Vector (RAODV), Energy Reverse Ad-Hoc on Demand Distance Vector (ERAODV) routing protocols.

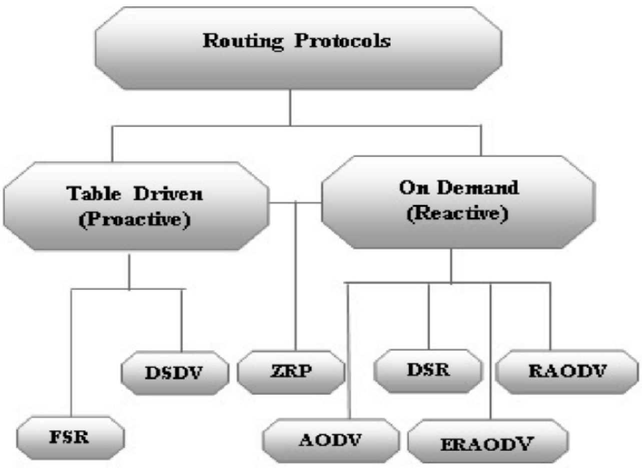

Fig. 1, "Classification of Routing Protocols"

A. Proactive Routing Protocols

In proactive (table-driven) protocols all nodes exchange with their neighbors information about shortest routes to other nodes periodically. After analyzing these routes they compute and store the shortest path to each possible destination in a table [16]. These types of protocols are not difficult to implements in the network but due to the resource hungry nature, limited energy of the node and slow propagation of routing information it becomes infeasible to use this protocol. DSDV (Destination Sequenced Distance-Vector), [17], [18] FSR (Fisheye State Routing Protocol), [19] and CGSR (Cluster Head Gateway Switch Routing Protocol) [19] [20] are table driven (Proactive) routing protocols.

B. Reactive Routing Protocol

In contrast, reactive (on-demand) protocols do not continuously exchange routing information with the neighbors, instead a route is constructed only when it is needed. When a source node needs a route to a destination node it starts a node discovery process, in which route request messages are flooded across the network. The destination node responds to this request hence establishing a route. The Route is maintained until destination become unreachable, or source is no longer interested in destination. AODV (Ad-Hoc on Demand Distance Vector Routing Protocol), DSR (Dynamic Source Routing Protocol), TORA protocol (Temporary-Ordered Routing Algorithm), [21] CBRP (Cluster Based Routing Protocol), [22] these are all On Demand (Reactive) Routing Protocols [23].

C. Hybrid Routing Protocol

Hybrid (proactive + reactive) protocols are simply the combination of two protocols stated above. ZRP (Zone Routing Protocol) being a typical example in which the whole topology is divided into a hierarchy of zones. Proactive routing is used locally within each zone, while reactive routing is used to create routes between the zones. All nodes within a radius of r hops are considered a zone.

IV. QoS Parameters

Typically, qualities of service (QoS) parameters are used to define the required performance of a connection or a network as described by QoS routing QoS MAC and resource reservation. However the same parameters may be used as performance metrics to study the effectiveness of a protocol. Following are some of the important QoS parameters that have been used in this study.

A. Packet Delivery Ratio

Packet delivery ratio is calculated by dividing the number of packets received at the destination by the number of packets originated at the source. For the best performance packet delivery ratio of routing protocol should be as high as possible. If the ratio is 1, it will be the best delivery ratio of the routing protocol.

B. Average Throughput

It refers to the amount of data delivered in a unit of time averaged over the number of nodes it is measured in bits per second (bps).

C. Average End-to-End Delay

It is the average time a packet takes to reach the destination from the source. Any retransmission delays at the Media Access Control (MAC) layer are also included. It is measured in the units of time (sec). Typically this can be calculated by dividing the difference of sent timestamp of the first packet and the receive timestamp of the last packet with the total number of packets received.

D. Normalized Routing Load (NRL)

The total number of routing packet transmitted per data packet defines the Normalized Routing Load (NRL). NRL is calculated by dividing the total number of routing protocol packets (i.e. control packets) by the total number of data packets (i.e. sent packets) from the source.

V. Scenario and Simulation Tools

A. Simulation Scenario

A scenario was created consisting of ambulances rushing on a highway (together with other vehicular traffic) and intercommunicating with each other with emergency voice messages. Figure 2 .shows a snap of a scenario used in this study. Vehicles are divided into two classes Black and Red, Black Vehicles are common vehicles and Red vehicles are ambulances and these ambulances are free to communicate each other's through common vehicles.

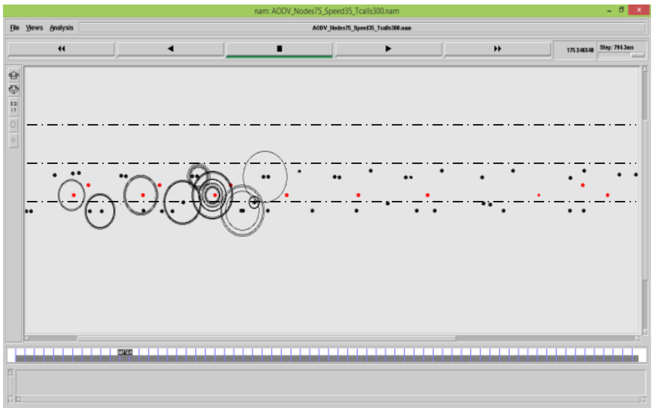

Fig. 2, "A Simulated Scenario"

B. Scenario Generator

To generate the data traffic load, we used a home-grown tool as shown in the figure 3. This tool can generate both two way and one way voice calls in a normally distributed fashion.

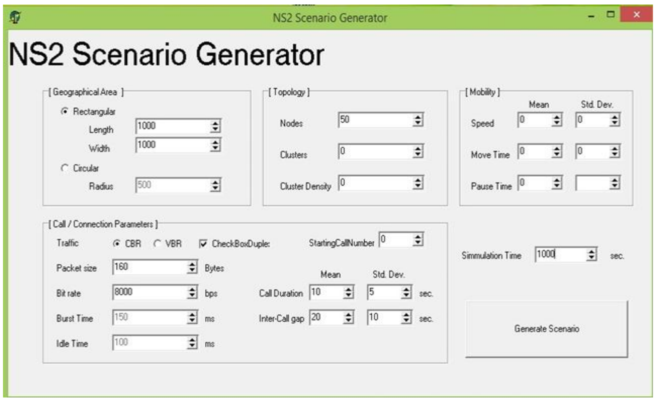

Fig. 3, "Scenario Generator"

C. Simulator

NS2 (Network simulator-2) is a discrete event simulator of networking used for the research purpose. It provides the full support for Transmission Control Protocol (TCP), User Datagram Protocol (UDP), Routing and multicasting routing protocols. This simulator is written is in a C++ and the script language called OTcl, script which is used for defined the number of mobile nodes, links, traffic type, agents, source, destination and which protocol will be use. This script is used by ns during the simulation time, the result the simulation is saved in a .trace file and .nam file. The trace file maintain the log+ event of the whole simulation that's why the size of this trace file may be large in Giga Byte. 99% data of the trace file is useless only 1% data is useable, .nam file is used to visualize the scenario by name editor it is the GUI interface of NS2 as shown in Figure 4.

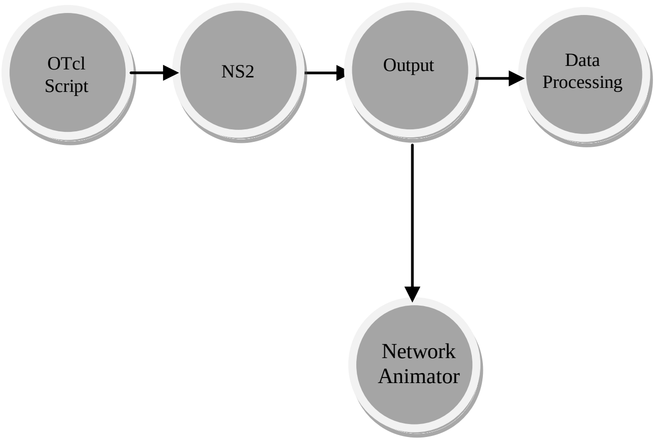

Fig. 4, "NS2 Simulator Structure"

VI. Simulation Results

The following tables summarizes our simulation parameters:

Parameters	Values
No. of Nodes	50,75,100
Speed	30,35,40 m/s
Total No. of Calls	400, 300, 200
Routing Protocols	AODV, DSDV
Road Length	20 km round trip
Average Call Duration	10 seconds
Traffic Type / Routing Agent	CBR / UDP
CBR Data Rate	8 Kbps
Packets Size	160 Byte
Mobility Model	Road Model for VANET
Type of Channel	Wireless
MAC Protocol	IEEE 802.11
Radio Propagation Type	Two Ray Ground
Interface Queue Type	Drop Tail Pri Queue
Queue Size	50
Antenna Model	Omni Antenna
Frequency	2.472 GHz
Transmission Range	1450 meters (Pout=0.031622777 watts) (RxThresh=2.97785e-10 watts)
Rate for Data Frames	50Mb
Rate for Control Frames	50Mb
Simulation Time	1000 Seconds

The following graphs summarize the performance of the AODV and DSDV routing protocols:

A. Packet Delivery Ratio

PDR is defined as the ratio of packets received to the number of packets sent. As depicted in the graph as shown in Figure 5, the PDR of DSDV Protocol remained embarrassingly low irrespective of the variations in the simulation parameters. The AODV protocol's PDR shows variation with respect to the number of nodes. With 50 nodes the PDR averaged around 30%, with 75 nodes it was around increase in node density is due to the fact that in more dense networks when a path breaks an alternate path is available

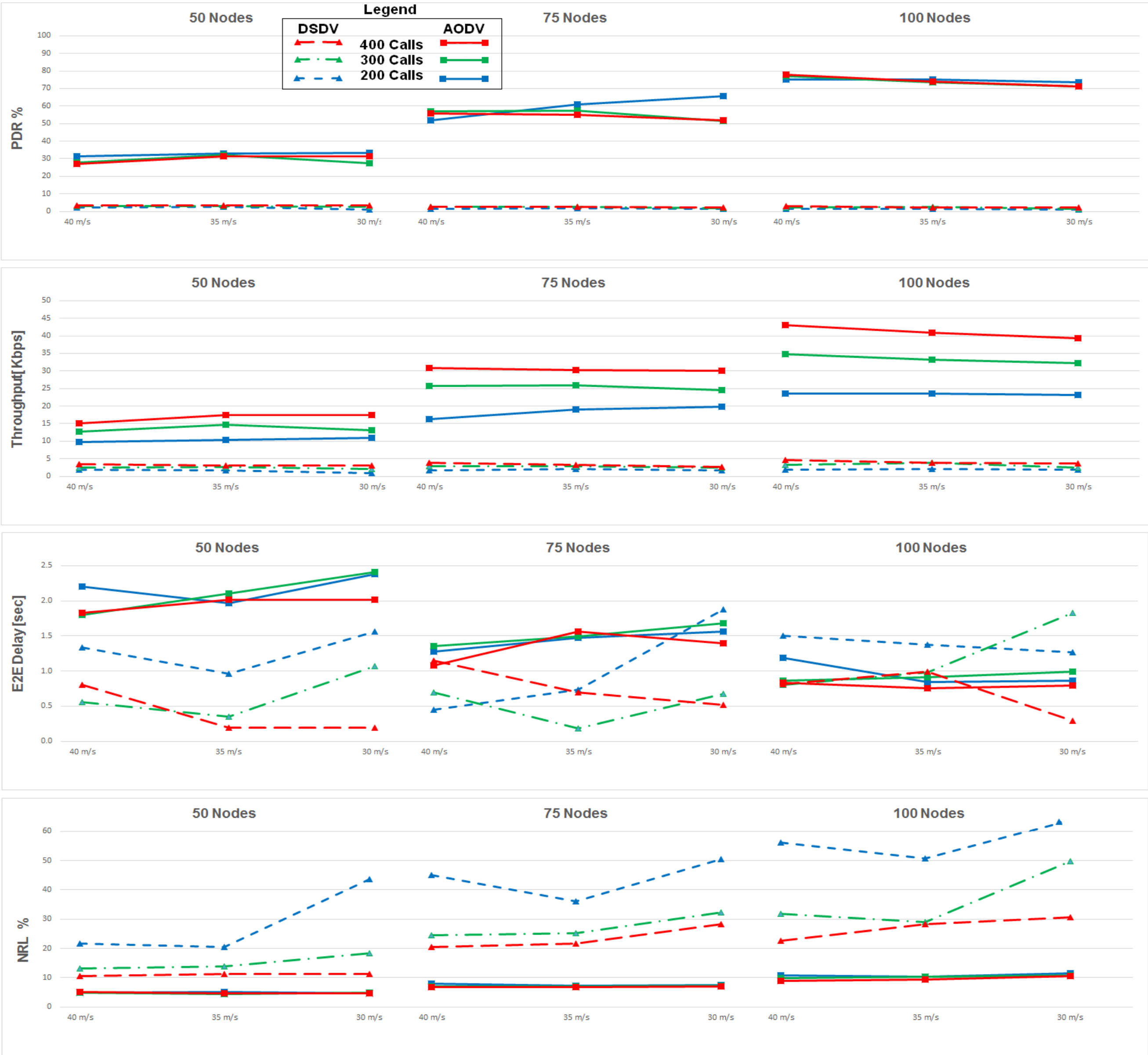

Fig. 5, "Simulation Results"

55% and for 100 nodes it averaged around 80%. The increase in PDR with the increase in node density is due to the fact that in more dense networks when a path breaks an alternate path is available while in less dense scenarios a broken path may not be reconstructed until another moving node comes in to bridge the gap. However the PDR of AODV was found little affected of the variation in speed.

B. Packet Delivery Ratio

PDR is the ratio of packets received to the number of packets sent. As depicted in the graph as shown in Figure 5, the PDR of DSDV Protocol remained embarrassingly low irrespective of the variations in the simulation parameters. The AODV protocol's PDR shows variation with respect to the number of nodes. With 50 nodes the PDR averaged around 30%, with 75 nodes it was around 55% and for 100 nodes it averaged around 80%. The increase in PDR with the while in less dense scenarios a broken path may not be reconstructed until another moving node comes in to bridge the gap. However the PDR of AODV was found little affected of the variation in speed.

C. Network Throughput

Network Throughput is the amount of data delivered in a unit of time averaged over the number of nodes. As depicted in the graph the Network Throughput of DSDV Protocol remained embarrassingly low irrespective of the variations in the simulation parameters. The AODV Protocol's Throughput shows variation with respect to the number of nodes. With 50 nodes the Network throughput averaged around 20kbps. With 75 nodes it was around 30 kbps and for 100 nodes it averaged around 45kbps.The increase in Network Throughput with increase in node density is due to is due to the flooding of control packets to find out the missing or broken routes. Therefore Network Throughput of AODV is much better than the DSDV protocol.

D. End to End Delay

End to End delay is the average time a packet takes to reach the destination. According to the graph, End-to-End Delay of AODV remained higher than that of DSDV in all the cases. The End-to-End Delay of DSDV shows no correlation with the variations in the parameters. The reason for this behavior is that DSDV failed to maintain routes due high mobility and was able to transfer only those data packets where the destination was located near the source node.

E. Normalized Routing Load

As depicted in the graph the NRL of DSDV remained higher than that of AODV because DSDV tried to maintain routes between each pair of nodes, but failed due to the very high mobility of the scenario, which is in contrast with the AODV protocol which establishes route as and when needed. The NRL of both AODV and DSDV showed a positive correlation with the number of nodes.

VII. Conclusion and Future Work

In conclusion the AODV performance remained much better than that of DSDV in all the studied QoS parameters an in all the simulated scenarios. The DSDV protocol was found very affected with the mobility. With high mobility the performance of DSDV was embarrassingly low, while, with no mobility the performance of DSDV was observed neck to neck with that of AODV.

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