AN ANALYTICAL ANALYSIS OF NEIGHBOUR AND ISOLATEDNODEFOR GEOCAST ROUTING IN VANET

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ABSTRACT

Geocasting is a special variant of multicasting, where data packet or message is transmitted to a predefined geographical location i.e., known as geocast region. The applications of geocasting in VANET are to disseminate information like, collision warning, advertising, alerts message, etc. The topology of VANET changes frequently and rapidly due to the fast movement of vehicles. Therefore, the link time between two neighbouring vehicles exist for a short span of time. This makes delivery of messages to a geocast region most challenging issue in VANET. In this paper, we have proposed a probabilisticanalytical model based on neighbour node and isolatednode on the highway. Where highway is divided in to cells.For the better network connectivity in multi hop vehicular ad hoc network each cell should have at least one node. The numerical results show how connectivity between nodes depends on the transmission range, network density and total network area.

KEYWORDS

VANET, Geocast, neighbour node, isolated node, probability, Cell.

1. INTRODUCTION

VANET is a special class of Mobile Ad hoc Network (MANET).A Mobile Ad hoc network is a dynamically reconfigurable wireless network with no fixed infrastructure. Every node in this network behaves like a router to relay a message from one node to another. In MANET, nodes are laptops, PDAs, palmtops, and other mobile devices whereas in VANET [1] nodes are vehicles. In addition, the other characteristics which differentiate VANET from MANET are mobility of nodes; structure of the geographical areas, delay constraint, privacy, etc.., node movement depends on the structure of road or structure of city or terrain etc.

While delivering message from source to destination node, if destination node is not within the transmission range of source node then the source node send message to the destination node with the help of intermediate nodes.In VANET, one vehicle can communicate directly with other vehicles withinitsone-hop region. If the destination node is not present in one-hop region the message is transmitted using multi-hop routing. Further, to provide good connectivity and increase the robustness of communication roadside units are deployed. The roadside unit can be used as a gateway to the Internet [23]. Ad hoc network is multi-hop in nature and message delivery depends on the connectivity among the intermediate nodes since message delivery is done with the help of intermediate nodes. The aim of Geocast routing protocols is to deliver a message from one location (i.e. sender) to a predefined location known as Geocast region with

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optimal number of nodes and time period. It is desirable that protocols should maintain the low end-to-end delay and high accuracy in delivering message i.e., high delivery success ratio, low overhead and total numbers of participating hops should be minimum.
The rest of paper is organized as follows. Section 2 presents work related to the geocast protocols. In section 3 overview of our proposed mathematical model is presented. In section 4 probabilistic analysis of one hop neighbour and effect of various network parameters and probability of existence of isolated node is discussed. Finally, the work presented in this paper is concluded in section 5.

2. RELATED WORK

Extensive works have been carried out by researchers, academicians and industries for successfully dissemination of messages from source to destination. There are several projects [2], [3], [4], [5] on VANET i.e. [CarTalk, FleetNet–Internet on the Road, NoW (Network on Wheel)] are going on for its deployment in the real world. The main focus of all these projects is to provide safety, and timely dissemination of message from one location to another location. One of the message delivery protocols proposed for VANET tries to deliver a message to a geographic region rather than to a node called geocast routing. Many protocols have been developed for geocast routing such as LAR [6], LBM [7], GeoTORA [8] is modified TORA, GRID protocol is modified to GeoGRID [9], DREAM [10], GRUV [11], etc. A comprehensive survey of geocasting protocol is presented in [12]. A Voronoi diagram based geocast protocol has been proposed in [13]. None of these protocols considered the road structure since they have been primarily designed for MANET. In [22], the authors proposed different modified LAR [6] algorithms. They have modified the request zone. Through simulation, the authors have established that their proposed algorithms reduces route request overhead as compared to original LAR. The performance analysis shows that their method outperforms original LAR especially, in a dense and highly dynamic ad hoc network. In [14] analysis of connectivity among nodes in one-dimensional multi hop ad hoc networks is done. This is based on minimum hop counts between source and destination.. They have considered well known greedy forwarding method, i.e. Most Forward within Radius (MFR). Through the numerical analysis shows the effect of various network parameters i.e. number of nodes and radio transmission range on the minimum hop counts.In [18], multilane highway model with two way traffic is considered. For traffic entry in the network one *entry point* and one *exit point* is defined based on homogeneous Poisson distribution. The probability distribution of node on the highway and their location distribution is derived. Through the numerical results, effect of node mobility on the connectivity in the network is shown.The mathematical analysis of VANET and ad hoc network characteristics and network connectivity are proposed in [15], [16], [17], [19].

The geocasting is the variant of multicasting, in geocasting source node will send message to a particular geographical area. We divided the geocast method in two phases.In the Phase-I, the source node will send a message to a node inside the geocast region and in the phase-II, the receiving node of the geocast region will deliver the message to the entire member in the geocast region. The node which is move to the geocast region will automatically become the member of the geocast region. In Phase-II, the message delivery inside the geocast region is done by simple flooding techniques. Here, in this paper we are only focused our work on the phase –I. In phase I, we have described the probabilistic analysis of neighbour nodes, isolated node and effect of various network parameters i.e., transmission range of node, node density and network area.

3. PROPOSED MODEL

We have considered the multi-hop environment, because it's very rare that source and destination node fall in each other transmission range. As there is no direct connectivity between source and destination node, to route the message intermediate nodes plays a vital role. The intermediate nodes are act as relay node. We have considered highway scenario to deliver message from source to geocast region shown in fig-1.

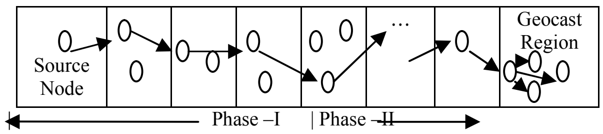

Figure1. Simple Scenario of Geocast on Highway

The highway is divided into small size cells [17] shown in fig.2. The cell size is considered in this paper as a rectangular structure. The cell length is equal to the transmission range of any nodes i.e. R and width is W. The transmission range for all nodes is fixed. The highway is divided into n number of equal sized cells. The advantage of cell is that it is used to identify the location of the vehicles.

$Cell_1$	$Cell_2$	$Cell_3$	…	$Cell_n$

Figure2. Single lane highway scenarios

The minimum number of nodes required to send a message from source to destination is depend on node's transmission range and distance between them. To compute the distance between two nodes we have to know the coordinate of both the nodes. Let's take (x1, y1) and (x2, y2) are the coordinates of two nodes. The Euclidian distance D between two nodes can be calculated by using equation-1

$$D = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}\,. \quad (1)$$

The two nodes are able to communicate to each other if the Euclidian distance between them is equal to or less than the transmission range.

4. PROPOSED MODEL

For our analysis, we assume that all nodes in the network have the same transmission range. The others parameters used in the analysis are given in the table1.

4.1 Analysis of One Hop Neighbour

Symbols	Description
N	Total number of nodes in network
A	Area of network
R	Radio range
m	Average number of one hop neighbours
N_{neigh}	Number of one hop neighbours
N_c	Total number of cell.
C_i	Area of Cell.

Table 1. Symbol notation

We have considered that a highway is divided into number of cell of rectangular shape. The size we considered here for highway is more realistic. The length of cell is L and width is W. The area of each cell will be C_i= L*W. The total area of network will be A= C_i*N_c. The probability of a node having m numbers of neighbours depends on the size of a cell and transmission range of nodes. The probability of a node having m numbers of neighbour nodes can be calculated according to theorem-1 proposed in [20] with the help of the following equation.

$$P\,(N_{neigh}=m)=\binom{N-1}{m}\left(\frac{W*R}{C_i*N_c}\right)^{m}\left(1-\frac{W*R}{C_i*N_c}\right)^{N-1-m};\ 0\leq m\leq N-1 \quad (2)$$

and the average number of neighbours per node can be calculated as follows in equation -3.

$$\bar{m} = \left(E_{neigh}\right) = (N-1) * \left(\frac{W*R}{C_i*N_c}\right). \quad (3)$$

4.1.1 Numerical Results

Parameter	Values
N_c	20,30,50

Table 2. Simulation parameters

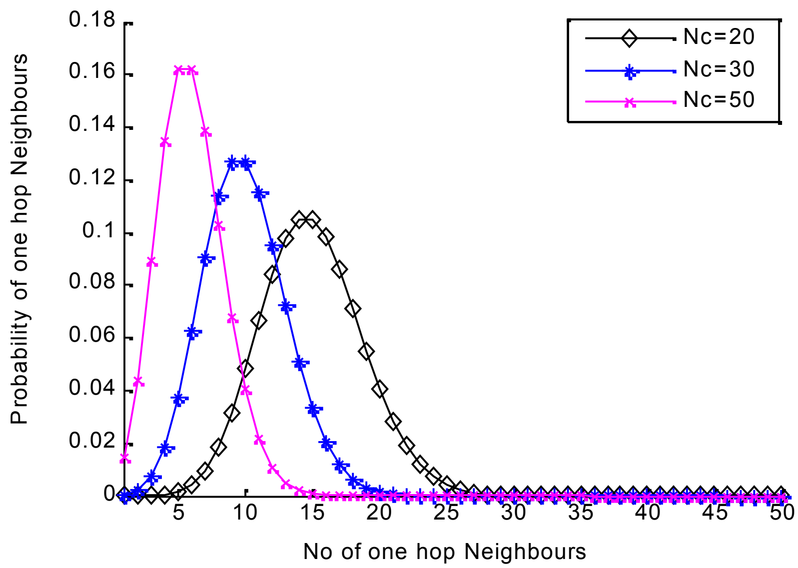

Figure 3. Probability of one hop neighbours with varying number of cells.

Fig 3 shows the one hop neighbour probability with varying the number of cells for 300 nodes in the network. We have considered value of radio transmission range 250, number of nodes fixed to 300 and number of cells 20, 30 and 50 given in Table 2. The result shows that when the number of cells is 20, the probability of having maximum number of one hop neighbours is 0.1. When the number of cells increased to 30 and 50 the probability of having maximum number of one hop neighbours is 0.13 and 0.17. The probability of having maximum number of one neighbour node is high when the no of cell is 20. This probability decreases as the numbers of cell increases.

Parameter	Values
N	100,200,300

Table 3. Simulation parameters

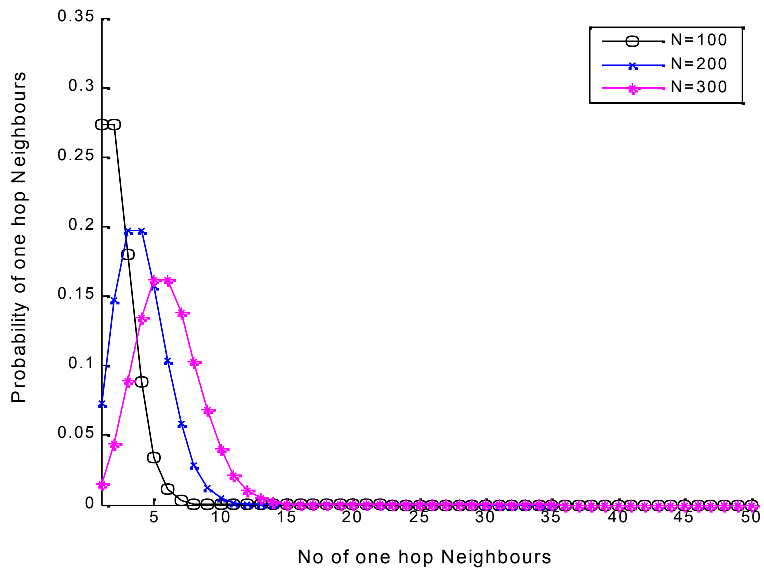

Figure4. Probability of one hop neighbours with varying numberof nodes.

Fig 4shows the one hop neighbour probability with varying the number of nodes for 50cells in the network given in Table 3. For a network size of100 nodes, the probability of having maximum one hop neighbour is nearly 0.27. For a network size of 200 and 300 nodes, the probability of having maximum number of one hop neighbours is 0.2 and 0.17, respectively. The probability of having maximum numbers of one hop neighbour is high when the number of node is high.

4.2 Probabilistic Analysis of Nodes Present in a Cell

We assume that the highway is a two dimensional structure. We have divided the entire road structure into number of cells of size W*L. The total number of nodes N is uniformly distributed over L_0 to L_{max}area on the Highway according to Fig.5. Here, we have analyzed the probability of number of nodes n_o present in each cell. In case each cell has n_0 numbers of node, the network will be fully connected. It is very essential in multi hop ad hoc environment that connectivity among nodes always exists for uninterrupted successful data transmission.

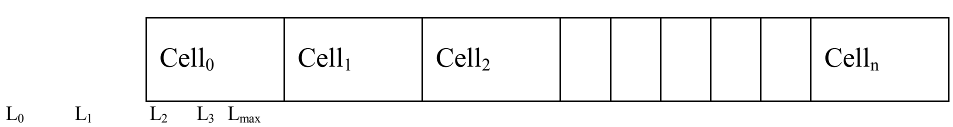

Figure5. Cells are divided in to subarea.

According to [21] we computed the probability of number of nodes, n_0 present in a cell. We assume that $n_0$out of N nodes are located in the interval [$L_{i,}$ L_j], where $0 \le L_i \le L_j \le L_{max}$ and i<0 and j<0.The total area of the network is denoted by *A* and each cell area is denoted by C_i where 0< i <n. The expected number of nodes present in a unit area is denoted by ρ =N/*A*.

A random variable d denotes the number of nodes within the given interval.The probability that a node is placed within the interval [$L_{i,}$ L_j] is p = $(L_j-L_i)/L_{max.}$ The probability that n_0 of N nodes are placed in a cell area C_i is

$$P\ (d=n_0) = \frac{\left(\frac{Ci*N}{A}\right)^{n_0}}{n_0!} * e^{-\frac{Ci*N}{A}}$$

$$= \frac{(Ci*\rho)^{n_0}}{n_0!} * e^{-\ Ci\ *\ \rho} \quad (4)$$

A node can transmit data within $\Pi*R^2$ area. But in our proposed model the area is not circular, as we divided the road into cells of size W*L. Therefore, the probability that a randomly chosen node has $n_0$neighbours is

$$P\ (d=n_0) = \frac{(\rho*W*R)^{n_0}}{n_0!} * e^{-\rho*W*R}. \quad (5)$$

For large value of N and *A*, we can approximate this solution with a Poisson distribution, i.e.

$$P\ (d=n_0) = \frac{(N\rho)^{n_0}}{n_0!} * e^{-N\rho}. \quad (6)$$

The node density ρ = N/A is the expected number of nodes present per unit area. For given density ρ we can calculate the probability that n_0 nodes are present in an interval of length $L_{21} = L_2 - L_1$ as

$$P\ (d=n_0) = \frac{(\rho L_{21})^{n_0}}{n_0!} * e^{-\rho L_{21}}. \quad (7)$$

4.2.1 Numerical Results

Parameter	Values
N	50,100,150,200,250,300,350…2000

Table 4. Simulation parameters

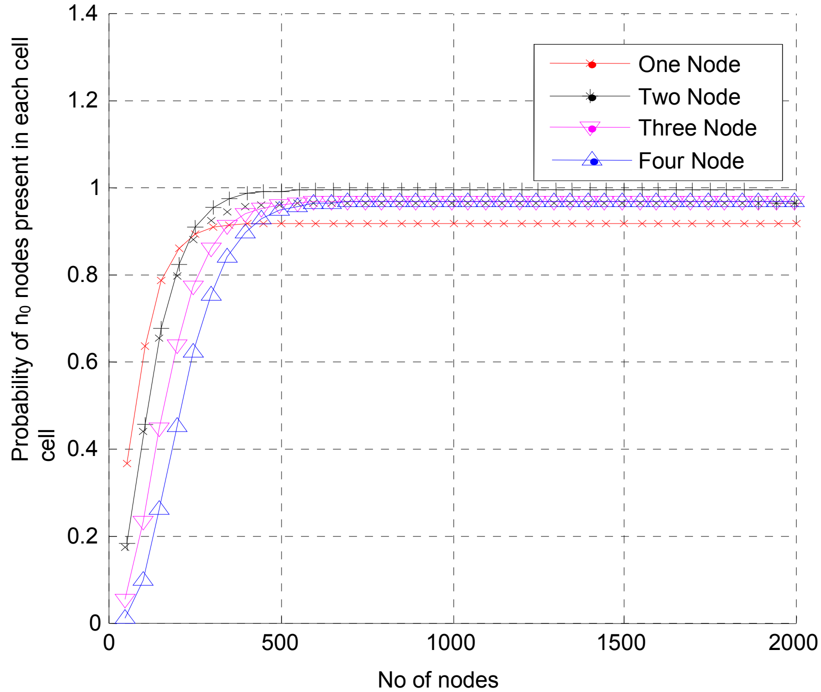

Figure 6.Probability of having n_0 numbers of node present in each cell Vs Node Density.

In fig. 6 shows the probabilitics analysis of numbers of nodes to be present in each cell area.The different parameters considered for the analysis is given in table-4. We have fixed the number of cells and the transmission range of node. The node density is vary here. We have shown the probability of 0,1,2,3 and 4 nodes present in each cell.The initial value of node is 50 and incremented by 50 maximum is 2000. When the number of node is 50 probability having zero node present in a cell is greater than 0.2. The probability of 3 and 4 nodes present in each cell is near to 0. When the number of nodes are increases upto 500 the probability of having 2,3 and 4 nodes in each cell is 1. As the number of nodes exceeds 500, it shows that 3 to 4 nodes are always present in each cell. As the number of nodes increases, presence of nodes in each cell is also increases and the network becomes fully connected.

Parameter	Values
R	100,110,120,…500

Table 5. Simulation parameters

In fig. 7 shows the probabilitics analysis for number of nodes present in each cell area. The parameters considered for this analysis is given in Table-5. The number of nodes considered is 500. The total network area considered is for simulation $2*10^5$ m^2. The transmission range varies from 100m to 500m in this analysis. Fora transmission range 100m and low node density, the probability of having 0 or 1 node in a cell is 0.3. When the node density and the transmission range increases, probability of availability ofnodes in cells also increases.The probability that each cell has one node is constant at0.0988,for transmission range beyond 260 m. Further, the probability that each cell has two, three and four nodes is constant at 0.2935,0.6026 and 0.9702, for transmission range beyond 310 m, 370 m and 410 m, respectively.If we transmit data with large transmission range, the network is always connected and successfully deliver data to the destination. We have shown in table 6, the probability for node presence with varying transmission range.

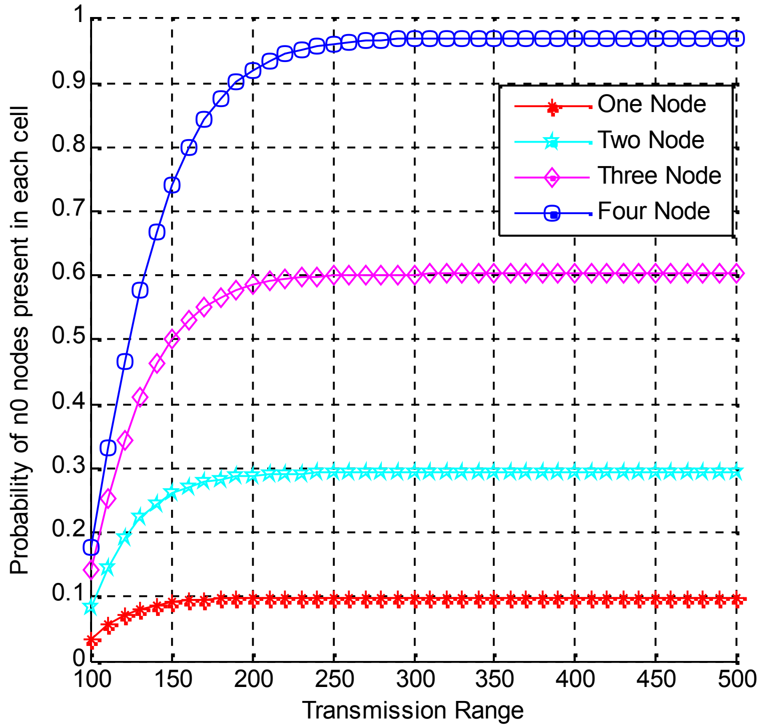

Figure 7.Probability of having n_0 numbers of node presence in each cell Vs Transmission Range.

Transmission Range (m)	Probability of node present			
	1	2	3	4
100	0.0337	0.0842	0.1404	0.1755
150	0.0913	0.2603	0.5028	0.7411
200	0.0980	0.2890	0.5855	0.9207
250	0.0987	0.2930	0.6000	0.9613
300	0.0988	0.2935	0.6022	0.9688
350	0.0988	0.2935	0.6025	0.9700
400	0.0988	0.2935	0.6026	0.9702
450	0.0988	0.2935	0.6026	0.9702
500	0.0988	0.2935	0.6026	0.9702

Table 6. Probability of node presence Vs Transmission Range

4.3. Probabilistic Analysis of Isolated node

The isolated node means a node does not have any neighbour node. This condition is mostly occurring when the network is sparsely populated. In multi hop ad hoc network this most unwanted circumstance.If isolated node exists in the network, data transmission is disrupted and fragmentation occurs in the network. We can refer this condition as *'dead end'*fromwhere no data transmission is possible in thenetwork.The isolated node only transmits data when it moves to within the transmission range of other node. According to [21] we can compute the probability of isolated node in the network as

$$P\{n_{isolated}\} = \frac{(\rho * W * R)^0}{0!} * e^{-\rho * W * R}$$

$$= e^{-(\rho * W * R)} \qquad (8)$$

4.3.1 Numerical Results

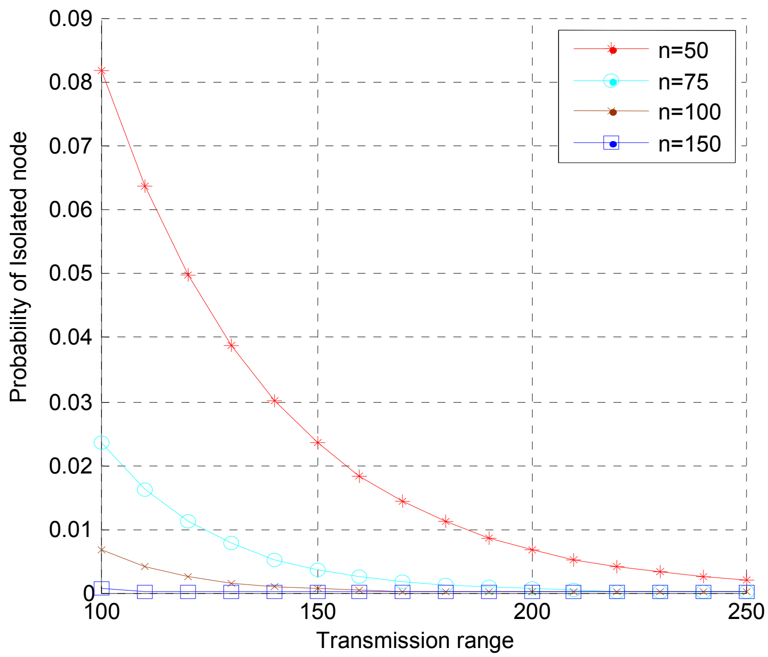

Figure 8.Probability of Isolation node Vs Transmission Range

In Fig.8, we have shown the probability of occuring isolated node in the network. For the graphical simplicity, we have considered upto 150 nodes. The results also show that regardless of number of nodes, probability of occurrence of isolatied nodes in the network declines with increasing transmission range. We have considered transmission range from 100m to 250 m. For s 50 nodes, the isolated node probability at transmission range 250 m is 0.0019. Therefore, when number of nodes is 50 in the network, data transmission at transmission range higher than 250 m gives better results. For 100 and 150 nodes, at transmission range 200 m and 230 m, respectively, the node isolation probability is zero.

No of node (n)	Transmission Range (m)								
	100	120	140	160	180	200	220	240	250
50	0.0821	0.0498	0.0302	0.0183	0.0111	0.0067	0.0041	0.0025	0.0019
75	0.0235	0.0111	0.0052	0.0025	0.0012	0.0006	0.0003	0.0001	0.0001
100	0.0067	0.0025	0.0009	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
150	0.5531	0.1234	0.0275	0.0061	0.0014	0.0003	0.0001	0.0000	0.0000

Table 7. Probability of node Isolation Vs Transmission Range

5. CONCLUSION

In this paper, we have presented a geocast protocol for Vehicular Ad hoc Network. In this protocol, we have proposed a model for highway scenario in which a highway is divided in to number of cells. The probabilistic analysis of nodes present in each cell is shown in our analysis. For the better network connectivity in multi hop vehicular ad hoc network each cell should have at least one node. We have analyzed the impact of various network parameters like node density, transmission range and network size and their impact in network connectivity. The simulation work is implemented using Matlab. The results show that when the number of node is 50,the probability having zero node in a cell is greater than 0.2. As the number of nodes exceeds 500, it shows that 3 to 4 nodes are always present in each cell. In sparse network,.e.g. for 50 nodes, the probability of isolated node exist in cell is very high. Therefore, to avoid this conditiion, transmission range should be 250 m for data transmission.. When number of nodes in the network is 100 or above, transmission range should be higher than 200 m for data transmission. According to network size and density, optimum value of transmission range can be determined and beused.

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