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Evaluation of Ad-Hoc Routing Protocols in a Vehicular Traffic Environment using SUMO and NS2

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Abstract: Considering the transition from a peripatetic world to a world full of vehicles all over, the need for a well-defined communication between vehicles is something to be thought of. There may be circumstances where we cannot rely on traditional methods of communication for message or data transfer. At times, speed is prioritized over reliability and vice-versa. This paper focuses on evaluating the performances of different Ad Hoc routing protocols which are Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Destination Sequenced Distance Vector (DSDV) in terms of their average throughput and average end-to-end delay. All the three protocols have been implemented in the same traffic environment. Six cases have been considered where these routing protocols have been implemented using User Datagram Protocol (UDP) and Transmission Control Protocol (TCP) as the transport layer protocols. The scope of this paper is to find out the best routing protocol, both on the basis of average throughput and even end-to-end delay and optimize it to improve its performance. Finally, the paper is summarized.
Keywords: MANET, VANET, Simulation of Urban Mobility (SUMO) simulator, DSDV, AODV, DSR

I. INTRODUCTION

A routing protocol consists of a set of rules that enables nodes of a network to find the path for communication with each other. Each routing protocol has its own approach towards finding the optimal path and it need not be necessary for any particular routing protocol to be the best in each and every applicable scenarios. Performance in such scenarios is governed by the routing protocols used.

A. Mobile Ad-Hoc Network (MANET)

Mobile ad hoc network [1] is a group of wireless mobile nodes in which nodes collaborate by forwarding packets for each other to allow them to communicate outside range of direct wireless transmission. The network topology is unpredictable and can vary over time. All the network activity, including discovering the topology and delivering the messages must be executed by the nodes themselves. The mobile nodes can directly communicate with the nodes that are in the range of each other whereas other nodes need the help of intermediate nodes. The MANET allows more flexible communication since the user is not limited to a fixed physical location. Mobile Ad-hoc network (MANET) is a dynamic wireless network in which each mobile node acts as a router. [2]The performance of routing protocols directly affects the performance of network. Performance of routing protocols is measured in terms of various qualitative and quantitative metrics. For better performance of Ad-hoc networks it is necessary to optimize the routing protocols. The AODV routing protocol is the most prominent among the reactive routing protocols.

B. Vehicular Ad-Hoc Network (VANET)

Vehicular[3] ad hoc networks (VANETs) are classified as an application of mobile ad hoc network (MANET) that has the potential in improving road safety and in providing travellers comfort. Cooperative Intelligent Transport Systems (C-ITS) use wireless technologies to enable real-time wireless communication between vehicles, roadside infrastructure, mobile devices and back-office systems, improving the safety and manageability of the transport network, and reducing congestion and costs. In [4] the author analyse the topic of vehicular networks in the context of C-ITS from an evolutionary point of view, scanning early concepts and enabling technologies, current status and future opportunities, with a look on a future fully networked vehicular environment.

C. Ad-Hoc Routing Protocols

1) *DSDV:* The DSDV [5] routing protocol routing protocol which follows the Bellman-Ford algorithm. A routing table is maintained by each node in the network that contains a series of parameters such as <destination, next hop, hop count, sequence number, install time>. The sequence number plays an important role as it depicts whether a link to a node is present or not by it

being even or odd. It also helps us to differentiate between stale routes and updated ones and avoids the loop formation. If a node receives new information, then the route is selected on the basis of the latest sequence number. If the sequence number is not updated, the route with the better metric is used.

2) *AODV:* As the name suggests, AODV [6] finds a path between the nodes only when requested by the source node. The routes are maintained as long as they are required by the sources. It defines 3 message types: RREQ, RREP, RERR. RREQ packets are used to initiate the route calculation and finding process. RREP packets are used to finalize the routes. RERR packets are used to notify the network of a link breakage in an active route. The source node broadcasts the RREQ packets to its neighbouring nodes. If one of the neighbouring nodes has the path to the destination node, then it sends an RREP packet back to the source. Thus, a path is discovered and message transfer is possible.
3) *DSR:* DSR is also an on-demand routing protocol which consists of three stages: - route discovery, route cache, and route maintenance. The difference between DSR and AODV is that in DSR, the source node keeps a track of the hop count required for communication with the destination node. The source node broadcasts the RREQ packets to all of its neighbouring nodes. If one of the neighbouring nodes is the destination node, then it will send back an RREP packet to the source node. If the neighbouring node is an intermediate node, it will add its own address to the route record in the RREQ packet and broadcasts it to its own neighbouring nodes, or it will discard the RREQ packet if it is duplicate message or if it finds its own address in the route record. However the commonly used protocols mentioned above face various challenges and thus limit their usage to a particular application. Hence various optimization approaches are suggested in the literature

II. REVIEW OF PERFORMANCE EVALUATION

Various routing protocols can be used for the transfer and we tried three – AODV, DSR, and DSDV. All the three protocols gave different results in terms of end to end delay and throughput accordingly the best one was chosen.

The two types of transport layer protocols, TCP and UDP were taken into consideration and the tests were performed on both of them with all the three routing protocols respectively. There were six such combinations produced for which we performed the simulation five times each giving us 30 results for the overall conclusion about the best transport layer protocol as well as the routing protocol for the algorithm.

III.IMPLEMENTATION

The software requirements for the simulation are:
1) Simulation of Urban Mobility (SUMO) simulator [7]
2) Network Simulator 2 (NS2) [6]

The steps involved are:

A. *Extraction of Map*

For simulation purpose, a map of a certain area is needed. The map is extracted from a website called Open Street Maps where a particular area of a map can be selected and corresponding Open Street Maps (.osm) file can be extracted and downloaded.

B. *Creation of Traffic Simulation (SUMO)*

We created a real-world traffic scenario for the map extracted from Open Street Maps. In this, we defined 50 [8] vehicles that will be running on the roads of the selected map. Thus, a VANET for the scenario is created.

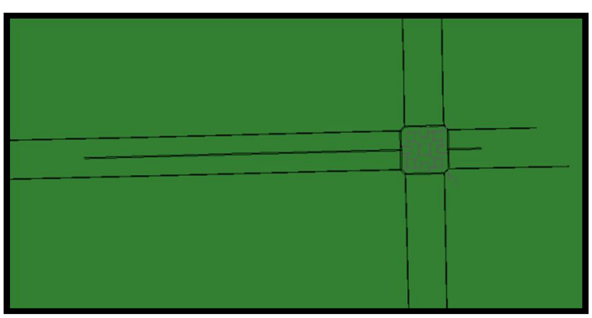

Fig. 1. Full image of the area selected (in SUMO)

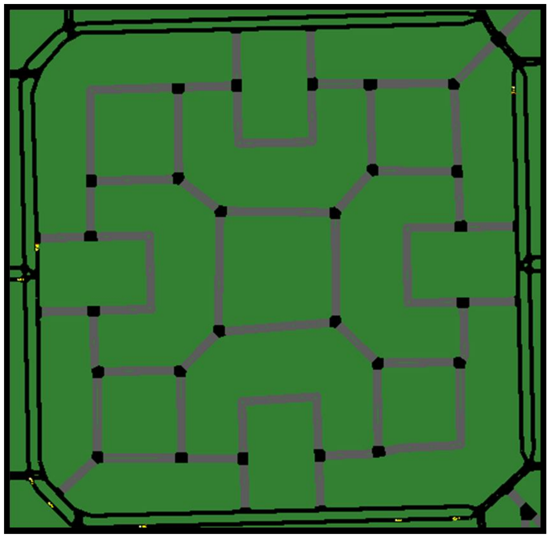

Fig. 2. A closer look of the internal area of the map

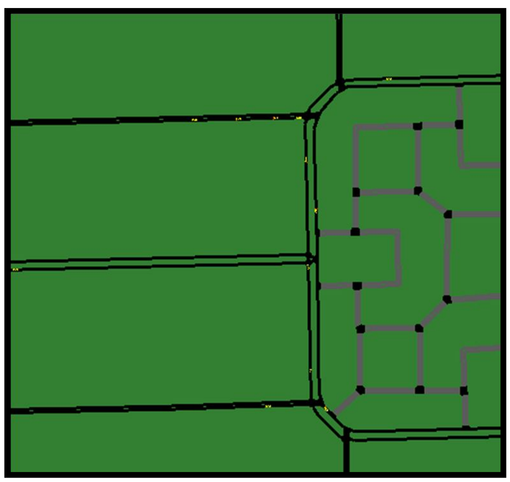

Fig.3. Yellow vehicles depicting mobile nodes

C. Creation of Equivalent Network Simulation (NS2)

The network simulation is implemented using NS2. This simulation consists of wireless mobile nodes. In this simulation, the packet flow between vehicles and their proximity among each other is observed. The source and destination of data packets are predefined using TCP or UDP connection. The start time and stop time is specified in the .tcl file (NS2 file). The simulation is then viewed in Nam simulator.

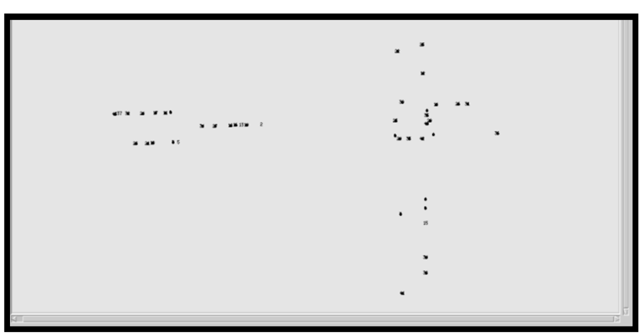

Fig. 4. 50 mobile nodes (in NS2)

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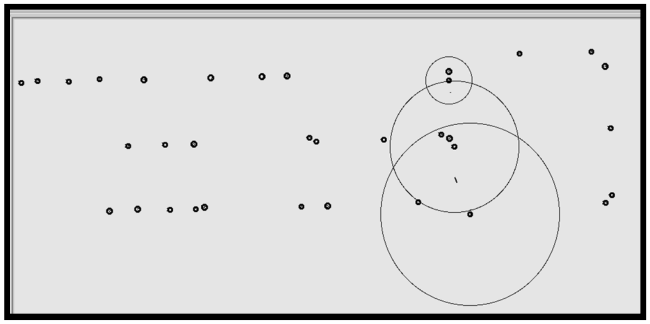

Fig. 5. Vehicles in each other's proximity

D. Scenarios Considered

Transport Layer Protocol	Routing Protocol
TCP	DSDV
	AODV
	DSR
UDP	DSDV
	AODV
	DSR

Running the simulations for each scenario 5 times, corresponding 5 trace files were generated.
An awk script was used on the trace files to extract relevant average end to end and average throughput.

E. Comparison

1) TCP

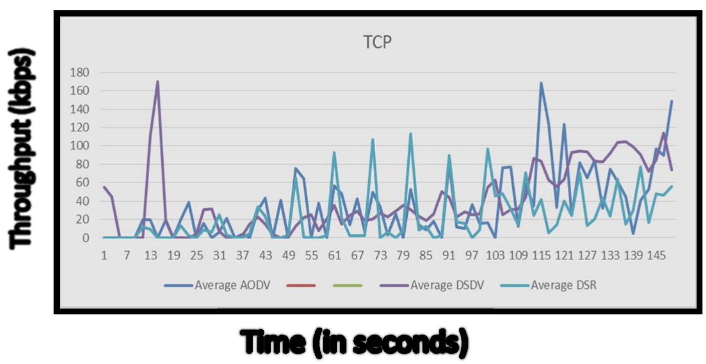

Fig 6. Throughput vs Time Graph for UDP

2) UDP

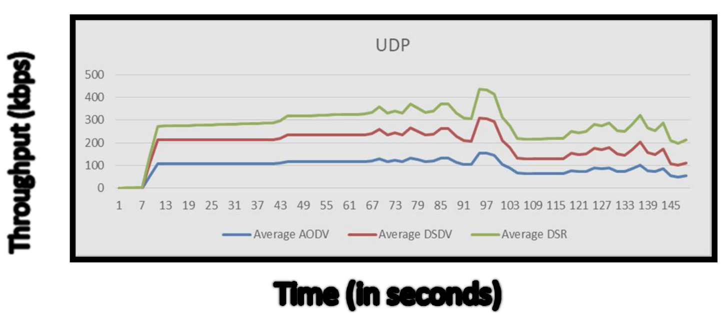

Fig 7. Throughput vs Time Graph for UDP

IV. SIMULATION ENVIRONMENT

The performance of the routing protocols such as AODV, DSR, and DSDV is analysed by simulating ad-hoc network using SUMO and NS-2. Simulation scenario consists of 50 mobile nodes (vehicles).

Parameters	Values
Number of nodes and Area	50 and 600*200 sq.m.
Node Placement	Uniform
Time of Simulation	5 minutes
PHY/MAC Layer Protocol	IEEE 802.11
Speed Range (m/s)	0-22
Mobility Model	Random Way Point(RWP)
Propagation Limit	-111 dBm
Path Loss Model	Two Ray Model
Channel Frequency	2.4GHz
Fading Model	Rayleigh
Map Model	OSM (Bagalkot, Karnataka)
Network Simulator	NS2
Traffic Simulator	SUMO v0.22
Routing Protocol	DSDV, AODV, DSR
Transport Layer Protocol	UDP, TCP

V. RESULTS

Performance of all the three routing protocols was analysed using simulation scenarios.

Upon generating the simulations and creating the graphs, it was concluded that there was a higher throughput when the DSR routing protocol was used and lesser delay when the AODV routing protocol was used. On the other hand, it was also seen that using UDP transport layer protocol gave a uniform result whereas the TCP transport layer protocol gave us a non-uniform result.

VI. FUTURE WORK

The efficiency of the AODV protocol can be further enhanced by optimising the AODV protocol. Two parameters considered are distance between the nodes and Received Signal Strength (RSS). The distance between a node and all its neighbouring nodes are calculated and the minimum distance is then considered. Furthermore, the signal strength [6], [1], [3] is accounted for a probabilistic approach for forwarding RREQ packets. Lesser the signal strength. Less is the probability of sending RREQ packets. More the signal strength more is the probability of sending RREQ packets.

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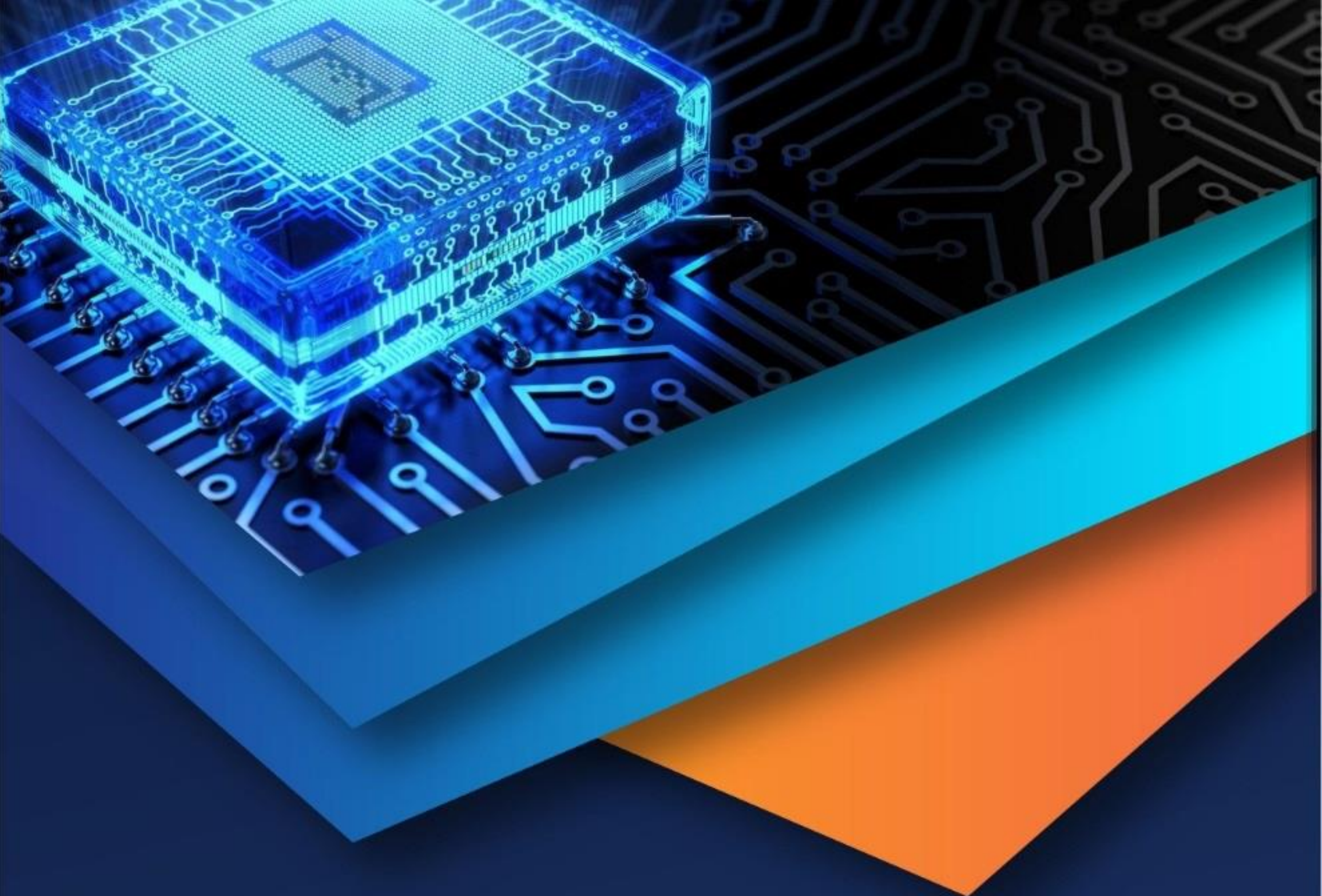

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