Performance Analysis of AODV Routing Protocol in Vehicular Ad Hoc Networks

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Abstract- Vehicular ad hoc networks (VANETs) is one of the interesting field for network researchers. It is gaining attention because of its characteristics and wide range of applications. This paper provides the performance evaluation of Ad hoc On demand Distance Vector (AODV) routing protocol in a synthetic highway scenario simulated in network simulator NS3. The performance is evaluated with the variation in vehicle density, simulation time, pause time, transmission range and path loss models. The AODV performance seeks its importance in upcoming VANET research by incorporating some necessary changes in the protocol such as security and authentication related.

Keywords: *AODV; Loss Model; NS3; Pause time; Transmission Power; VANET.*

I. INTRODUCTION

A lot of research has been done in Ad Hoc networks MANETs and VANETs [1][2]. But due to no realistic approach in MANET, researchers are gaining attention for working with Vehicular Adhoc Networks [1]. It is an extended view of MANET in which the mobile nodes are replaced by the vehicles and issues like limit to geographical area, limit to node battery, nonrealistic approach are overcomed by the VANETs [3]. Many already existing protocols of MANETs are used in VANET [4]. Although new approaches are incorporated in the existing protocols by many researchers to provide better results [5]. AODV was mainly designed for MANET but is also used in VANET and is the base for many routing as well as security algorithms designed for specially VANET [5][6]. AODV Routing Protocol is an on demand protocol that discovers route using RREQ messages and further receives RREP as route reply message as acknowledgment from the relaying nodes. It is specially designed for ad hoc networks. The relaying nodes then further broadcast the packet to the next hop with source ID and adding sequence number to the message. If any route mismanagement happens then a RERR message is received by the source nodes. In many studies, AODV remains the base routing protocol for implementation of other required additional features in it. It is easy to adapt with new conditions and modification in its algorithm for security related features using cryptographic techniques [7].

II. RELATED STUDY

This section provides some of the related work on the path loss models, mobility models and transmission power.

A. On Path loss Models

Caleb Phillips et. al. [8] presented a survey paper on wireless path loss and coverage methods. The path loss models are classified in the following seven models: theoretical, basic, terrain, supplementary, stochastic, many ray and active measurement models. We are considering here only three particular model. Friis path loss model is described in the foundational or theoretical model. The free space transmission loss in a friis path loss model is described as

$$\frac{P_{rx}}{P_{tx}} = \frac{A_{rx} \times A_{tx}}{d^2 \lambda^2}$$

Where P_{rx} is the received power, P_{tx} is the transmitted power, A_{rx} is the area of the receiving antenna, A_{tx} is the area of transmitting antenna, d is the distance between two antennas in meters and λ is the wavelength of the carrier. Itur1411 is classified in the terrain model which considers the building losses along with the free space propagation loss. Two ray ground is another fundamental model which uses Friis equations for the case where receiving antenna are not so far to receive ground reflected path loss. For longer distances the path loss formula is an extension to the existing Friis model

$$P_{rx} = \frac{P_{tx} h^2{}_{tx} h^2{}_{rx}}{d^4}$$

where h_{tx} is the height of transmitting antenna and h_{rx} is the height of receiving antenna

B. On Mobility Models

Micro Musolesi et al. [9] presented a survey on the performance of mobility models. The paper outlines different pure synthetic models (like Random walk, Random way point, obstacles modeling, single node mobility, group mobility models), trace based mobility models, analytical models, social network based models.

C. On Transmission Power

Yu Qiao et al.[10] presented a work on the impact of transmission power for selecting tall vehicles as next hop for communication in the vehicular networks. The simulations were performed in OMNET++ with IEEE 802.11p protocol. The scenario comprises of 15% tall vehicles and rest with smaller vehicles. The performance of the network was analyzed on the basis of average success rate of packets and selection rate of tall vehicles as next communication hop. The simulation results for a realistic environment are better in terms of packet success rate for taller vehicles selection as communication next hop instead of smaller vehicles. Other findings from the results was that average success rate for packets is proportional to that of transmission power.

III. PARAMETERS FOR PERFORMANCE EVALUATION

This section presents the various performance parameters in order to evaluate the performance of AODV routing protocol in the designed VANET scenario.

A. Average Goodput:

This parameter is also known as application layer throughput and the calculate value is always less than throughput value. The goodput considers only useful information and not information related to routing overheads, also the flow control of TCP layer affects its value. The lost packets and retransmission of packets are not considered in the goodput. It is considered as an evaluation parameter over throughput in VANET as it considers only useful data that is in the form of basic safety messages. It is calculated as the ratio of information file size over the time needed to transfer it. Goodput is generally measured in kilo byte per second (kbps) [11].

B. MAC/PHY overhead:

Routing protocols generate routing packets for information related to route update in the network. These routing packets are related to transport layer and contains no information for application layer. The network bandwidth is shared by both routing packets and application packets. Therefore routing packets are known as overheads in the network and these should be less in number for better performance of a routing protocol [12]. It is calculated with the formula shown below:

$$\text{MAC} \therefore \text{PHY layer overhead} = \frac{\text{total physical bytes} - \text{total application bytes}}{\text{total physical bytes}}$$

C. Vehicle Density:

In the vehicular communication the number of vehicles act as mobile nodes for routing the information from source to destination using the routing protocol. Besides all other performance parameters the vehicle density is considered as a variation parameter for analyzing the average goodput and MAC/PHY overheads [13].

D. Simulation Time:

The permitted time for the simulation to run is also a deciding factor for the evaluation of different performance parameters. Depending on the network density and simulation time, the parameters like Goodput and MAC/PHY overheads are calculated for the designed scenario [13].

E. Pause Time:

It is the particular for which the nodes will not move and simulation will get time to enhance the network performance. If pause time = 0 that means the nodes will be continuously moving and will not be idle or stop within the full simulation time[14].

III. SIMULATION SCENARIO

A synthetic highway scenario of dimension 250m × 3000m using IEEE 802.11p is designed in NS3 for vehicular ad hoc networks. The different simulations are performed to evaluate the performance of AODV routing protocol on the basis of performance parameters such as average good put and MAC/PHY overheads with the variation in number of vehicles, variation in simulation time, variation in pause times. Also the performance of AODV is observed with the change in path loss model, and change in transmission power. A detailed description of simulation scenario is presented in TABLE 1.

TABLE.1 Simulation Setup

Parameter	**Specifications**
Platform	Ubuntu16.04 LTS
Simulation TOOL	Network Simulator-3.28
MAC Layer	IEEE 802.11p
Mobility Model	Random Way Point
No. of Vehicles	30,60,90,120
Pause Time	0, 10, 20, 30, 40, 50
Speed of Vehicles	20 m/sec.
Traffic Type	TCP
Path loss Model	Friis, ItuR1411, Two ray ground
Routing Protocols	AODV
Transmission Max. Delay	10 ms
Simulation Area	250m × 3000m
Transmission Power	7.5, 15, 30, 45 dBm
Channel	Wireless Channel
Simulation Time	20,40,60,80,100,120 sec.

IV. RESULTS & DISCUSSIONS

This section presents the simulation results and discussions on the basis of simulations and parameters discussed in previous sections.

A. AODV performance on the basis of variation in simulation time

The VANET scenario has been used to analyze the performance of AODV routing protocol under the different density of vehicles. The number of vehicle are varied from 30, 60, 90 and 120 over the synthetic track with the sped of vehicles taken 20 m/s. The average goodput and MAC/PHY overheads are observed with the variation in simulation time from 20, 40, 60, 80, 100 and 120 seconds as shown in Fig.1 and Fig 2 respectively. The goodput as shown from Fig.1 is highest for 60 vehicles in all the simulation time. When we observe the goodput for 120 vehicles it continuously rises with the increase in simulation time, which is for the reason that more time is required to receive the packets transmitted by a large number of vehicles. As in case of 120 vehicles the number of transmitted packets also increases and for smaller simulation time not all vehicle get time to participate fully in the network. While for 30 and 90 vehicle the goodput is below the other two densities due to some other parameters of the network. The MAC/PHY overheads are shown in Fig. 2 which shows the performance of 30, 90 and 120 vehicles is consistent throughout the different simulation times except for 60 vehicles in which overheads rises with the simulation time of 120 seconds which may be due to the less number of application bytes left after 100 seconds of simulation and thus rise in overhead performance.

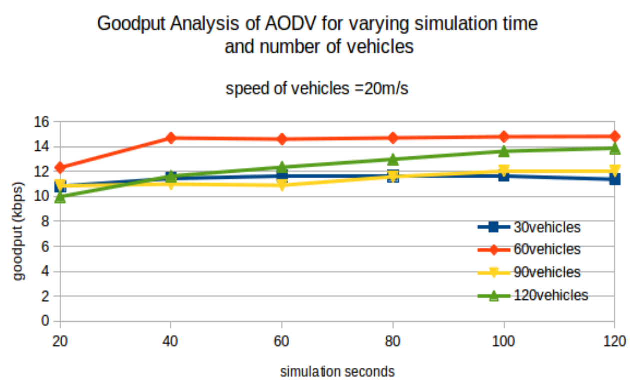

Fig.1 Average goodput analysis of AODV with variation in simulation time

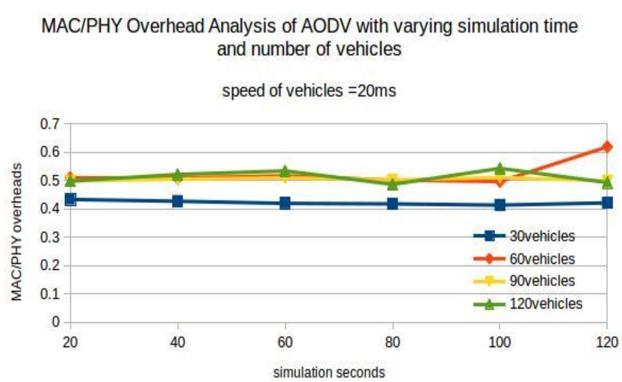

Fig.2 MAC/PHY overhead analysis of AODV with variation in simulation time

B. AODV performance on the basis of variation in pause time

The performance of 60 vehicles was observed as best in all the simulation times from analysis in the previous section. In this section the protocol performance is observed on the basis of pause times 0, 10, 20, 30, 40 and 50 for 60 vehicles moving with speed of 20m/s and 20 seconds and 40 seconds of simulation time. The response for goodput with 20 seconds simulation time is shown in Fig. 3 which shows a fair increase of 3kbps with 10 pause time and then it increases for one more time because thereafter no effect of pause time due to simulation time ends

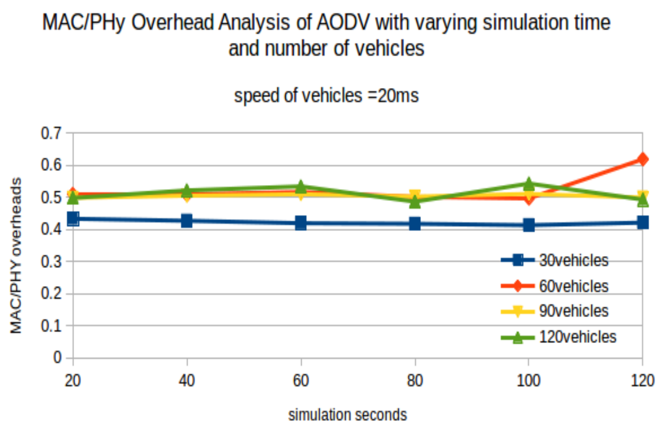

Fig.2 MAC/PHY overhead analysis of AODV with variation in simulation time

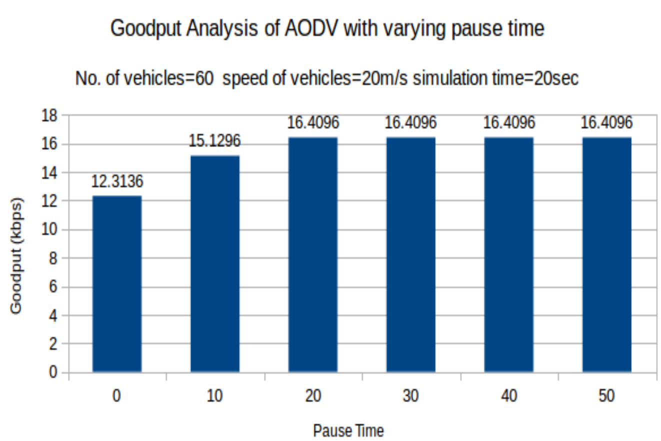

Fig. 3 Average goodput analysis of AODV with variation in pause time and simulation time 20seconds

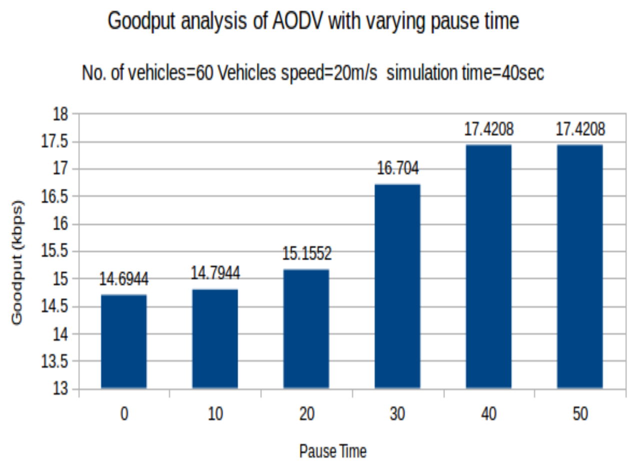

Fig. 4 Average goodput analysis of AODV with variation in pause time and simulation time 40 seconds

. Similar graphs are observed with simulation time of 40 second as shown in Fig no. 4 where the goodput rises up to 40 pause time and remains same after that due to simulation end time. One more thing can be observed from the two figures that with the increase in simulation time the goodput increases.

C. AODV performance on the basis of variation in transmission power

The change in average goodput with the increase in transmission power with 60 vehicles and 20 seconds simulation time and vehicle speed of 20m/s is presented in Fig. 5. The transmission power is varied from 7.5, 15, 30 and 45 dBm. As stated in paper by Yu Qiao et al. the average goodput increases with the increase in transmission power. It increased by 6 kbps (approx.) when transmission power is switched to 15 dBm from 7.5 dBm.

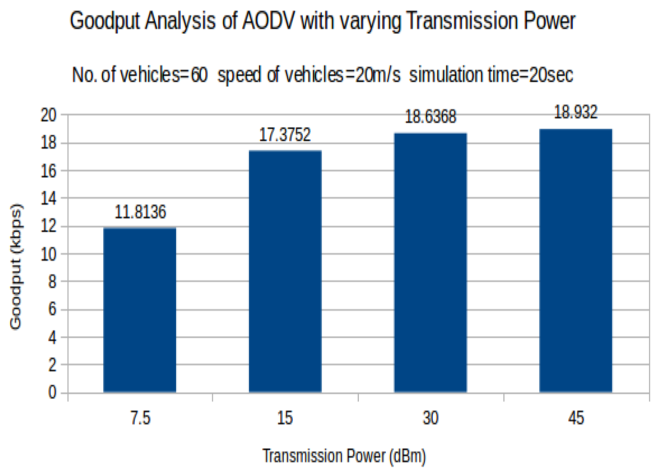

Fig. 5 Average goodput analysis of AODV with variation transmission power

D. AODV performance on the basis of variation in path loss model

The three path loss model discussed in section 2 are used to evaluate the performance of AODV on the basis of average goodput as shown in Fig. 5. The Friis and two ray ground performed almost equal with goodput of 12.21 and 12.31 kbps respectively. As there are no obstacles and buildings in this scenario the goodput decreases in ItuR path loss model case to a value 10.83 kbps.

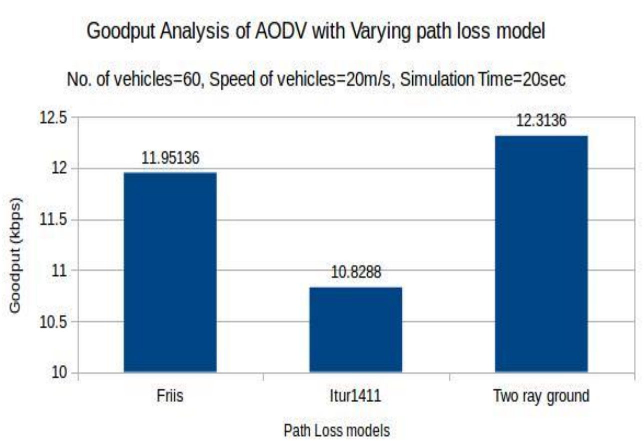

Fig. 5 Average goodput analysis of AODV with variation transmission power

V. CONCLUSION & FUTURE WORK

The performance of routing protocol AODV is evaluated in vehicular ad hoc networks on the basis of different parameters. From the simulation results it can be concluded that the density of vehicles do make a difference in the performance provided simulation time is set accordingly so as to participate the all vehicles in the network fully. AODV shows that pause time do effect the performance so these should be selected according to the application point of view. The increase in transmission power definitely increases the goodput and other parameters to make the routing protocol efficient, but it should be increased only with proper control over other network parameters. As in a synthetic highway scenario the vehicles distance changes frequently so the two ray ground model is best suited for VANETs. In the future work the performance of AODV is to be evaluated under various VANET attack situations. Also security solutions to such attacks is an area of interest among the researchers now a days[15].

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