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Link and Path Duration of Routing Protocols in Mobile Ad-hoc Networks and Vehcular Ad-hoc Networks

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ABSTRACT

Mobility constraints and speed cause the radio link to break frequently, the main issue in Mobile Ad-hoc Networks (MANETs) is how to select the path which is more reliable. In this paper, we propose a model to calculate the reliable link between the nodes and reliable path for the purpose of communication. This paper also evaluates and compares the performance of routing protocols with different number of nodes, mobilities and speeds in MANETs and VANETs using Packet Delivery Ratio (PDR), Normalized Routing Overhead (NRO), End-to-End Delay (E2ED), Average Link Duration (ALD) and Average Path Duration (APD). We select three routing protocols namely Ad-hoc On-demand Distance Vector (AODV), Fish-eye State Routing (FSR) and Optimized Link State Routing (OLSR). We perform these simulations with NS-2 using Two Ray Ground propagation model. The Vanet MobiSim simulator is used to generate a random mobility pattern for VANETs. From the extensive simulations, we observe that AODV is more efficient than both FSR and OLSR at the cost of delay but the ALD and APD of FSR and OLSR are greater as compared to AODV. Moreover these protocols perform better in MANETs as compared to VANETs

KEYWORDS: AODV, FSR, OLSR, packet delivery ratio, end-to-end delay, normalized routing load, link duration, path duration, MANETs, V.

I. INTRODUCTION

Mobile Ad-hoc Networks (MANETs) comprise of wireless mobile nodes in which each node acts as a specialized router, thus, it is capable of forwarding packets to other nodes. Topologies of these networks are random and frequently changing. In MANETs, nodes are communicating with each other without any centralized control. Special routing protocols are needed to solve this issue because traditional routing protocols for wired networks like link state and distance vector algorithms cannot work efficiently in MANETs.

Vehicular Ad-hoc Network (VANET) is a special type of MANETs in which vehicles with high mobility can communicate with each other. VANETs are distributed, self-organizing communication networks built up by moving vehicles. These nodes are highly mobile and have limited degrees of freedom in the mobility patterns. There should a be broad level study so that the movement patterns of vehicles can be modeled accurately.

For calculating routes in wireless ad-hoc network, special routing protocols are used. These protocols are divided into two main categories; proactive and reactive. Proactive routing protocols are table driven, in which routes are calculated periodically and each node maintains the complete information about network topologies. Whereas, reactive routing protocols calculate routes for destination in the network when demand for data is arrived, therefore also known as On-demand routing protocols. It usually takes more time to find a route for reactive protocol compared to a proactive protocol.

Link duration is the time in which two nodes are within the range of each other and path duration is defined as the minimum link duration between the nodes in an active route. After getting the information of link and path duration, we can increase the efficiency of routing protocols. Because when any link breaks, the overhead of routing protocols increase due to exchange of control packets. So, if we know the link and path duration we can easily set the optimal value of route expiry time. Reactive routing protocol like Ad-hoc On-Demand Distance Vector (AODV)

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[11] selects the first available path and Optimized Link State Routing (OLSR) [13] calculates the path periodically. If we add the knowledge of link and path duration in these protocols, the efficiency of these protocols increase. Multiple QoS path parameters[38], energy efficient MAC protocols [34], sink mobility [32] and heterogeneity[32] are also important parameters.

For our analysis, we select one reactive routing protocol AODV and two proactive routing protocols FSR and OLSR. We perform these simulations in NS-2 through taking different scalabilities, mobilities and speeds.

II. RELATED WORK

A number of studies have been presented using different mobility models or performance metrics in which performance of different routing protocols are compared. Some of the studies also propose analytical model of link and path duration. In the study [4], Reactive routing protocols in VANETs are compared by varying mobility, number of sources and speed. Mobility constraints also help in achieving better network lifetime [37]. One of the comprehensive studies is done by Monarch Project [5]. In this study, AODV, Destination-Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR) and Temporally-Ordered Routing Algorithm (TORA) are compared using some performance metrics.

N. Javaid *et al.* [6], compares the performance of three reactive protocols and three proactive protocols under mobility in wireless multi-hop networks. In [7], authors calculate the link duration of random way point model in Mobile Ad-hoc Networks. Authors also find that link duration is determined by the relative speed and active distance between two nodes, which are in turn determined by the angles of the two nodes' velocities and the incident angle of one node to the other node's transmission range. The study presented in [8] compares DYMO and OLSR in MANETs and VANETs by varying scalability using performance parameters: Packet Delivery Ratio (PDR), End-to-End Delay (E2ED) [36] and Normalized Routing Overhead (NRO).

In [16] Ding Yong *et al.* first makes a summary the the existing routing metrics then finds the several key characteristics of wireless sensor networks communication link. Authors also show that the wireless links in real sensor networks can be extremely unreliable, secondly the EEA (Expect Efficient Algorithm) is provided which is based on power control. In [10] authors used Error Control Coding (ECC) for efficient energy consumption. Z.Abbas *et al.* presents the efficient encoder selection and transmits power with respect to its critical distance which results in energy saving in WSNs. Encoder selection is performed by using critical distance which is estimated from coding gain of that encoder. ECC in this context, becomes energy efficiently as encoders and their transmit powers are selected adaptively, which results in energy saving of these particular encoders. EAST is an IEEE 802.15.4 standard compliant. In this scheme [23], open-looping feedback process is used for temperature-aware link quality estimation and compensation, whereas, closed-loop feedback process helps to divide network into three logical regions to minimize overhead of control packets.

HEER [20] was proposed for both homogeneous and heterogeneous environments. This protocol takes into account the initial and residual energies of the nodes for the selection of CHs. Data transmission in HEER, is dependent on two threshold values, i.e. Hard Threshold (HT) and Soft Threshold (ST). In this technique, the nodes sense their environment repeatedly and if a parameter from the attributes set reaches its HT value, the node switches on its transmitter and transmits data. This paper [19] presents mathematical framework and study of proactive routing Protocols. The performance analysis of three major proactive routing protocols: Destination-Sequenced Distance Vector (DSDV), Fish-eye State Routing (FSR) and Optimized Link State Routing (OLSR) are under consideration in this work. Taking these routing protocols into account, authors enhance existing framework.

B. Manzoor *et al.* [21] proposed Q-LEACH for the efficient energy consumption of nodes. According to this approach, sensor nodes are deployed in a territory. In order to acquire better clustering, the network area is divided into four regions. Through this division, optimum positions of CHs are defined. Moreover, transmission load of other transmitting nodes is also reduced. By doing such sort of partitioning, better coverage of the whole network is achieved. In [22] N. Javaid *et al.* proposed EDDEEC. It is a three level heterogeneous protocol which assigns different probabilities to each energy level node to become CH, so, nodes with high energy become CHs more frequently as compared to the nodes with less energy. In EDDEEC, authors defined a residual energy level threshold. Under that threshold, all normal, advance and super nodes have same probability for CH selection. EDDEEC [20] is adaptive energy aware protocol which dynamically changes the probability of nodes for the selection of CHs.

H-DEEC and MH-DEEC [24] routing protocols are proposed as energy aware adaptive clustering protocols for heterogeneous WSNs. In H-DEEC, the network is divided into two parts on the basis of initial and residual energy. Normal nodes elect themselves as CHs and Beta nodes collect data from CHs and send it to BS using multi-hopping. Unlike SEP and DEEC, H-DEEC and MH-DEEC perform better in a heterogeneous wireless sensor field. Moreover, it also considers the problem of locating BS outside the network.

In [25], authors introduce adopted authentication approach for protecting our Ad-hoc wireless network by even- odd function. In this function, mobile node computes and generates random even or odd number during signaling process. If first node generates random odd number then next node will compute and generate random even number by increment of digit numbers.

In [26], Ad-LEACH is proposed for WSNs. This is an energy efficient routing protocol which is based on legacy static clustering approach. In this scheme, CH selection mechanism is inherited from DEEC, whereas, protocol architecture is adopted from LEACH protocol. Simulation results validate the performance efficiency of Ad-LEACH in the case of two level heterogeneous networks as compared to LEACH and DEEC.

The main objective of a routing protocol is to efficiently utilize the energy of the nodes. This is because these nodes are not rechargeable and in order to make them useful for a longer period of time, routing protocols have been proposed. Routing protocols improve the lifetime of a network and specifically the stability period of a network. Protocols [14], [15], [16], [18], [19], [27], [28], [29], [30], [31], [35] and [40] are proposed to achieve these goals.

When the sink is static, the probability of coverage holes is greater [33]. After some rounds, there is a possibility that the energy of some part of the network becomes low and that results in a coverage hole. Coverage holes are the greatest enemies of a WSN because authors cannot monitor the whole network area because some nodes are not functioning.

III. MOTIVATION

In [9] authors estimate the analytical model of path duration using link residual time, distance between relay node and destination node. Whereas, we propose not only analytical model but also find the link and path duration of routing protocols from simulations. In [10] authors compared DYMO, AODV, AOMDV and DSDV in VANETs in which performance is evaluated on the basis of average E2ED, throughput, and overhead versus number of nodes, speeds and number of packets.

AODV and OLSR are compared with respect to E2ED, PDR and NRO against varying scalabilities of nodes [11]. But this evaluation is performed only in VANETs. Whereas, we compare the routing protocols with respect to PDR, E2ED, NRO, link duration and path duration in both MANETs and VANETs.

In this paper, we propose a model link and path duration and compare one reactive; AODV and two proactive protocols; FSR and OLSR both in MANETs and VANETs. We also find the average link duration and average path duration from simulations in NS-2 with varying number of nodes, mobilities and speed.

IV. LINK AND PATH DURATION

In [9], authors find link and path duration, first the source selects the relay node whose distance from destination is less as compared to other nodes which are in the transmission range of source. After selecting the relay node, authors find the distance between relay node and destination node using the intersection area of source transmission range and destination transmission range. By using the distance and relative velocity of node, authors find link duration between the nodes and then find the path duration by choosing the minimum link between the nodes.

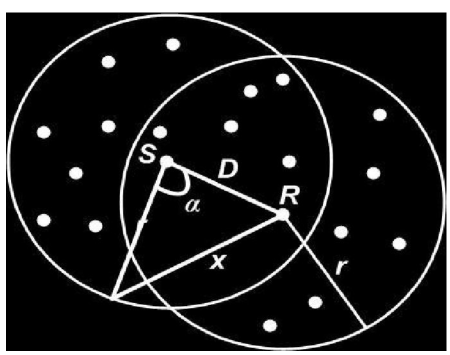

Figure 1: Link Connectivity Model

In this paper, we find the link duration by using distance and relative velocity of nodes, which is:

$$t = \frac{v_r}{R} \tag{1}$$

In eq. (1), v_r is relative velocity of nodes and R is the distance between source nodes and next forwarding node N.

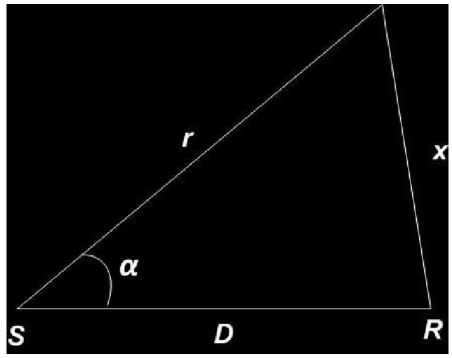

Figure 2: Triangle Formed by S and N

A. DISTANCE

First, source S selects the next forwarding node R. The next forwarding nodes is the node whose distance from the destination is minimum. Initially the distance between the S and R is D as shown in fig. 1.

For finding D, we have to find x, the distance between transmission range r and next forwarding node R as depicted in fig. 2, which is

$$x = r\alpha \times \frac{\pi}{180^o} \tag{2}$$

and

$$x = \sqrt{r^2 + D^2 - 2rDcos(\alpha)} \tag{3}$$

As, we want to find the distance D between S and R, by solving eq. (2) and eq. (3), we get

$$D^2 + 2rcos(\theta)D - (r^2 - x^2) = 0 \tag{4}$$

As eq. (4) is the quadratic equation then by using quadratic formula, we get

$$D = rcos(\alpha) \pm \sqrt{(rcos(\alpha))^2 - (r^2 - x^2)} \tag{5}$$

Probability Density Function of distance D is calculated in eq. (6) below,

$$f_d(D) = \frac{r^2 - x^2 - D^2}{2rD} \tag{6}$$

Here, we discuss two cases for finding the distance when nodes move from their initial position,

Case-1: If source moves with acute angle and forwarding nodes move with obtuse angle,then the distance D_{t_1} between them as shown in fig. 3 is,

$$D_{t1} = D - Y_1cos(\alpha_a) + Y_2cos(180 - \beta_0) \tag{7}$$

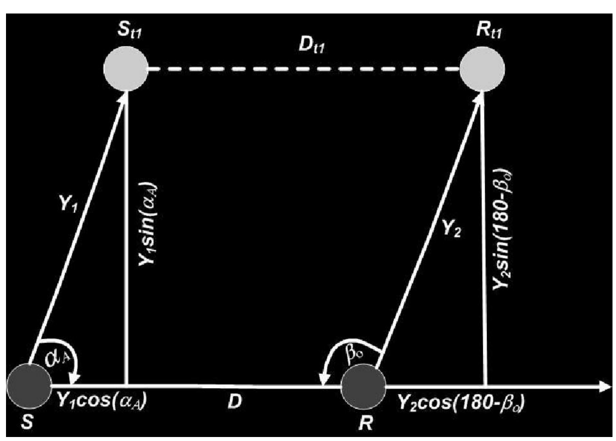

Figure 3: Link Connectivity Model when Source moves with acute angle and Next Forwarding Node moves with obtuse angle.

Case-2: If source moves with obtuse angle and forwarding node moves with acute angle, then the distance D_{t_2} between them as shown in fig. 4 is,

$$D_{t2} = D + Y_1 cos(180 - \alpha_0) + Y_2 cos(\beta_a) \tag{8}$$

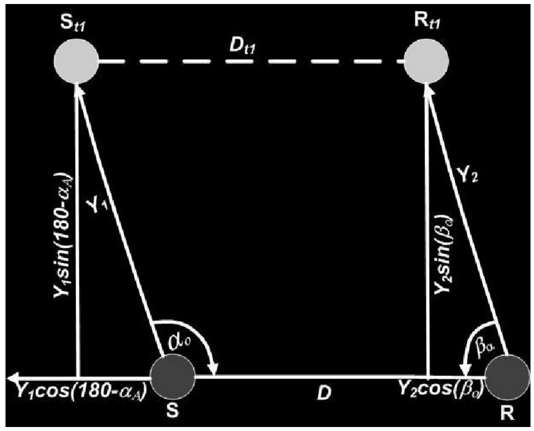

Figure 4: Link Connectivity Model when Source moves with obtuse angle and Next Forwarding Node moves with acute angle

B. RELATIVE VELOCITY

Now, we find the relative velocity between source and next forwarding node. There are two cases: **Case-1:** relative velocity (v_r) of both nodes is same; **Case-2:** v_r of both nodes is different.

$$v_r = \sqrt{v_1^2 + v_1^2 - 2v_1 v_2 cos(\alpha)} \tag{9}$$

Case-1: when ($v_1 = v_2 = v$)

$$v_r = v\sqrt{2 - 2cos(\alpha)} = 2vsin(\alpha/2) \tag{10}$$

From [7], Probability Distribution Function (PDF) of the relative velocity related to case-1 is given by,

$$f_{v_r}(v_r) = \frac{1}{\pi\sqrt{4v^2 - v_r^2}} \tag{11}$$

Case-2: when ($v_1 \neq v_2$)

$$v_r = \sqrt{v_1^2 + v_2^2}\sqrt{1 - \frac{2v_1 v_2}{v_1^2 + v_2^2} cos(\alpha)} \tag{12}$$

which can be approximated as,

$$v_r = \sqrt{v_1^2 + v_2^2}\left(1 - \frac{2v_1 v_2}{v_1^2 + v_2^2} cos(\alpha)\right) \tag{13}$$

Now, in this case PDF of v_r will be,

$$F_V(v_1, v_2) = 1 - \frac{1}{v_1 v_2} - v_r\sqrt{v_1^2 + v_2^2} \tag{14}$$

then,

$$f_V(v_1, v_2) = \frac{\partial^2 F_V(v_1, v_2)}{\partial v_1 \partial v_2} \tag{15}$$

$$= \frac{-1}{v_1^2 v_2^2} - \frac{v_r v_1 v_2}{v_1^2 + v_2^2} \tag{16}$$

C. LINK DURATION

Link duration is the time in which two nodes are within the range of each other. Hence $f_T(t)$ which is the PDF of link duration is given by,

When velocity of nodes is same then,

$$f_T(t) = \int_0^{V_{max}} f_d(D)\, f_V(v_r)\, \mathrm{d}v_r \tag{17}$$

$$= \int_0^{V_{max}} f_d(D) \frac{v_r}{\pi\sqrt{4v^2 - v_r^2}}\, \mathrm{d}v_r \tag{18}$$

When velocity of nodes is different then,

$$f_T(t) = \int_0^{V_{max}} f_d(D)\, f_V(v_1, v_2)\, \mathrm{d}v_r \tag{19}$$

$$= \int_0^{V_{max}} f_d(D)\left(\frac{-1}{v_1^2 v_2^2} - \frac{v_r v_1 v_2}{v_1^2 + v_2^2}\right) \tag{20}$$

where V_{max} is the maximum speed of node.

D. PATH DURATION

The time for which a route is active in a routing table is path duration. The path duration is derived from the PDF of link duration, which is,

$$P_D = min(t_1, t_2, t_3, t_4, ...t_h) \tag{21}$$

where h is the number of hops to reach the destination and t_n is the link duration corresponding to n^{th} link. Now, the PDF of path duration is,

$$f(P_D) = \int_0^{\alpha} P_D \times f_{P_D}(P_D)\, \mathrm{d}P_D \tag{22}$$

where $f_{P_D}(P_D) = h \times F_{P_D}(P_D)(C_{P_D})^{h-1}$ which comes by using baye's theorem and $C_{P_D} = 1 - F_{P_D}$ which is commulative distribution function (CDF) of P_D and F_{P_D} which represents the CDF.

V. SIMULATIONS AND DISCUSSIONS

In this section, we provide the details for the simulations conducted for this study. Table 1 is showing the different useful simulation parameters which we used here.

Table 1: Simulation Parameters for MANETs and VANETs

PARAMETERS	VALUES
NS-2 Version	2.34
OLSR Implementation	UM-OLSR [12]
FSR Implementation	FSR [13]
Number of nodes	10, 20, 30,……., 70
Speed	Uniform 40 kph
Data Type	CBR
Simulation Time	900 seconds
Data Packet Size	1000 bytes
PHY Standard	802.11/802.11p
Radio Propagation Model	TwoRayGround
SUMO Version	0.13

PDR of Protocols in MANETs PDR of Protocols in VANETs

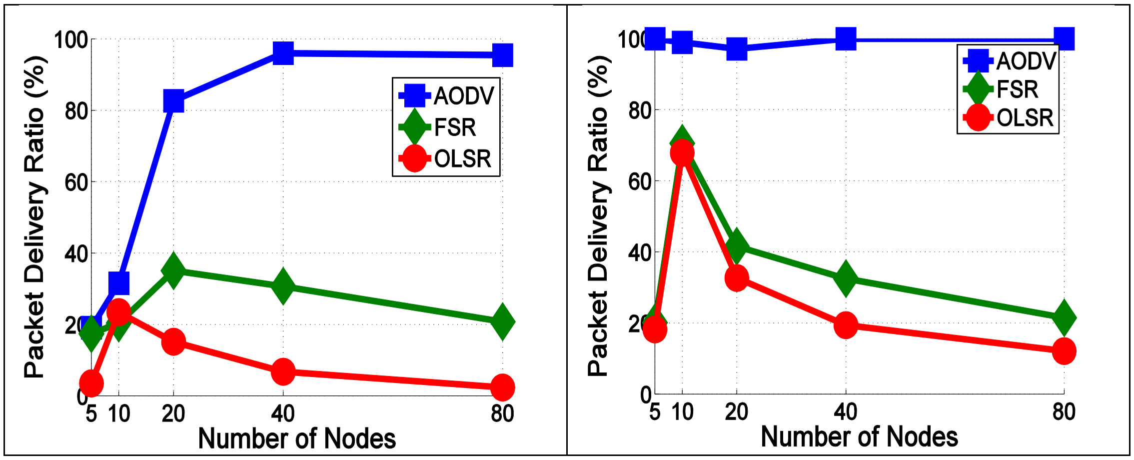

Figure 5: PDR achieved varying Scalability

PDR of Protocols in MANETs PDR of Protocols in VANETs

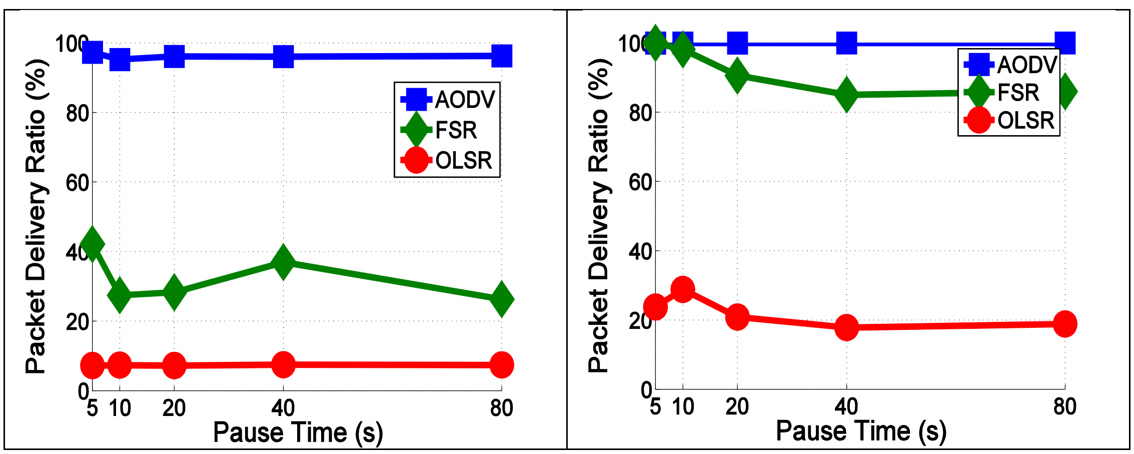

Figure 6: PDR achieved varying Mobility

PDR of Protocols in MANETs PDR of Protocols in VANETs

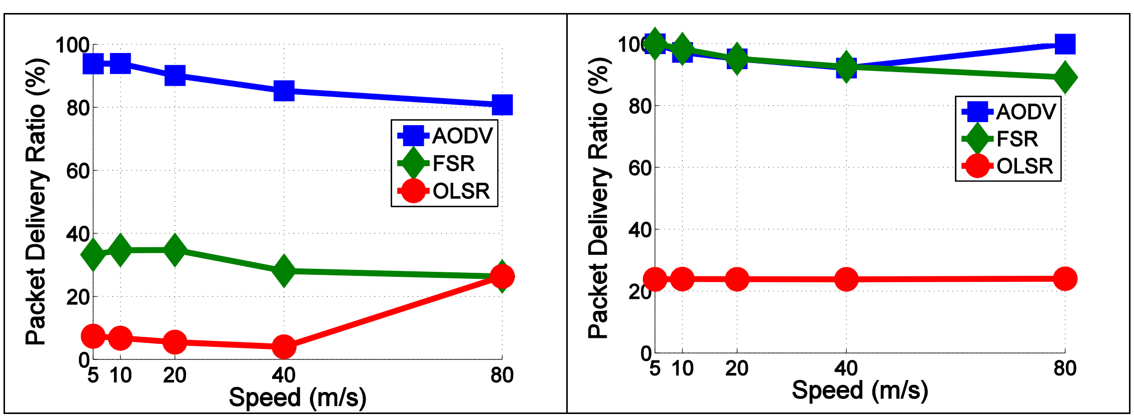

Figure 7: PDR achieved varying Speed

AE2ED of Protocols in MANETs　　　　AE2ED of Protocols in VANETs

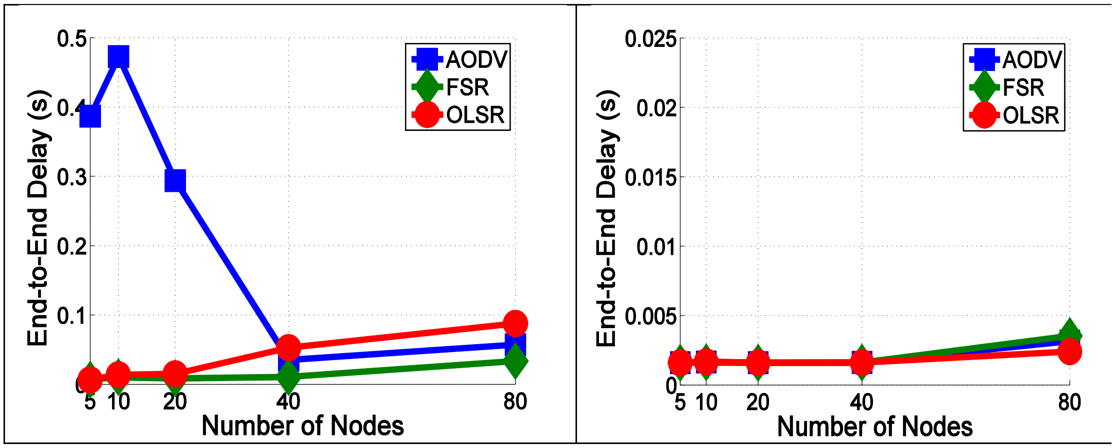

Figure 8: End-to-end delay produced by protocols under Scalability

AE2ED of Protocols in MANETs　　　　AE2ED of Protocols in VANETs

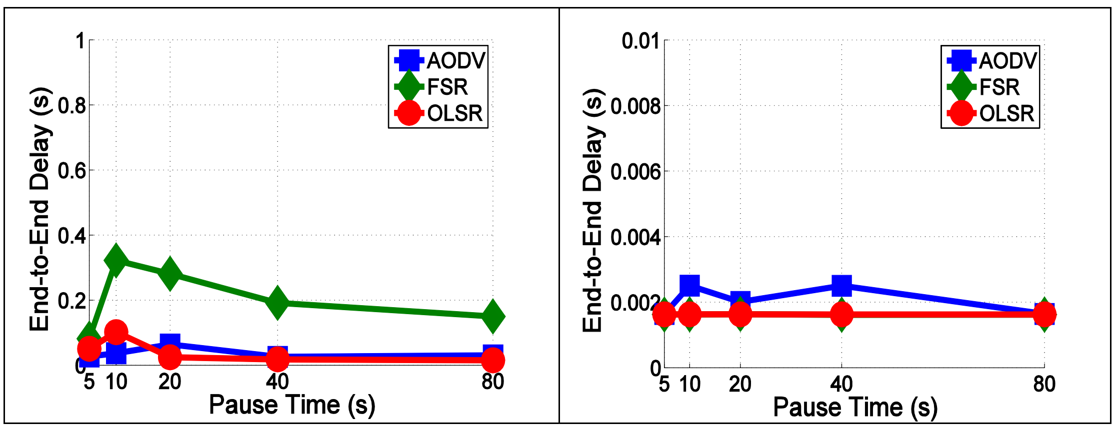

Figure 9: End-to-end delay produced by protocols under Mobility

AE2ED of Protocols in MANETs　　　　AE2ED of Protocols in VANETs

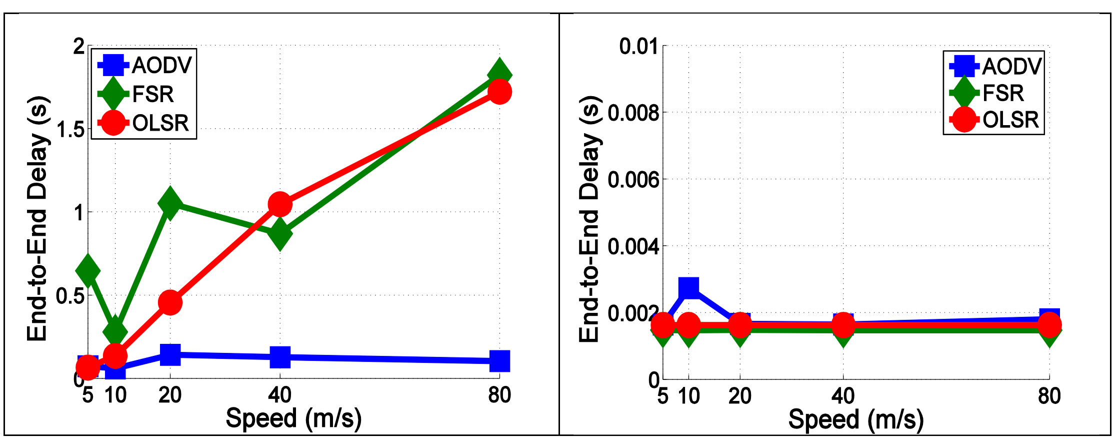

Figure 10: End-to-end delay produced by protocols under Speed

NRO of Protocols in MANETs NRO of Protocols in VANETs

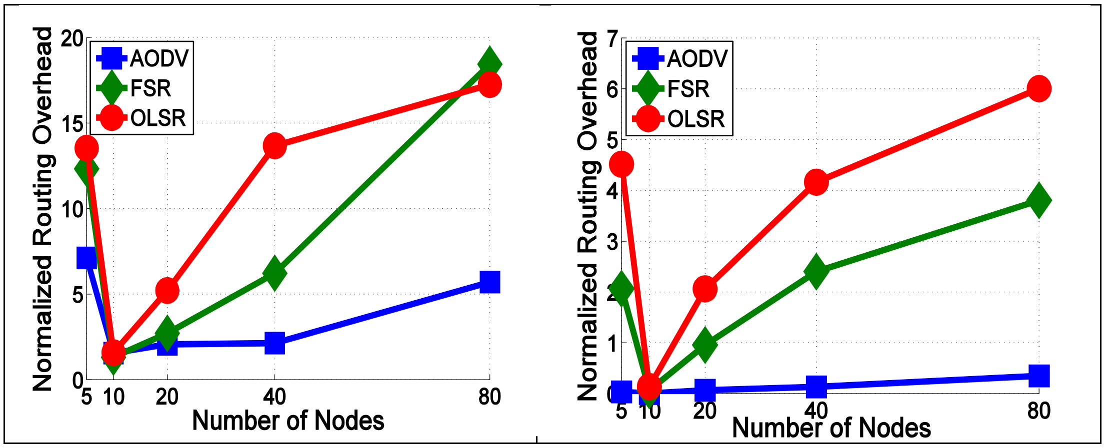

Figure 11: Routing overhead faced by protocols with varying Scalability

NRO of Protocols in MANETs APD of Protocols in VANETs

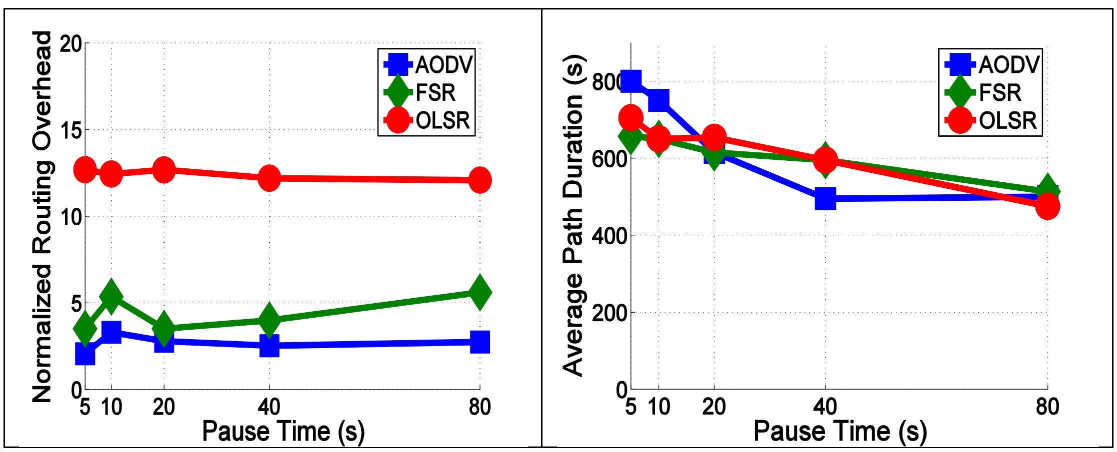

Figure 12: Routing overhead faced by protocols with varying Mobility

NRO of Protocols in MANETs NRO of Protocols in VANETs

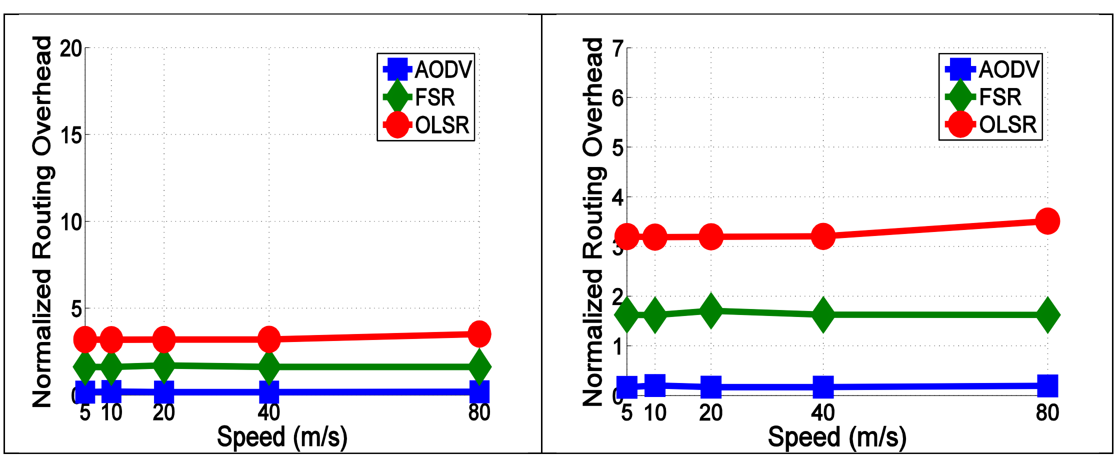

Figure 13: Routing overhead faced by protocols with varying Speed

A. AVERAGE LINK DURATION (ALD)

Average link duration is the time when two nodes are within the range of each other.

i. SCALABILITY

ALD of AODV is less in lower scalabilities because when nodes move with same speed as shown in eq. (18), AODV repairs the link quickly but due to less number of hops it takes more time to repair the links. In higher scalabilities, ALD is greater and due to more number of hops, link is maintained quickly as depicted in fig. 14. Due to this behaviour, delay of AODV also increases as shown in fig. 5. As ALD is less in lower scalability, the delay is very high, so when ALD increases in higher densities, delay also increases as shown in fig. 8. NRO of AODV is lower in all scalabilities as shown in fig. 11.

ALDs of FSR and OLSR rise with increase in densities because proactive protocols calculate the routes before transmission of data as shown in fig. 14. In eq. (18) and eq. (20), if velocity of nodes increases.

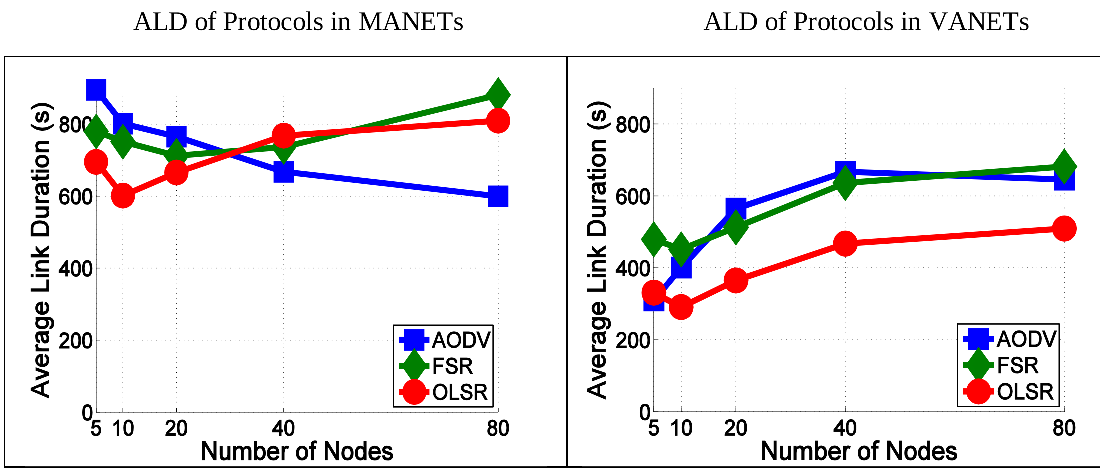

Figure 14: Average Link Duration of protocols with varying Scalability

ii. MOBILITY

ALD of AODV rises with increase in mobilities as shown in fig. 18 because it uses LLR algorithm which repairs the route quickly even when there is high mobility as shown in eq. (20), which shows that if velocity of nodes increases, ALD also increases to some extent. As ALD of AODV is greater, PDR of AODV is also high as shown in fig. 6. So, as a result, in the presence of a reliable link, packet drop ratio also decreases. Due to quick repair NRO of AODV is low as depicted in fig. 15 but its delay is higher as shown in fig. 9. ALD of FSR and OLSR decreases in higher mobilities because proactive protocols can not repair the link quickly whenever a link breakage occurs as can be seen from fig. 18. As ALD of FSR and OLSR is low, their PDR is also low because link between node is not reliable, which in turn, causes more packets to drop as shown in fig. 6. Delay of both OLSR and FSR is low as shown in fig. 9 but due to link breakage, more control packets are exchanged between the nodes which cause more NRO as depicted in fig. 15.

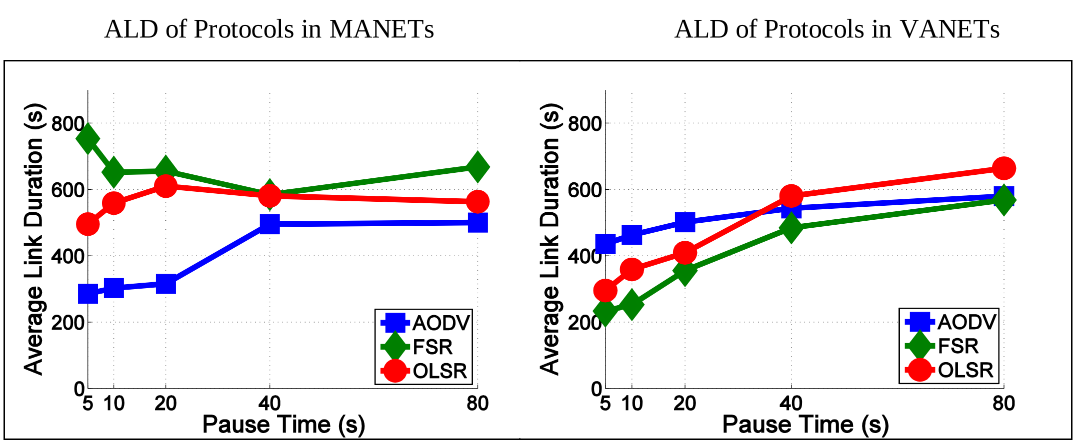

Figure 15: Average Link Duration of protocols with varying Mobility

iii. SPEED

As shown in fig. 16(a), ALD of FSR and OLSR is high in low speeds as shown in eq. (18) and eq. (20). If the velocity is lower, ALD gets high and as a consequence, their PDR is also high at lower speeds. On the other hand, if we increase the speed, ALD will decrease, thus PDR also decreases as shown in fig. 7. Delay of FSR and OLSR is low for all speeds because of pre-computation of routes packets are transmitted quickly as shown in fig. 10. As ALD decreases, NRO of both protocols increases due to generation of more control packets as shown by fig. 13. ALD of AODV is low as compared to FSR and OLSR as shown in fig. 16(a). Whereas, in higher speeds, link breakage is quite frequent, so, ALD is low as can be seen from eq. (18) and eq. (20). Due to the fact that ALD of AODV is low its PDR is also low as depicted in fig. 10. Delay and NRO of AODV is low as shown in figs. 10 and 13.

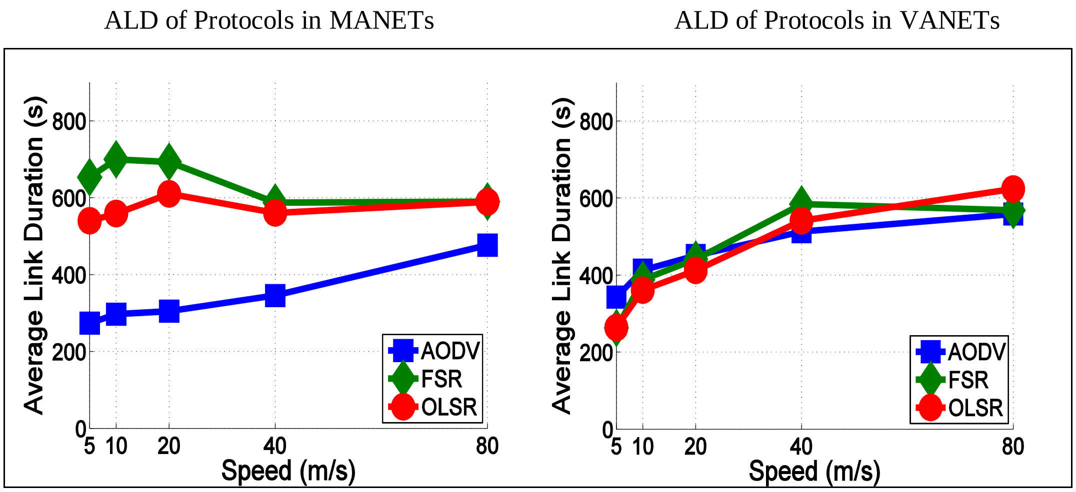

Figure 16: Average Link Duration of protocols varying Speed

B. AVERAGE PATH DURATION (APD)

Average path duration is the time for which the path is available for communication.

i. SCALABILITY

As shown in fig. 17, APD of FSR and OLSR is high because in proactive protocols, path is established all the time and if any link breakage occurs, these protocols calculate new routes. As eq. (22) and eq. (23) show that the APD depends on ALD, as ALD increases APD also increases. Due to this behaviour, PDR of FSR and OLSR gets higher in lower scalabilities as shown in fig. 5, however, delay of FSR and OLSR is low in all types of scalabilities as depicted in fig. 8. Due to this increase in APD, NRO of FSR and OLSR is high as shown in fig. 11. APD of AODV is high in lower densities, so, its PDR is also high as shown in fig. 5. Delay of AODV is high due to more number of hops and NRO of AODV is low as depicted in figs. 8 and 11.

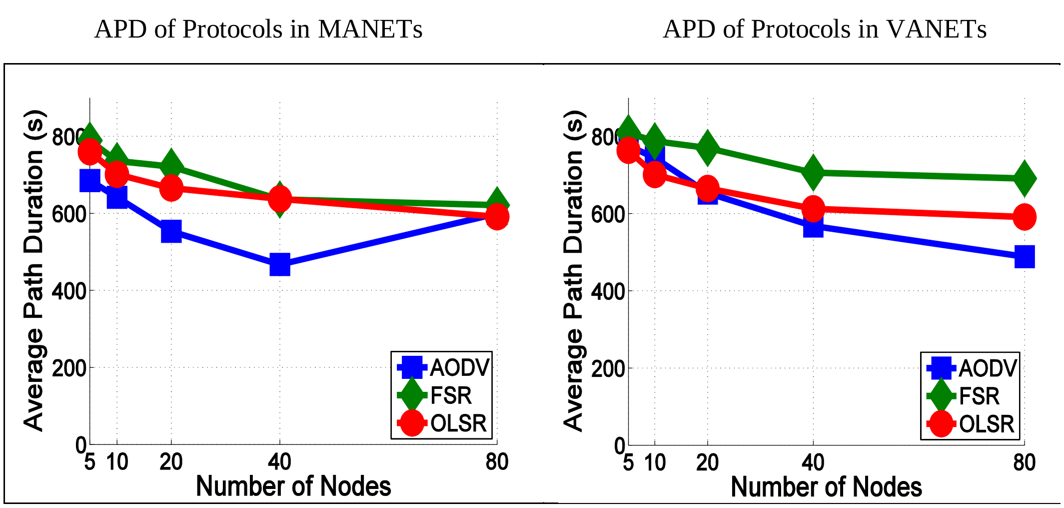

Figure 17: Average Path Duration of protocols with varying Scalability

ii. MOBILITY

In fig. 18(a), we can see that APD of all protocols is almost the same in lower mobilities, however, APD of AODV decreases in higher mobilities. Fig. 18(b) shows that the APD of AODV is higher as compared to FSR and OLSR in low mobility and when mobility increases APD of AODV decreases. In general, we can say that APD of FSR and OLSR is better than APD of AODV, whereas, PDR of FSR and OLSR is low as shown in fig. 6. Moreover: APD of FSR and OLSR is high in VANETs as compared to MANETs. APD of FSR and OLSR is high due to this

APD of Protocols in MANETs APD of Protocols in VANETs

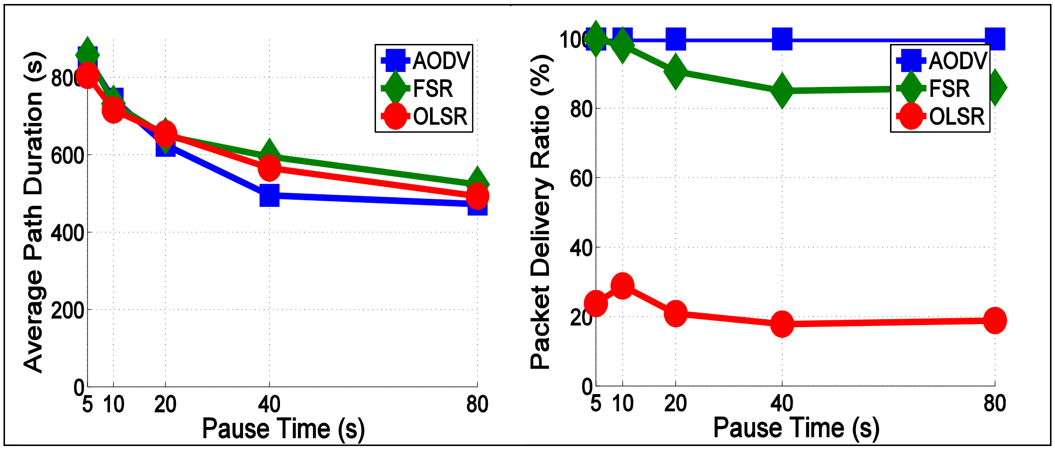

Figure 18: Average Path Duration of protocols with varying Mobility

their delay decreases in higher mobilities as shown in fig. 9 and NRO is high due to control packets as depicted in fig. 12.

iii. SPEED

APD of OLSR is higher in 5m/s and 10m/s as compared to AODV and FSR, however, its APD decreases with increase in speed as can be seen from eq. (23). As speed increases link duration decreases thus path duration decreases. Due to this reason PDR of OLSR is low as shown in fig. 7 and its delay is less because of its proactive nature as shown in fig. 10. NRO of OLSR increases with increase in speed as depicted in fig. 13. Also the APD of FSR is high as compared to AODV as shown in fig. 19(a). In VANETs, APD of AODV is higher in the case of 5m/s and 10m/s, however, if speed increases the APD of all protocols becomes almost equal as represented by fig. 19(b). In general, we can say that performance of AODV and FSR is better as compared to OLSR thus their PDR increases with speed as shown in fig. 7, delay decreases and NRO is almost constant as depicted in figs. 10 and 13. Moreover, performance of both AODV and FSR is better in VANETs as compared to MANETs.

APD of Protocols in MANETs APD of Protocols in VANETs

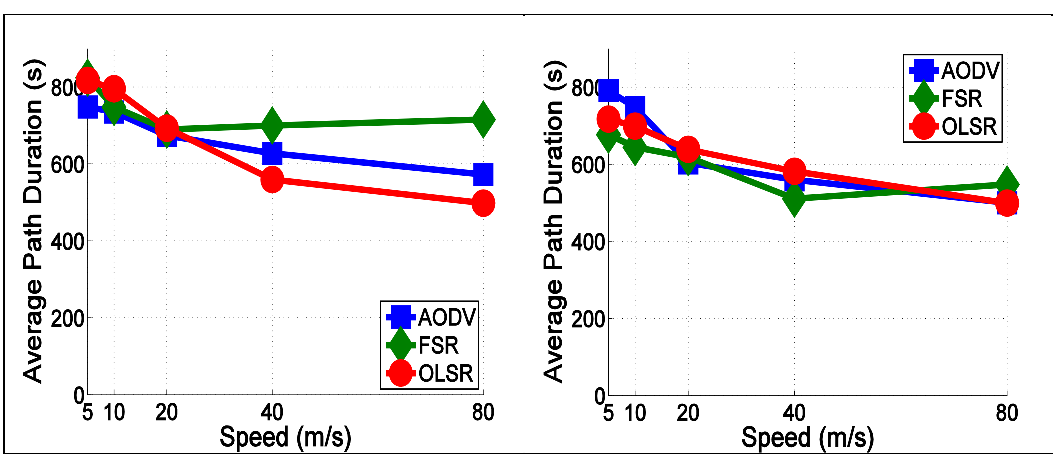

Figure 19: Average Path Duration of protocols with varying Speed

VI. CONCLUSIONS AND FUTURE WORK

We propose a model for calculating the link and path duration in this paper. From analysis, we observe that link and path duration can be used as parameters to increase the efficiency of routing protocols. Also in this paper, we evaluate and compare the performance of one reactive protocol; AODV and two proactive protocols; FSR and OLSR in both MANETs and VANETs using NS-2 simulator and TwoRayGround radio propagation model. The VanetMobiSim is used to generate a mobility pattern for VANET to evaluate the performance of selected routing protocols for three performance parameters, E2ED, NRO and PDR. Our simulation results from PDR, E2ED and NRO show that AODV performs better at the cost of delay in MANETs and in VANETs but ALD and APD results show that FSR and OLSR perform better as compared to AODV. These three protocols perform better in VANETs as compared to MANETs. Application of Routing Link Matrices on the proposed scheme can be useful in achieving efficient consumption of energy in the network[39]. In future, we aim to introduce multiple QoS path parameters[38], energy efficient MAC protocols [34], sink mobility [32] and heterogeneity [40] in our work.

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