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Mobility Aware Efficient Location based Routing Protocol for Vehicular Ad Hoc Networks

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Abstract: ***The Vehicular Ad Hoc Networks (VANETs) also known as subclass of Mobile Ad hoc Networks (MANETs), however the routing methodologies designed for MANET practically proven inefficient because of high mobility & network area characteristics of VANET communications. Thus, the position based routing protocols is alternative technique to address the challenges in VANET communications. Number of position based routing protocols recently proposed for VANET communications. This research proposed novel location based routing protocol by considering the key parameters of selecting the next relay node such as mobility speed, geographical distance and packet relying characteristics. To optimize the route establishment process, we perform the position based route establishment tasks using Ant Colony Optimization (ACO). The ACO forwards several ants towards the destination vehicle, which is the closest one to the destination vehicle. While selecting the next hop, ACO accesses the packet relaying quality and mobility speed of vehicle in order to generate more efficient and stable data transmissions in network. The proposed location based protocol is called as Mobility Aware VANET using ACO (MAVA). The simulation results of MAVA compared with the recent location based protocols in terms of throughput. The outcome demonstrates the efficiency of MAVA.***

Keywords: Ant colony optimization, Ants, mobility, location based routing, vehicular ad hoc networks, routing overhead

1. Introduction

There is an increasing trend of dependence on the road transport in rural as well as urban areas across the globe. Road Safety and efficient traffic becomes obvious areas of concern. Further, the increase in the time spent on the roads and advent of internet and mobile telephones leads to the exploration and realization of infotainment requirements. For the purpose of supporting these applications and addressing the highly dynamic vehicular mobility, a suitable architecture needs to be designed, developed and implemented [1]. Various supporting standards are required in order to deal with the sporadic development in academic research to meet the VANET challenges & issues while balancing the practical and feasible VANET architectural component design. Moreover, efficient routing protocols are required to be developed for quality attainment of VANET applications services [2].

VANETs have dynamic topologies and limited and variable shared wireless channel bandwidth. Design of dynamic routing protocols under such networks is a challenging task [3]. Here the protocols need to be efficient and consume less overhead. The routing protocols need to perform three basic functionalities viz. Route discovery, maintenance and selection of the efficient path from the various available paths [4]. Under topology-based routing mechanism, the information regarding network layout of the nodes need to be available. Packet Forwarding should be possible using the available information about the nodes and links within the network. Under the position based routing mechanism the location of nodes should be known for packet forwarding. However, due to the high dynamics in network the topology based routing protocols are inefficient for VANET communications as compared to position based routing protocols [5].

Position-based routing protocol is normally dependent on the location or position of the data during the execution of the routing mechanism. Every node recognizes geographical position of its own as well as its neighbouring nodes. The transmitting node sends data packet information to the receiving node using the location of the packets. The node decides the location of its adjacent within current node the radio range [5]. When the data packet is sent by the source node, the location of the destination is saved in the header of the packet which helps in transmitting the data packet to its destination node. In this situation, there is no need of the processes like route discovery and maintenance. Therefore, these routing protocols are assumed to be much appropriate and stable in extremely mobile VANET network conditions.

As of late there are number of position constructed directing conventions outlined situated in light of different qualities and parameters for course foundation from the source vehicle to goal vehicles. Up until now, a few steering conventions have been proposed for VANETs. Geological directing conventions [6] have indicated better execution in this exceptional unique condition, however these conventions much of the time experience the ill effects of neighbourhood maximums. Gytar [7] progressively affixes an arrangement of convergences and picks the following applicant street section with harmony between vehicle thickness and street length. Gytar anyway does not consider the channel stack condition for course determination. VADD [8] is a min-delay directing convention which just uses activity parameters issued from authentic information. Also some ongoing works answered to address the difficulties of position based directing in VANET correspondence. As the VANET is exceedingly powerful system, accordingly choosing the following hand-off hub for information transmission must be more dependable. The reliability of vehicle mainly depends on the mobility speed and its packet relying probability along with minimum distance from the destination node. The recent position based protocols failed to effectively address above parameters to improve the QoS performance of VANET routing. In this paper, we proposed the novel position based routing protocol called MAVA to address the problems by considering the probabilities computation of next relay node using the mobility and packet relying characteristics of vehicle. The optimization technique called ACO exploited to enhance the route construction process in MAVA. Section II presents the brief discussion of position based routing protocols. Section III presents the design of proposed MAVA routing protocol. Section IV, presents the simulation results and its discussion. Finally the conclusion is discussed in section V.

2. Literature Survey

There are several position based routing protocols has been designed since from last two decades for MANET and then modified the same for VANET. In this section we discussing the recent position based routing protocols.

In [9], researcher proposed the underlying geographical source routing (GSR) convention to tackle the issues of ordinary position based routing protocols.In GSR, the source hub finds the most limited way to the goal by utilizing Dijkstra's calculation on a road delineate. The figured way comprises of a succession of intersection IDs known as anchor points (APs). Anyway the fundamental and vital issue with GSR convention is that it doesn't think about the high elements of vehicles while processing the most limited way.

In [10], researcher displayed the audit of position-based and geocast routing conventions for VANET correspondences. Creators examined the advantages and issues for the position and geocast based routing conventions and further guaranteed the adequacy of position based routing conventions for the city and interstate system conditions.

In [11] [12], researcher propelled new position based routing convention utilizing ACO. The ACO used to figure the parcel transferring nature of every road section situated between two intersections. It is expected that there is a RSU at every intersection to spare routing data and discover courses for parcels. To set up a route, the source node forwards several ants toward a target RSU, which is the closest one to the destination vehicle. At the target RSU, backward ants are generated and sent back to the source. However, the solution is not efficient and costly for the RSU deployment. Additionally, the reliability and scalability of communication may degrade if the RSU failed.

In [13], the recent position based routing protocol proposed for the VANET communications in which the algorithm designed to address the challenges caused by the obstacles such as building, trees etc. in city environment. The position based routing performed by avoiding such obstacles. However the challenges of mobility based route discovery is not addressed in this paper, also the QoS may degrade is the next hop node does not have capability to relay the packets.

In [14], researcher planned and demonstrated that new convention for VANET called VNIBR (VANET intersection-based routing on virtual nodes) to accomplish preferred execution over best in class position based routing conventions. This convention conveyed an effective and computationally doable blend of topological and geographical routing for VANET correspondences. Notwithstanding, the versatility and dependability is issue for VANET.

In [15], most as of late another position based routing convention proposed. Creator assessed the execution of existing position based routing strategies for the VANET correspondence by considering the quantity of convergences affect on execution. They proposed the crossing point based separation and activity mindful routing (IDTAR) convention and contrasted and movement mindful routing conventions. In any case, these techniques intensely depend on the convergence remove approach which probably won't be the handy conditions and furthermore constrains the pertinence of convention.

Thus, in this paper we mainly intended to solve the problem of mobility aware position based routing protocol for VANET communications in order to enhance the QoS performance in network.

3. Methodology

Recently we studied the ACO technique used to enhance the QoS performance of routing protocols in different types of wireless networks such as MANET and VANET due to its superiority. In this work, we exploited the ACO technique for route establishment to relay the data from source vehicle to destination vehicle. ACO optimization algorithm used in wireless networks to address the various challenges such as optimal cluster head selection, optimal forwarder node selection, nodes deployment, node localization. In this wok, it is used to discover the position based route. Figure 1 shows the proposed ACO based path formation approach.

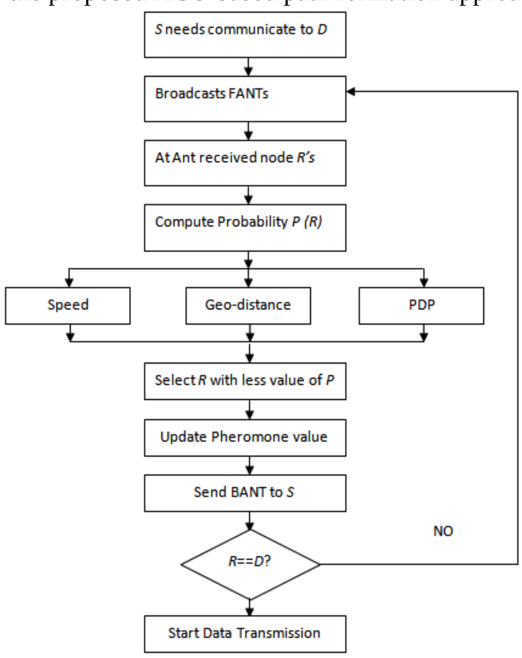

Figure 1: Working of MAVA Routing Protocol

As observe in figure 1, after the VANET deployment, the reactive route construction process starts by any source node *S* in network by generating and broadcasting the forward Ant (FANT) packets towards the actual destination node *D*. FANTs are broadcasted to all the vehicles within the communication range of node *S* in order to find the routing paths. All the neighbours of node source or current intermediate node are recorded into the set N_i^D (set of all neighbours of node *i* towards destination *D*). Thus the path from current node *i* to next node *j* is constructed by computing the probability of each neighbouring node of node *i*. The probability of next hope node is computed using three most important parameters such as mobility speed of vehicle, packet forwarding probability (PDP) of vehicle, and geographic distance between i^{th}vehicle to j^{th}vehicle. The computed probabilities of each neighbouring node are considered as the pheromone value and at each session it can be updated in routing table. Once the FANTs received by neighbouring nodes, then the probability is computed as:

$$P_j^i = S_j + D_{ij} + PDP_j \quad \ldots (1)$$

Where, the P_j^i is the probability value of node *j* for becoming the relay of node *i*. The S_j and PDP_j is the speed and PDP of node *j*. As this is position based routing protocol, our aim is to select the less path with minimum geographic distance from *S* to *D*. D_{ij} is the geographic distance from i^{th}nod to j^{th}node. The speed of current node is computed as:

$$S_j = \frac{\hat{S}}{100} \quad \ldots (2)$$

Where $\hat{S}$ is the current moving speed of node *j*. In this paper, we assume max speed of vehicles is 100 km/hr. Thus, we obtain the speed value in range of 0 to 1.

Further the PDP of next hop node *j* is determined by bandwidth availability of node *j*. The bandwidth is computed as the amount of data transferred from one node to another node in specific amount of time. We fetch the current bandwidth value of node *j* from node *i*. It is computed as:

$$PDP_j = 1 - \left(\frac{\beta}{2048}\right) \quad \ldots (3)$$

Where β is the current bandwidth value of node *j* in kbps? In this paper, we set max bandwidth among all vehicles communication is 2Mbps (2048 kbps). Thus, we obtain the speed value in range of 0 to 1. The node with minimum PDP value will be the strong candidate to select as next intermediate node for the data transmission. Finally the distance from node *i* to node *j*is measured as:

$$D_{ij} = \frac{\left|V_{xy}^i - V_{xy}^j\right|}{1000} \quad \ldots (4)$$

Where, V_{xy}^i & V_{xy}^j is location value $V_{xy}$of node vehicle *i* and *j*. We considered the maximum distance between two nodes in 1000 meters. We received the distance value in range of 0 to 1.

In this way, all the values of three parameters added to generate the final probability value each neighbouring node at current time. This value is stored as the pheromone value in each nodes routing table. Thus, whenever the node *j* receives the FANT packet, its pheromone value updated in routing table. The node with minimum pheromone value is selected as the intermediate node to relay the data from source node or previous intermediate node to next intermediate node or destination node. Once the intermediate node selected, the backward Ant (BANT) generated and sent back to the source node *S* following the corresponding reverse route. The process is repeated till to destination node reach. Once the final reverse route traced, the *S* launches the data transmission from the selected optimum path towards the destination. At each interval, the pheromone values computed simultaneously from each intermediate node to discover the optimum route according to ACO method. The supersite of proposed approach is its very simple and having minimum overhead. The experimental evaluation of proposed method is discussed in next section.

4. Experimental Result

The MAVA protocol is designed and simulated using the NS2 tool. To claim the efficiency of proposed method, we compared to the performance of MAVA with GSR [9] and VACO [11] position based protocols. The VANET networks designed with varying mobility speed from 40 km/hr to 70 km/hr. We deployed the 100 vehicles randomly using the grid mobility model by consider the city network conditions. In table 1, we displayed the other network parameters used in evaluation. In this work, 802.11p protocol is used for the VANET networks. The IEEE 802.11p standard in NS2 is represented by IEEE 802.11Ext, thus same we used in our simulations. Finally, the mobility model generated by using the mobisim framework which supports the various mobility models for VANET.

Table 1: Network design parameters

Number of vehicles	100
CBR Traffic	6vehicle-to-vehicle (V2V) pairs
Simulation Time	300 second
Mobility (Km/hr)	40, 45, 50, 55, 60, 65, 70
Routing Protocols	GSR, VACA, MAVA
MAC	802.11p
Propagation Model	Two-Ray Ground
Area	7000 m x 7000 m
Mobility	Manhattan grid mobility model
Antenna	Omni Antenna

The proposed method is evaluated using the various performance matrices such as average throughput, Packet Delivery Ratio (PDR), average delay, and communication ovehad. The performance metrics computed using below equations.

Average Delay: This metrics calculates the average time between the packet origination time at the all sources and the packet reaching time at the all destination nodes. It is computed as:

$$D = \frac{\sum_{i=1}^{N} d_t^i + d_p^i + d_{pc}^i + d_q^i}{N} \quad (5)$$

Where N is number of total transmission links, d_t^i is transmission delay of i^{th}link, d_p^i is propagation delay of i^{th}link, d_{pc}^i is processing delay of i^{th}link, and d_q^i is transmission delay of i^{th}link.

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AverageThroughput: This metrics calculates the total number of packets delivered per second i.e. total number of messages which are delivered per second. The average throughput in Kbps is:

$$T = \left(\frac{R}{T^2 - T^1}\right) \times \left(\frac{8}{1000}\right) \quad (6)$$

Where R is complete received packets at all destination nodes, T^2 is simulation stop time and T^1 simulation start time.

PDR: It is the calculation of the ratio of packet received by the destinations which are sent by the various sources of the different traffic patterns. It is computed as:

$$P = \left(\frac{P_r}{P_g}\right) \times 100 \quad (7)$$

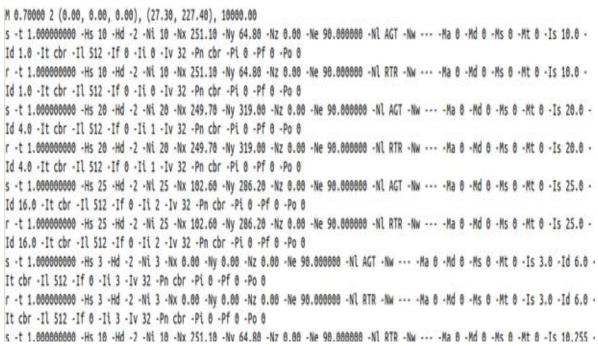
Where, P_r is number of received packets and P_g number of generated packets.

Communication Overhead: It is computed as the ratio of total number of routing packets to the total number of data packets in network. It is computed as:

$$O = \sum_t \left(\frac{RT^t}{DT^t}\right) \quad (8)$$

Where, RT^t is total number of routing packets and DT^t is total number of data packets at time t.

The performance metrics computed by applying on trace (TR) file in NS2. The scripting language called 'AWK' used to design the equations defined above and apply that AWK on output tr file to scan the all simulation acitivities and record the results for each parameter. Figure 2 shows the example of trace file with some rows. It contains various events such as sending (s), receiver (r), forwarding (f) events with timining, number packets, source node address, and destination node address.



```
M 0.70000 2 (0.00, 0.00, 0.00), (27.30, 227.40), 10000.00
s -t 1.000000000 -Hs 10 -Hd -2 -Ni 10 -Nx 251.10 -Ny 64.80 -Nz 0.00 -Ne 90.000000 -Nl AGT -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 10.0 -
Id 1.0 -It cbr -Il 512 -If 0 -Ii 0 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
r -t 1.000000000 -Hs 10 -Hd -2 -Ni 10 -Nx 251.10 -Ny 64.80 -Nz 0.00 -Ne 90.000000 -Nl RTR -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 10.0 -
Id 1.0 -It cbr -Il 512 -If 0 -Ii 0 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
s -t 1.000000000 -Hs 20 -Hd -2 -Ni 20 -Nx 249.70 -Ny 319.00 -Nz 0.00 -Ne 90.000000 -Nl AGT -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 20.0 -
Id 4.0 -It cbr -Il 512 -If 0 -Ii 1 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
r -t 1.000000000 -Hs 20 -Hd -2 -Ni 20 -Nx 249.70 -Ny 319.00 -Nz 0.00 -Ne 90.000000 -Nl RTR -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 20.0 -
Id 4.0 -It cbr -Il 512 -If 0 -Ii 1 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
s -t 1.000000000 -Hs 25 -Hd -2 -Ni 25 -Nx 102.60 -Ny 286.20 -Nz 0.00 -Ne 90.000000 -Nl AGT -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 25.0 -
Id 16.0 -It cbr -Il 512 -If 0 -Ii 2 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
r -t 1.000000000 -Hs 25 -Hd -2 -Ni 25 -Nx 102.60 -Ny 286.20 -Nz 0.00 -Ne 90.000000 -Nl RTR -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 25.0 -
Id 16.0 -It cbr -Il 512 -If 0 -Ii 2 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
s -t 1.000000000 -Hs 3 -Hd -2 -Ni 3 -Nx 0.00 -Ny 0.00 -Nz 0.00 -Ne 90.000000 -Nl AGT -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 3.0 -Id 6.0 -
It cbr -Il 512 -If 0 -Ii 3 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
r -t 1.000000000 -Hs 3 -Hd -2 -Ni 3 -Nx 0.00 -Ny 0.00 -Nz 0.00 -Ne 90.000000 -Nl RTR -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 3.0 -Id 6.0 -
It cbr -Il 512 -If 0 -Ii 3 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 0
s -t 1.000000000 -Hs 10 -Hd -2 -Ni 10 -Nx 251.10 -Ny 64.80 -Nz 0.00 -Ne 90.000000 -Nl RTR -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 10.255 -
```

Figure 2: Sample of trace file

Figures 3 shows the simulation outcomes for all three position based routing protocols. As observed in figure 3 and 4 the performance of throughput and PDR is decreasing as the mobility speed increasing. Due to higher mobility the tasks of frequent route breaks and constructions leads the leads the performance degradation for the same network.

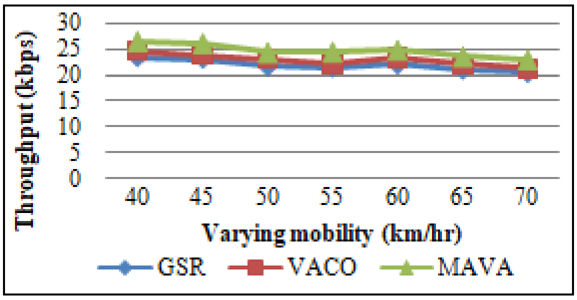


Figure 3: Average throughput analysis

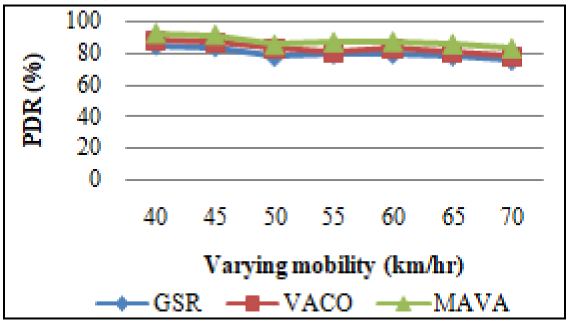


Figure 4: PDR performance analysis

Figure 5 shows the communicatiover overhead performance. The complexity of route construction in VACO delivers the worst performance for routing overhead compared to GSR protocol as well. The MAVA protocol overcomes the challenges of both GSR and VACO as MAVA construct the position and mobility based routes that helps to deliver the more stable and reliable paths for data transmission. The long life paths deliver the enhanced QoS performance for VANET.

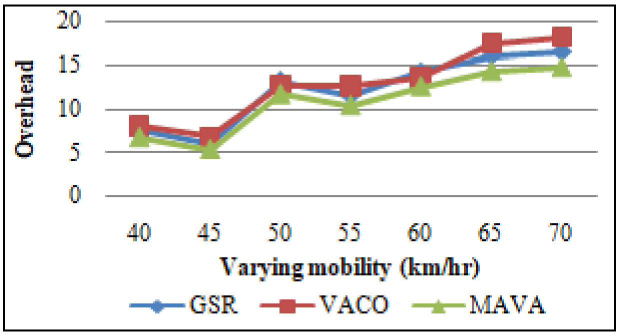


Figure 5: Communication overhead analysis

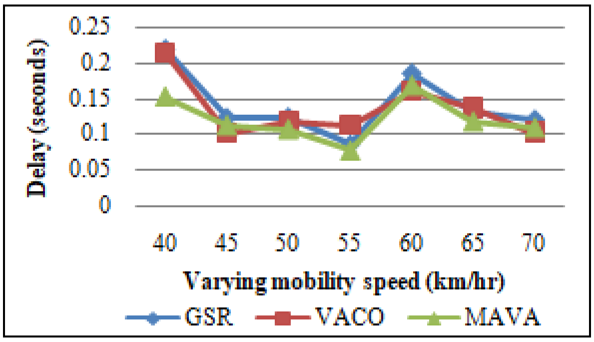


Figure 6: Average delay analysis

The figure 6 shows the average end to end delay performance for all protocols. An average the MAVA having little less delay compared to other protocols. The delay parameter does not showing the improvement under all network conditions, it may be due to traffic conditions in network which not considered in MAVA protocol.

5. Conclusion

In this paper we first discussed the importance of position based routing methods compared to topology based routing protocols for the VANET communications. We discussed about the mobility as the key metric that helps to optimize the routing protocol performance in VANET. We designed and evaluated the new MAVA protocol in this paper. The MAVA location based routing protocol designed by considering the key parameters of selecting the next relay node such as mobility speed, geographical distance and packet relying characteristics. The path construction process is optimized using the ACO algorithm. We presented the simulation outcomes of proposed routing protocol with GSR and VACA protocols. The results prove the proposed method outperforms the existing protocols. For future directions, there are numbers of points to work such as (1) it will be interesting to investigate the different network conditions, (2) MAVA can be extended or improved by using the suitable technique for traffic aware data transmission, (3) data security is vital while evaluating the nodes probability, as attacker may misguide the source node.

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