VANET: Expected Delay Analysis for Location Aided Routing (LAR) Protocol

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Abstract – The Vehicular Ad-hoc Network (VANET) is a networking technology uses to create wireless network using mobile vehicles. In this network, the mobile vehicles work as intermediate node to transmit data packets over the wireless network and mobile nodes are free to move from one network to other network. All nodes in VANETs are highly movable and their movements area and direction to be restricted within a predefined geographical areas. All nodes in VANETs nodes must has to follow certain conditions such as their speed to be restricted by standard speed limit, patterns of the road, and traffic conditions. Due to high speed of nodes in the network, links may breaks frequently due to this failure in data delivery occurs in the network. Routing of data packet in the VANETs are more challenging task due to highly dynamic natures. Performance of the VANET depends upon the selection of the suitable next-hop nodes for further transmission in the network. Due to highly movable vehicular nodes, the link may break very frequently caused network delay; therefore, it is important to select the appropriate next-hop forwarding node to complete the data transmission. In this paper, we have computed the node distribution at the border area, expected one hop distance and expected delay using one-hop distance between first two nodes. Further, we have analyzed the numerical results using MATLAB.

Index-Terms - VANET, Expected Distance, IVC, V2V, LAR, Expected Delay.

1.0 INTRODUCTION

VANET is a wireless local area network uses vehicles as mobile nodes to form an ad hoc network. In VANET, efficient routing protocols are needed to transmit data packets over the network via number of intermediate nodes. In order to this, if intended destination vehicle is inside the communication range of the source vehicle, then source uses unicast forwarding and directly send message to the destination node. If destination node is out of the communication range of the source's node, then source node use multicast forwarding technique to send message [4].

VANET integrates wireless networks capabilities and have a number of applications such that traffic monitoring, traffic control, blind crossing, collisions preventing, and services of near by information, and real time detour routes and computation. VANET enables an Intelligent Transport System (ITS) known as Inter-Vehicle Communications (IVC) or Car - to-Car (C2C) communications that is used for vehicle-to-vehicle communication.

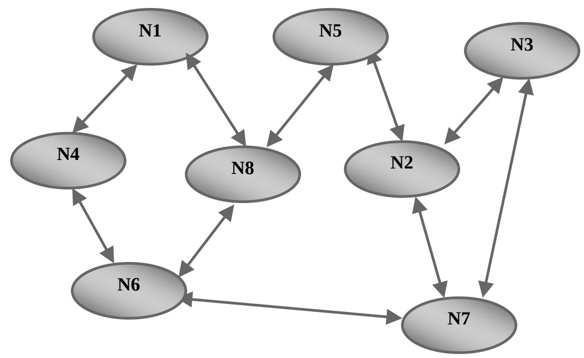

Figure 1: Movement of Mobile Nodes in Ad-hoc Network

To transmit data packets throughout the network, if destination node is out of the transmission range of the sender node some routing protocols to be required. The basic aim of routing protocol is to search a better route for packet delivery to the correct destination in the network. Now these day study of various routing protocols in VANET have been a popular research area for researchers from many years. According to behavior of the routing protocol, we can classify it into three types such as Reactive, Proactive and Hybrid routing protocol.

In Reactive routing protocols whenever a node would like to communicate with other nodes on the network. Then communicating node initiates a RREQ message with other nodes throughout the network. Once a route discovery process has been finished the route maintenance process has to maintain the route until the destination node becomes inaccessible [7].

Functionality of Proactive routing protocol is that each node maintains the location information of it's neighbors in the network. If there is any change in the current location of any node in the network the routing table will be updated this information because routing information is time to time periodically transmitted throughout the network, The Proactive routing protocol has a measure advantage such as the transmission will be completed without any delay, if a route already existing the network before arriving of traffic in the network. If route already does not exist in the network the data packets has to wait until unless node receives routing information of corresponding destination node. The proactive

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routing protocols requires significant amount of resources for keeping routing information up-to-date and reliable for highly dynamic network topology[9].

The hybrid routing protocol combinations advantages of the both routing protocols such as proactive and reactive. Initially proactive routing protocol is responsible to establish a connection after this reactive routing protocol takes care of remaining operations. The main disadvantages of this routing protocol are:

- **i.** Depends upon the number of other nodes activated.
- **ii.** Traffic demand reaction depends on gradient of traffic volume.

Zone Routing Protocol (ZRP) and Zone Base Hierarchical Link State Routing Protocol (ZHLS) are examples of hybrid routing protocols. ZRP uses IARP as pro-active and IERP as reactive component.

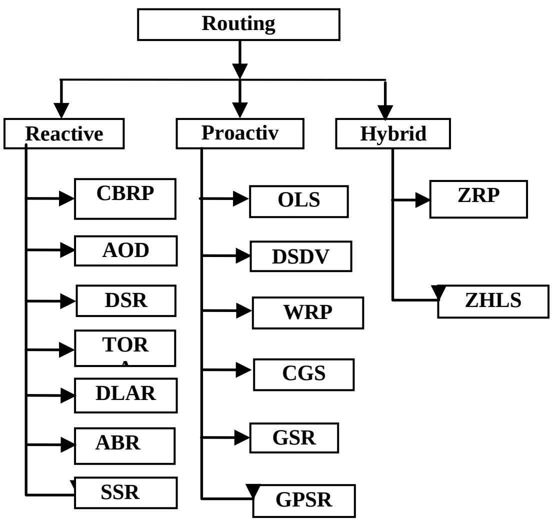

Figure 2: Classification of Routing Protocols in VANET

Generally, VANET has following three types of communications:

- **i.** C2C Communication
- **ii.** C2I Communication
- **iii.** C2R Communication

1.1. C2C (Car to Car) Communication

The basic purpose of Car to Car communication is to increase driving comforts and safety measures during driving time. C2C communications to be integrated with a wireless network with the help of those automobile nodes send messages to each other. The data transmitted on the network must have to include certain parameters such as speed location and of node, travelling direction of node, braking, and loss of stability. The C2C communication uses a technology known as DSRC (dedicated short range communications). The C2C communication uses one of possible frequency such as 5.9 GHz so it can be referred as Wi-Fi network. The Range of this varies from 300 meter to 1000 feet or about 10 seconds at a highway. The Car-to-Car communication behaves like a mesh network because every node in this can send, retransmit and capture signals. With 5 to 10 nodes technology in the network is able to gather a mile a head traffic conditions.

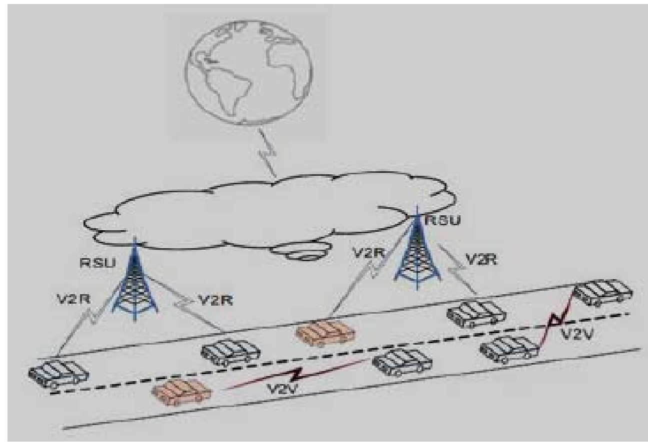

Figure 3: Various communications through VANET[21]

In Car-to-Car communication car driver must be able to receive an alert message such as a flashing red light in the instrument panel. Most of the prototypes have been advanced to stage where the cars brake. Sometimes steer around hazards C2C could captured and transmit these inputs, among others. C2C arrives in cars by time to time; some may be stripped out for the sake of simplicity or cost-cutting.

- Velocity of vehicle
- Position of vehicle and direction of travel
- Accelerating and slowing
- Brakes on and anti-lock braking
- Lanes Changing
- Controlling of stability
- Windshield wipers, defroster and headlamps should be on in daytime in case of raining and snowing
- Gear positioning

1.2. Car to Infrastructure (C2I) Communication

Infrastructure in the Car to Infrastructure Communication works as a coordinator between devices; it gathers information about the traffic and road conditions globally or locally. Then after, certain behaviors to be imposed on a group of vehicles. The ramp metering is an example of Car to Infrastructure communication that requires limited sensors and actuators such as traffic density measurements and traffic light on the highway.

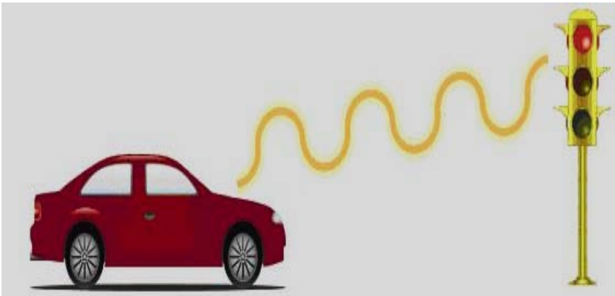

Figure 4: Car to Infrastructure Communication [22]

The infrastructure in the Car to Infrastructure Communication suggests the velocities and accelerations of vehicle and inter-vehicular distance on the basis of the traffic conditions if scenario is more sophisticated. The main objective of this is to optimize overall emissions, fuel consumptions and traffic velocity. If there is any suggestion for a vehicle it could be broadcast to the drivers via wireless connections such as via road displays or directly to vehicles.

Further if there is any suggestion it could be integrated into the vehicle controls and implemented semi-automatically. For longer-range vehicular networks Car to Infrastructure communication widely provides solutions for the problems. Preexisting network infrastructures are used by C2C communication such as wireless access points such as Road-Side Units (RSUs). Car to infrastructure (C2I) signs and signals could transmit traffic and weather indicators:

- Green, yellow and red are traffic signal phase.
- Stop sign.
- Left turn should not be at the left turn.
- Temperature at a bridge that freezes over before the ground
- Cars ahead signals
- Approaching emergency vehicle

To get true picture of traffic scenario of ahead multiple sensors are used on the multiple cars. Suppose that, if only one car's wiper is on, then it will indicate that the driver is cleaning the windshield or stalk is hilted by the mistake; if a large number of cars are doing the same things then it will show raining or snowing. If a tight cluster does, it could be a truck spewing oil or snowmelt dripping off a bridge. That could be verified by the average speed of all the cars.

1.3 Car to Roadside (C2R) Communication

In Car to Roadside Communication, the Roadside Unit (RSU) acts as wireless access vehicular environment (WAVE) providers. The WAVE keeps the advertising their presence and the offered services through periodic broadcasts. The Wave Service Advertisements (WSA) control information sent by the RSUs over CCHs. The wave-based basic service set (WBSS) is setup after WSAs are sent data exchange over the SCHs can only occur after the vehicle successfully receives the WSA. The signal strength of the RSU should be tuned to the network latency and the lane speed at that location, so as to not miss any vehicles coming in its range.

It is expected that vehicle will send the GPS location using the DSRC Service Channel to relieve the RSU of too much computation and keep it real-time. For the GPS data from vehicle, channels are exclusively reserved, informed of this and is tuned to sufficient bandwidth. However, there are some concerns due to a separate channel dedicated like switching between channels can cause delay etc. which needs to be addressed, so the RSU will now be receiving the location updates from the vehicles. Using this information the RSU will determine the nearest vehicle to the intersection. There are two methods to compute the distance of the vehicle from the intersection as pair wise Computation method and pair wise computation using Historic data.

To avoid the shadowing effect sometimes when a larger building or a larger vehicle shadows other vehicles, we use the mechanism of piggybacking the WAVE based parameters which would further reduce the communication gap between the car and the RSUs.

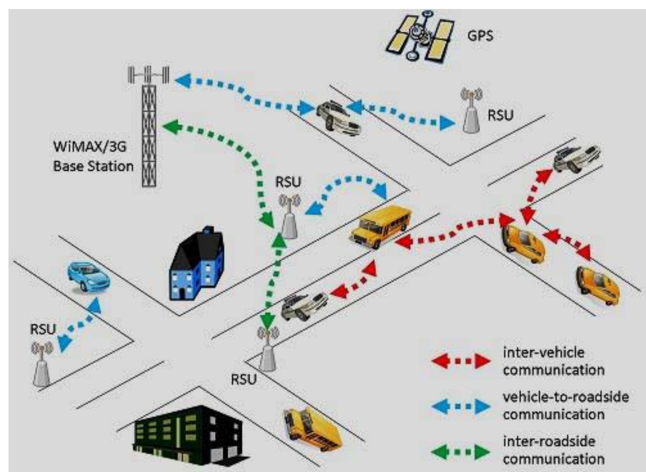

Figure 5: Car to Roadside Communication [23]

Rest of this paper is structured as Section-2 covers the related work. The proposed work in this has been discussed in section-3, numerical analysis and simulation results are discussed in section 4 and at last section 5 concludes this paper.

2.0 LOCATION AIDED ROUTING (LAR)

Generally, for VANET we use two types of routing protocols such as namely traditional topology and GPS position based routing protocols. Topology based routing protocol is divided into two category that is reactive and proactive routing protocols. Reactive routing protocols are more secure routing schemes for VANET and perform on-demand basis, in which source node initiates the route discovery process using flooding.

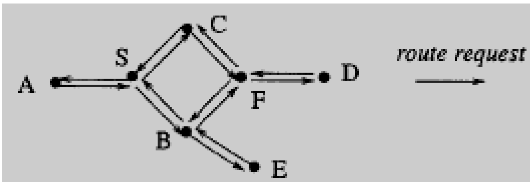

Figure 6: Message flooding

In figure 6 we can see when the source node S would like to communicate in the network with a destination node D. For this source node S will try to find out a route for destination node D in the network. For the same purpose source node Swill broadcast a message known as route request (RREQ) message to its all neighbors. After receiving the RREQ message, nodes Band C will forward the RREQ message to its all neighbors in the network. We can see in the figure 6 after receiving RREQ message from the node B, the node F will forward it to its all neighbors node. The node F will discard the RREQ message; however, it receives the same RREQ message from the node C. As RREQ message has been propagated to various nodes on the network, now path can be discovered on the basis of RREQ message. To decide that intended destination is reachable or not from the sender node flooding algorithm m can be used. The intended destination node will respond by sending a RREP message to the sender node after receiving RREQ message. The RREP message will always follow the same path that is obtained by route discovery process.

During some circumstances or some time it may be happened that intended destination node is not able to receive a RREQ message such that when it is not reachable from the sender node or it may be possible due to transmission errors in the network. In such cases route discovery process will be reinitiated in the network by the sender node. The sender node will set a timeout when it again initiates route discovery process. If sender node does not receive a RREP message during this timeout interval then a new route discovery process will be initiated by the sender node with the help of other sequence number that is different from the previous route discovery recalls. To detect the multiple receptions of the same route request, the sequence numbers play very important role in the route discovery process. Timeout occurs in both cases such that first one is if intended destination node does not receive a message of route request and second one is that if route reply message from the destination is lost during the route discovery process.

In vehicular ad hoc network designing of routing protocol is a crucial problem and several numbers of routing protocol algorithms have been developed to find out the suitable path in the network. Adaption of traffic patterns is a desirable qualitative property of the routing protocol [7].

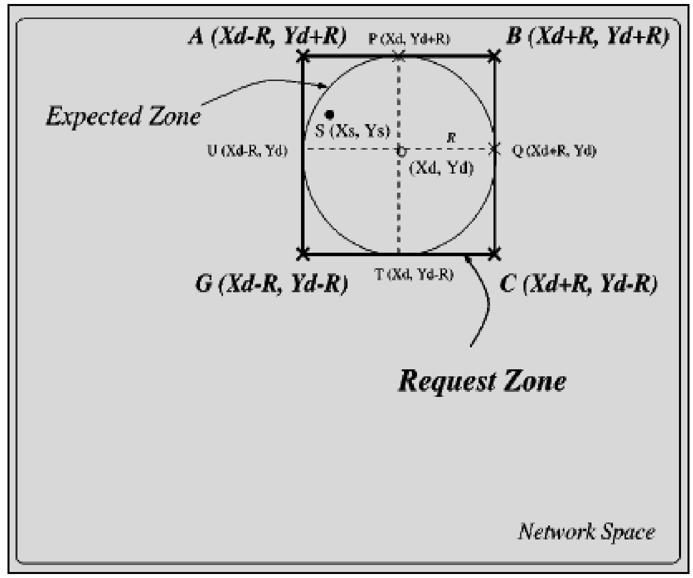

Figure 7: Source node outside the expected zone [20]

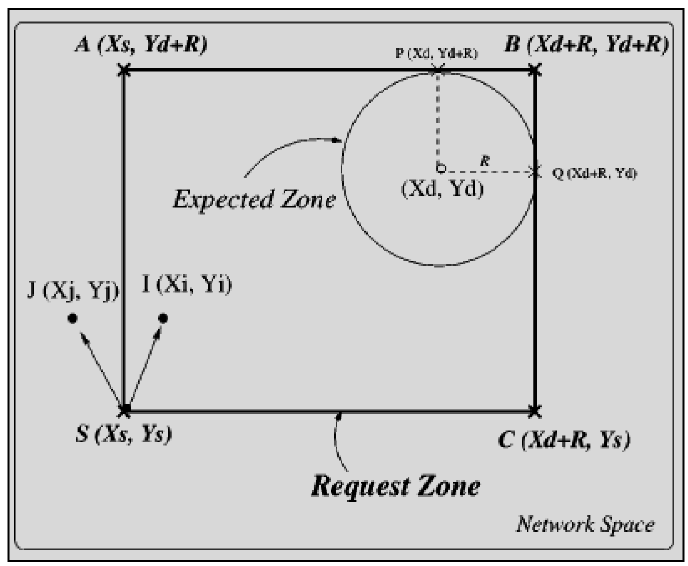

Figure 8: Source node inside the expected zone [20]

Maltz and Johnson [9, 11] has been discussed conventional routing protocols those are not sufficient for the ad-hoc networks. Protocols those use periodic updates of routing tables may waste the wireless bandwidth and amount of routing related traffic. They proposed a routing protocol based on the on-demand route discovery process by using Dynamic Source Routing (DSR).

If once request zone is formed in the LAR protocol, the neighboring nodes that are falling out of the request zone will be removed. Only neighboring nodes that exist in the request zone can accept and forward the request message for further processing in the network. Therefore, in order to control flooding and overhead in the network, LAR places a limit on the number of advancing nodes.

The routing protocol presented by Royer and Perkins in [12] is known as AODV routing protocol that uses a demand-driven route establishment procedure. The routing protocol designed by H. T , Karp, B. and Kung in [13] named TORA that minimize the reactions of topological changes in the network by localizing routing related messages to a small set of nodes near the change.

Hass and Pearlman in [14] have combined properties of the both routing protocol such as proactive and reactive approaches to design ZRP. The recent papers have presented comparative performance evaluation of several routing protocols. During the route discovery process in the vehicular ad hoc network Young-BaeKo and Nitin H. Vaidyain [17] are proposed a LAR routing protocol that uses concept of fractional flooding to decrease the control overhead. Position of the nodes in the vehicular ad hoc network is obtained by using a location finding system such as GPS. Determination of the next forwarding node in the network to establish a route, the Location Aided Routing protocol uses the position information of the node. Searching area in the LAR protocol for a node in the network to be restricted within a specific area, due to the limited route discovery area and condensed search area, route request (RREQ) packet is forwarded to an inadequate number of nodes gives reduced route discovery overhead.

Some of Location Aided Routing protocols have been proposed and these are needed geographical information for the selection of next forwarding nodes. Karp and Kung in [13]proposed routing protocol based on position of the nodes that uses geographical information of nodes in the network which are closest to intended destination node in order to forward the data packets and make successful communication. The measure drawback of this algorithm is that when it is evaluated for the large geographical area or large city, communication may be interrupted by the existing obstacles such as buildings in the city environments. Several other protocols have been defined in [14, 15] to overcome such problems. The proposed a position based routing protocols in [14] that use topology information to deliver the data from source to destination. In the next section, we have explained the minimization of one-hop delay that can be further used to enhance the performance of LAR protocol.

3.0. PROPOSED WORK

In this paper proposed model is known as LAR protocol that uses current location information of the nodes in the network. The basic purpose of this technique is to reduces routing overhead. Position of the node in the network can be obtained by using a device known as GPS [11]. By using such location finder device it is possible to know the physical location of mobile node. Position information of the node obtained by GPS always includes some errors which are the differences between the coordinates calculated by GPS and actual coordinates. The GPS NAVSTAR has positional accuracy of about 50 to100 meters and Differential GPS offers accuracies of a few meters [12]. In the proposed model, we have assumed that each node is aware with its current location precisely with no error.
In the proposed model each node knows its location and speed through some separate location service, such as GPS. Once when RREQ message is received at the destination node, the destination node unicast a RREP message back along with the reverse route found in the header. The LAR is a one of more popular routing protocol uses a concept known as LAR Box, in that a neighbor of source node, S, is determined if it is within the common transmission range of two intersecting circles in LAR box area. The radius of the transmission circle can be defined as radius, $R=V_{avg}\times (t_1-t_0)$ centered at (X_D, Y_D). In proposed model [16],author is discussed about the node distribution, velocity, link duration and path duration but distance related and average numbers of hop counts are not discussed.

Young-BaeKo and Nitin H. Vaidyain [17] suggested a substantial reduction in the number of routing messages by creating request zone and expected zone for LAR protocol. Basic objective of our proposed model is to find out average distance between source and next-hop nodes then we have calculated one-hop delay during the data transmission. If the destination node is already available in the source's transmission range then source node directly transfer the packet to destination using unicasting.

To forward information in the network when the destination is outside the sender's transmission range next-hop forwarding node (intermediate node) is required for further transmission [6].In order to reduce one-hop delay, we need to minimize the hop count from source node to next-hop node. In this case we can select the next-hop node which positioned at the maximum transmission range of sender node in the network.The figure 9 is showing the shaded area having the nodes positioned at the maximum distance (border) of the source node.

3.1. Probability of Next-Hop Node Selection

In figure 9 we can see that source node S would like to communicate on the network with the destination node D. The destination node D is out of the range of communication range of the source node S. In this situation to complete the communication intermediate next forwarder nodes are required. In our propose model we have considered vehicle to vehicle communication scenario that has no infrastructure or road side unit along the road side. To receive and transmit valuable information sensors are used on the vehicle. In the proposed model transmission range of every vehicle is assumed to be equal, denoted by R. In this communication link between two vehicles depend only on the distance between them means as long as vehicles are within the transmission range of each other. In VANETS, each vehicle is able to obtain won current location and velocity information because each vehicle to be equipped with GPS and digital road maps. Suppose there is *K* nodes are arriving in the shaded area in figure 9 and they are following Poisson distribution process and can be calculated as follows:

$$P(K) = \sum_{N=K}^{\infty} \binom{N}{K} (p)^{K} (1-p)^{N-K} \left(\frac{(0.352 * \rho * X^2)^N * e^{-0.352*\rho*X^2}}{N!} \right)$$

Therefore,

$$P(K) = \frac{(0.352 * \rho * p * X^2)^N * e^{-0.352*\rho*p*X^2}}{N!} \quad (2)$$

We can find out the probability of at least *K* neighboring nodes consequently in the given area as shown in the above figure is:

$$P(K_a) = 1 - \sum_{i=0}^{K-1} \frac{(0.352 * \rho * p * X^2)^i * e^{-0.352*\rho*p*X^2}}{i!} \quad (3)$$

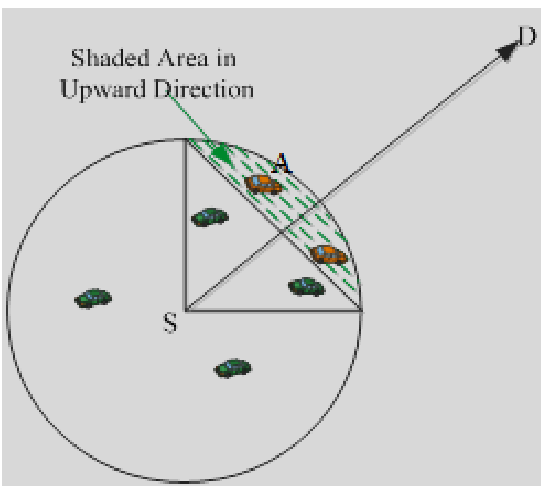

Figure 9: Selection of node with maximum distance

Now, we are able to calculate selection probability of at least one node in the shaded area within the transmission range *R* with the help of equation 3as following:

$$P = 1 - P(X = 0)$$

$$P = 1 - e^{-0.352*\rho*p*R^2} \quad (4)$$

3.2. Expected Distance Calculation

As shown in the figure9, we can see the first sender node is source node S and border node is node A. The border node A can be used as a next-hop forwarding node positioned at the maximum distance within transmission range R. Suppose there are n neighboring nodes of source node, S in the forward area towards the destination node, *D*. Let n-1 nodes out of n nodes are within shaded area and node is at maximum distance or closer to border of the sender's transmission range.Now node distributions of , i=1,2,…n. Suppose f(k) and F(k), where k=1,2,…n denotes the PDF and CDF of these distances. Thus probability distribution function (PDF) of finding the first neighbor can be given as:

$$F(k) = P[d1 \le k, d2 \le k, d3 \le k, \ldots, d_n \le k]$$

$$F(k) = \prod_{i=1}^{n} P[d_i \le k] = \left(\frac{k}{X}\right)^n \quad (1) \qquad = \frac{d}{dk} F(k)$$

$$F(k) = \frac{d}{dk}\left(\frac{k}{X}\right)^n = \frac{n}{R}\left(\frac{k}{X}\right)^{n-1} \quad (5)$$

Similarly, the expected value of *k* can be computed as:

$$E(k) = \int_0^X k.f(k)\,dk = \int_0^X k.\frac{n}{X}\left(\frac{k}{X}\right)^{n-1} dk$$

$$E(k) = \frac{n}{X^n}\left[\frac{x^{n+1}}{n+1}\right]_0^X = \frac{n}{X^n}\left[\frac{X^{n+1}}{n+1}\right] \quad (6)$$

3.3. Expected Delay

To improve the network performance in VANETs, it is required to select a suitable next-forwarder hop with suitable path in the network to forward data packets. To minimize the delay during data transmission, suitable routing protocol such as position based routing protocol communicates packets using radio waves as earliest. Since, in VANET, roads can be used as a medium for vehicular nodes through which the packet has to be transferred, therefore, the road with maximum velocity is selected first.

During data transmission, all the routing protocols in VANET assumes that smart vehicular nodes are furnished with computing device, sensors, digital maps, and advanced information processing tools. Digital map in the vehicle provide street and lane level map for drivers and traffic related information such as traffic density on the road, direction of nodes, position and velocity of vehicular nodes on the roads at disparate times of the day. Total delay is the time required to transmit data packet from source node to destination node. Therefore, the expected delay between two hops can be defined as:

1) $T_{delay} = Probabilityofatleastonenode * Speed + Probabilityo$

In the sender's transmission range, probability of at least one node can be given as:

$$P(x = 1) = (1 - e^{-\rho R}) \quad (7)$$

Similarly, the probability of no node in the transmission range is:

$$P(x = 0) = e^{-\rho R} \quad (8)$$

Therefore, the expected delay can be written as

1) $T_{delay} = (1 - e^{-\rho X}) \cdot \frac{E(k)}{S} + e^{-\rho X} \cdot \frac{E(}{}$

Where,

E(k) = Expected Distance between two hops

X= Communication Range of the Node

S= Speed of vehicles

= Node density in the network

4.0. RESULT ANALYSIS

In this paper we have analyzed and presented the results for the above mathematical equations carried out with the help of MAT LAB simulation tool. In this results analysis section, first we have shown the distribution of nodes the given area for different values of node density. Further, we have computed the results in terms of expected delay with respect to communication range and speed of the node in the network.

4.1. Probability of Next Hop Selection

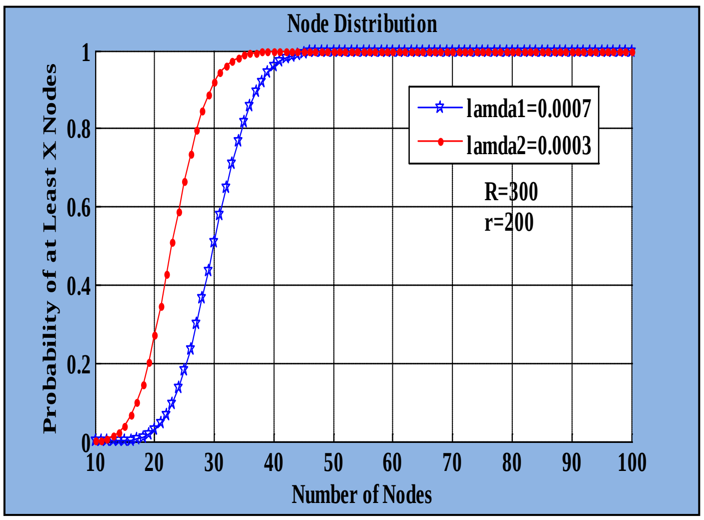

Figure 10: Next-hop selection probabilities

The figure10 is showing selection probability of the next- hop node with respect to number of nodes to forward data packets in the network. We can see in the figure, next hop selection probability is higher when range of nodes is lower and it's start decreasing when numbers of nodes are increasing in the network.

Also in figure11, we have shown next- hop node selection probability with respect to communication range; it is increasing as well as communication range is increasing.

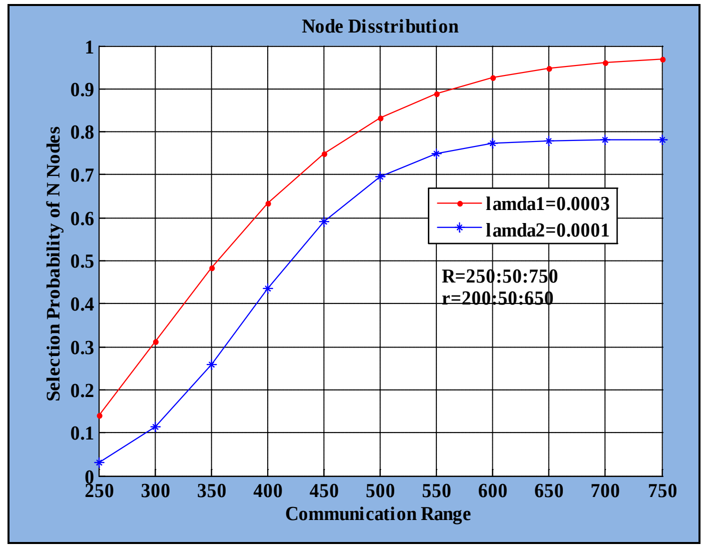

Figure 11: Next-hop selection probabilities

4.2. Expected One Hop Distance

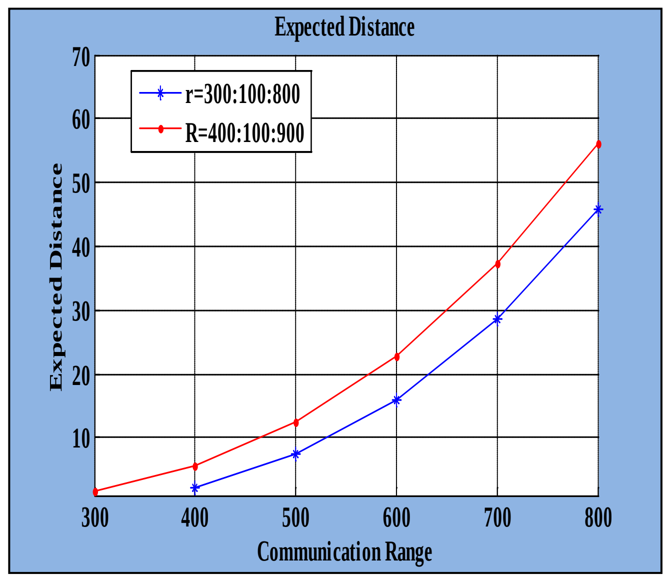

Figure 12: One hop expected distance with respect to communication range

The figure 12 is showing expected one hop distance between sender node and next forwarder node with respect to communication range. We can see in the figure expected one hop distance between sender and next forwarding node is increasing as well as communication range is increasing.

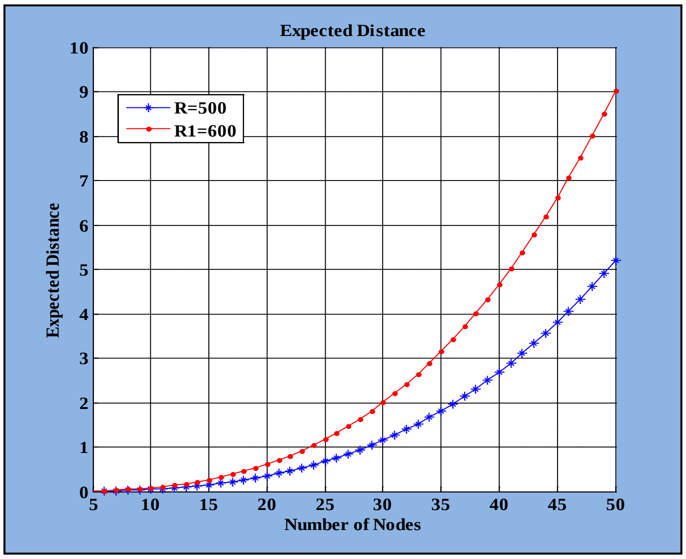

Figure 13: One hop expected distance with respect to nodes

The figure 13 shows expected one hop distance between sender node and next forwarder node with respect to number of nodes. We can see in the figure expected one hop distance between sender and next forwarding node is increasing as well as number of nodes are increasing.

4.3. Expected Delay

In figure 14, we have shown the graph for expected delay with respect to communication range. As shown in the figure, as the communication range increases, the expected delay between nodes decreases because of distance between the source and border node is also increasing.

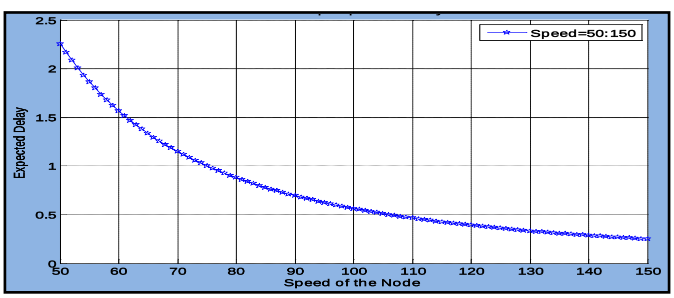

Figure 14: Expected delay vs. communication range

Further, we have computed the expected delay with respect to speed of the node in VANET. As, we know that, VANET is highly dynamic in nature. It means packet transmission is high due to high speed of the vehicular nodes in the networks. As shown in the figure 15, as the speed of the node is increasing, the expected delay is decreasing. It means packet delivery ration will be more.

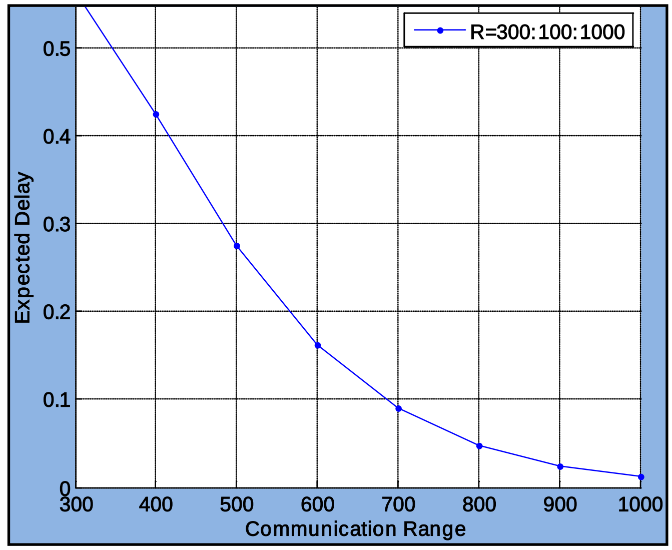

Figure 15: Expected delay vs. speed of node

5.0. CONCLUSION

In this work, we have discussed the position based routing protocols for VANET and used LAR protocol for mathematical calculations. We have analyzed LAR routing protocol by considering the border node as a next-hop forwarding node to transmit the packet from source to destination in the network. Further, we have computed the results in terms of expected delay with varying communication range and speed of nodes. The mathematical analysis and simulated results shows that the nominated next-hop neighboring node as a border node gives better performance in the network. Therefore, message can be forwarded appropriate to minimize the large number of road accidents and enhance the routing performance.

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