International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

Multilevel Prioritization based Effective and Reliable Communication Model for Vehicular Network

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***Abstract:** Vehicular network always suffers from the issue of heavy traffic and load that increases the communication delay and loss. In this paper, a multi level prioritization method is applied within the existing GPSR protocol for effective route generation and improving the functionality of vehicular network. The proposed model is divided in two sub stages. In first stage, the prioritizations to the vehicle nodes are assigned. The priority assignment is done based on the role, behavior, communication characteristics of vehicle. Once the priorities are assigned, the communication is performed in the network. The rules are defined for considering the priority nodes as the intermediate node or not. The proposed prioritization based communication model is also sensitive to unbalanced load and network attack issue. Based on these considerations, the vehicle priority can be changed. The proposed protocol is defined as an improvement to GPSR protocol. The proposed work is simulated in NS2 environment. The simulation results show that the improved protocol enhanced the packet communication and reduced the packet loss and communication delay effectively.*

***Keywords:** VANET, Prioritization, V2V, GPSR, Load Balancing.*

I. INTRODUCTION

Vehicular Adhoc Network (VANET) is the vehicle driven network defined a particular region or scenario. It is the network that hybrid the features of mobile and sensor network. The vehicle nodes are mobile and defined with energy restrictions. The infrastructure devices are present within the region for the communication support. The actual communication is performed by adapting the cooperative communication between the vehicle nodes. The network is equipped with road side units for controlling the region communication. The technological requirement and the performance decision are different in this network. The network also faces the various challenges issues respective to the region, technology and vehicles. The traffic driven challenges also exist such as the accidental situations. The rerouting methods are required for changing the route as some accidents occur in the network. The vehicular network is application driven and environment control network which is applied in real scenarios [1, 2]

Revised Manuscript Received on November 15, 2019.

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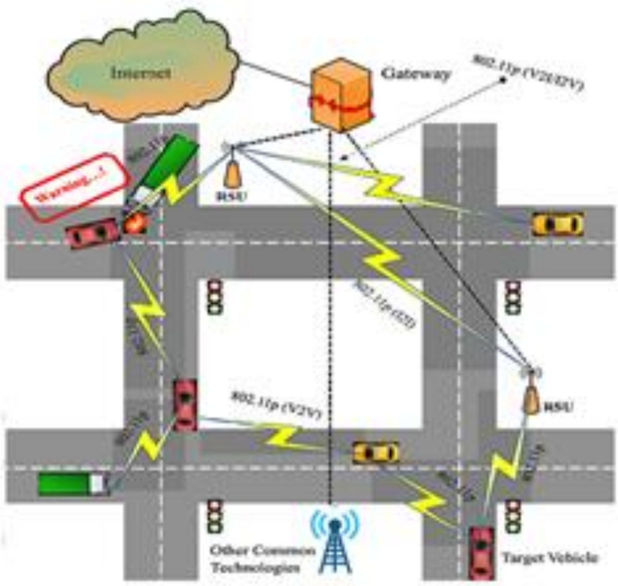

Fig. 1 : Vehicular Adhoc Network

Figure 1 is showing the vehicular network. The figure is showing the view of city scenario in which the two lane network is shown. The vehicles are moving in their lane. The infrastructure devices are installed in the region at appropriate positions for controlling the network traffic. The traffic lights are also present in the network for controlling the flow of vehicles in the network. Various routing protocols are present for enabling the traffic control and effective communication in vehicular network. One such protocol is Greedy Perimeter Stateless Routing (GPSR) protocol. In this work, GPSR protocol is improved. The standard functioning of GPSR protocol is defined in this section.

A) GPSR Protocol

GPSR protocol uses the greedy forwarding mechanism while acquiring the positional information of node and neighbor nodes. The GPS devices enabled information is acquired and which is further processed by the GPSR protocol in its two work stages. At first the greedy forwarding is applied for identifying the most effective neighbor based on positional information. When the greedy forwarding fails to provide effective solution, the perimeter forwarding is applied. This stage identifies the next effective neighbor based on local maxima [3, 4]. The functioning of GPSR protocol is shown in figure 2.

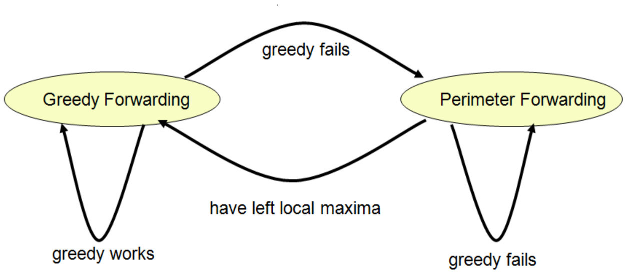

Fig. 2 : Working of GPSR Protocol

In this paper, the prioritization based communication model for vehicular network is presented. In this improved protocol, the load and communication failure issues are addressed. In this section, an introduction to the behavior and features of vehicular network are provided. The section also explored the functioning of GPSR protocol. In section II, the work provided by the earlier researchers for optimizing the communication in vehicular network is provided. In section III, the research method for proposed prioritization based method is defined for optimizing the vehicular communication. The algorithm and research design of proposed work are also provided in this paper. In section IV, the results and analysis of the proposed work against the existing GPSR protocol are also provided. In section V, the conclusion of the work is presented.

II. RELATED WORK

In this work, a prioritization adaptive communication model is presented for optimizing the reliability and effectiveness of vehicular network. In this section, the works defined by earlier researchers are discussed. The work on optimizing the VANET communication and route optimization are discussed. The work on various issues such as load condition is also explored in this section. In [5] provided the performance analysis of VANET in congestion situation. Author considered the various dynamic features of networks and nodes including power rate, fairness and prioritization factor. The analysis was performed for different environments and situations. The protocol was defined to handle these situations and to improve the communication in such challenging network. Defined a work on congestion control and provided the traffic and network safety in vehicular network [6]. The gatekeeper protocol was defined by the author that includes the packet prioritization and linear control over the network. The priority queuing and multihop communication method was defined for improving the communication in load and starvation situations. In [7] provided a detail study on road traffic analysis based routing method for city network. The road path generation and handling various probabilistic measures and situations were provided in this work. The contention analysis based packet forwarding was provided in this work. The work achieved the prioritization based on multiple criteria so that the non uniform radio propagation would be managed. The work reduced the communication delay and improved the performance over existing protocols.

In [8] defined priority based routing protocol for improving the safety and communication reliability for vehicular network. The proposed protocol achieved the effective driving route for distributed environment. The node position and quality feature based routing method was defined for reducing the collision and for improving the reliability in such complex network and situations. The delay, collision and message reception rate were handled by the author in this work. In [9] defined a method for improving the effectiveness for V2V communication in vehicular network. The scenario specific routing and the vehicle priority assignment were discussed in this work. The multi-hop routing method was defined by the author for handling the emergency situation and for enhancing the data delivery rate in complex situations. The work was discussed in different topological scenarios for improving the reliability of work. In [10] proposed a new routing algorithm for handling the multiple priority factors and geographical positions of nodes for generating the directional route over the network. The work was defined for generating the opportunistic route over the vehicular network. The security alarm adaptive high priority packet transmission method was defined by the author. The work was defined by the author for improving the retransmission mechanism by observing the neighbor list. The position based routing methods were defined for enhancing the capabilities of vehicular network.

In [11] defined the priority based routing method for improving the reliability and effectiveness of vehicular network. The acknowledgement and retransmission mechanisms were improved for increasing the packet delivery ratio over the network. The physical layer protocol was modified by the author and for the reception rate and communication effectiveness of vehicular network was improved. This priority based work was applied on fully distributed environment. In [12], defined the probabilistic prediction method was improving the route efficiency and reliability for vehicular network. The single variation and vehicle utility analysis method was defined for weighted neighbor identification. The priority based method on multiple parameters was defined for improving the routing algorithm for vehicular network. The [13] presented a work on reliability aware and history analysis based opportunistic routing method for improving the communication reliability and routing for vehicular network. The packet forwarding method was improved by including the reliability, location and history aware features. The effective immediate link was identified with directional control analysis for improving the communication route in vehicular network. In [14] presented a work on load balanced routing for improving the network stability and life time for vehicular network. The infrastructure devices based network control method was defined for improving the network usage and load considerations. In Paper [15] provided a V2V based and RSU control method for handling the load conditions in vehicular network. The modified protocol was defined for improving the effectiveness of cooperative communication in vehicular network. In [16] proposed the cluster stability based routing method for improving the uplink connections in vehicular network and in [17-22] clustering algorithm for MANETs was discussed in terms of clustering overhead, stable cluster head, reduced cluster head changes and quality of services. The intelligent cluster formation method was defined by the author for improving the connectivity and reliability of the network.

III. RESEARCH METHODOLOGY

Vehicular network is the complex network in which high mobility energy node are defined a specific network scenario. The network suffers from the issues of reliable data communication because of complex scenario and congested situations. In this paper, an intelligent prioritization method is presented for optimizing the network traffic and communication. The proposed prioritization based vehicular communication model with work stages is shown in figure 3. The model has performed the level based prioritization. These levels cover the node, network and communication feature characterization for assigning the priorities. The proposed model is divided in two main stages. In the earlier stage, the network analysis is done along with node characterization. In this stage, the node type, its role and contribution in the network is identified. The critical nodes are assigned with higher priority. The medium priority is assigned to the healthy and light weight nodes. The heavy nodes and having the communication issues are assigned with least priority. Once the priorities are assigned, the decision on the selection of node in communication can be decided. The high priority nodes are never considered as an intermediate node while generating the route over the network. The prioritization adaptive routing method is integrated within the GPSR protocol so that the communication effectiveness of vehicular network will be improved. The route formation in the work is done while considering the load balancing issue. The reliable and safe communication is achieved in this work by performing the V2I and V2V communication.

Figure 3 shows the functional behavior of proposed prioritization based communication model. The function of the proposed model begins with generation of network scenario in real environment. The city scenario is considered for presenting the work. The network is setup with placement of road side units (RSUs). The characteristics of the infrastructure devices and vehicle nodes are set based on the scenario consideration. The node and device coverage parameters are defined. After characterizing the infrastructure devices in the scenario, the vehicle control and physical features specifications are done. The node coverage and connectivity with the associated RSU and its control is defined. The information stage on the RSU is also done in this stage. The feature that defines the role of vehicle includes vehicle type and speed. Rest of the evaluation is done by the RSU devices. In this stage, the traffic features of node and region is done. The coverage density, vehicle type and load related features are acquired. Now as the communication begins, the traffic analysis is performed for a session. The communication features are also evaluated in this session. The communication throughput, load and delay features are evaluated for the communication session. Based on these features, the priority of nodes is assigned. This prioritization rule is integrated within the GPSR protocol for effective path generation. The vehicle nodes with high priority are not included in the path formation and the vehicle nodes with low or medium priority are selected under the rule. Once the route is generated the V2V and V2I communication is performed over the network.

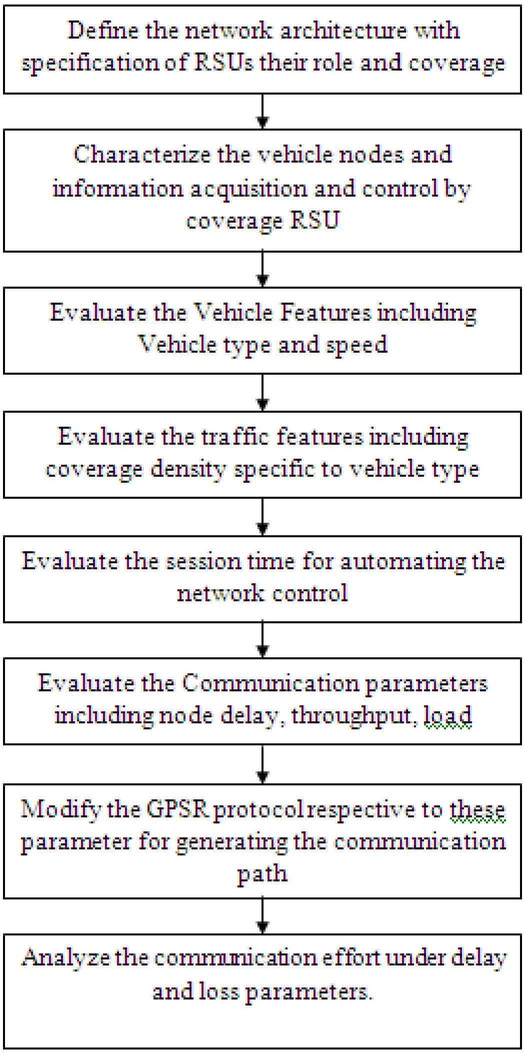

Fig. 3 : Work flow of Proposed Prioritization based Communication Model

The algorithm for priority adaptive route formation is shown in Table 1. The algorithm is defined to generate the route between two vehicle nodes. The coverage region of these vehicle nodes can be different. The algorithm is defined on the prioritized vehicle nodes. The work is defined as an improvement over the existing GPSR protocol. As the source and destination vehicle nodes can exist in coverage of different RSUs, the V2I based communication route can be generated. The load, fault are considered int his work for effective route formation. The algorithm shows the identification of intermediate node. The neighbors are identified for the current node. Only the low priority nodes can be used as intermediate node. If there are more than one such node, then the load and error based consideration can be done for effective neighbor consideration. This effective and low priority node will be considered as next hop. This process will be repeated till the destination node will not occur. Once the route will be generated, the communication is performed over the route. The analytical evaluation is done in terms of packet communication, communication loss and delay parameters. This improved protocol is simulated in NS2 environment. The comparative results against the existing GPSR protocol are provided and discussed in the next section.

Table I: Route formation on Prioritized Vehicle Nodes

```
Algorithm(Nodes, Src, Dst)
/*Nodes is the list of prioritized vehicle nodes in the network, Src is the source node and Dst is the destination node*/
{
    1.  Set Cur=Src
        [Cur as the current vehicle node]
    2.  While Cur<>Dst            /*Repeat the process till the destination node will not appear*/
        {
    3.  Neighbors=GetNeighbors(Cur)   /*Get the neighbors under coverage specification*/
    4.  ENeigh=GetEffective(Neighbors, Low)
        /*Identify the low priority nodes in the coverage, as such nodes are best suitable to set as intermediate nodes*/
    5.  If (ENeigh.Count=0)
        /*If no neighbor node is identified*/
        {
    6.  ENeigh=GetEffective(Neighbors, Medium)
        /*Identify the Medium priority nodes in the coverage as the next effective choice as intermediate nodes*/
        }
    7.  . If (ENeigh.Count=0)
        /*If no such neighbor node is identified*/
        {
    8.  ENeigh=GetEffective(Neighbors, High)
        /*Identify the High priority nodes in the coverage as the next effective choice as intermediate nodes*/
        }
    9.  If (ENeigh.Count=0)
        /*If no neighbor node is identified*/
        {
    10. Print "Route not possible"
        }
    11. For i=1 to ENeigh.Lengh
        /*Process all the neighbors*/
        {
    12. [load, loss, delay)=GetStatistics(ENeigh,RSU)
        /*Get the Communication statistics for each neighbor*/
        }
    13. Enode=GetPriorityNeighbor(ENeighs,Load, Loss, Delay)
        /*Identify the effective neighbor with lesser load, delay and loss*/
    14. Set Cur=Enode             /*The next effective intermediate node is identified*/
        }
    15. Return Route
}
```

IV. RESULTS AND DISCUSSION

In this work, the vehicle node prioritization based vehicular network optimization method is presented. The proposed communication and routing model is integrated in GPSR protocol. The proposed model is simulated in NS2 environment. The city scenario is defined with placement of infrastructure controller devices. The network is defined with different kind of vehicles at the varying vehicle speed. The scenario parameters for this simulation are shown in Table 2. The network is defined for a larger network region with specification of roadside units. The network is defined for city scenario with 2 lane communication. The V2V and V2I communication is possible in the network.

Table II: Network Scenario

Parameters	Values
Number of Vehicles	40
Number of Road Side Units	4

Infrastructure Devices	4
Scenario Type	City Scenario
Simulation Time	100 Sec
Packet Size	512
MAC Protocol	802.11
Routing Protocol	GPSR
Packet Size	512 bytes
Channel	Wireless Physical
Network Area	990x990 mtr
Energy Adaptive	Yes
Number of Lanes	2
Communication type	V2V and V2I
Traffic Light	Yes
Vehicle type	Hybrid
Mobility	Varying
Antenna	Omi Antenna

The proposed prioritization method is integrated within the existing GPSR protocol. The functional behavior of GPSR protocol is already defined in section I. The existing and improved protocols are simulated in the network scenario defined in Table 2. The simulation results are computed in terms of packet communication, packet loss, throughput and PDR ratio analysis. The comparative results of the work are provided in the form of graphs. Figure 4 is showing the comparative analysis of proposed and existing GPSR protocols in terms of packet communication. The analysis results are provided in terms of line graph. In this figure, x axis represents simulation time and y axis shows the packet communication in the network. The blue line is showing the result for proposed GPSR protocol. The line graph shows that the number of packets communication over the network in case of proposed work is higher than existing GPSR protocol.

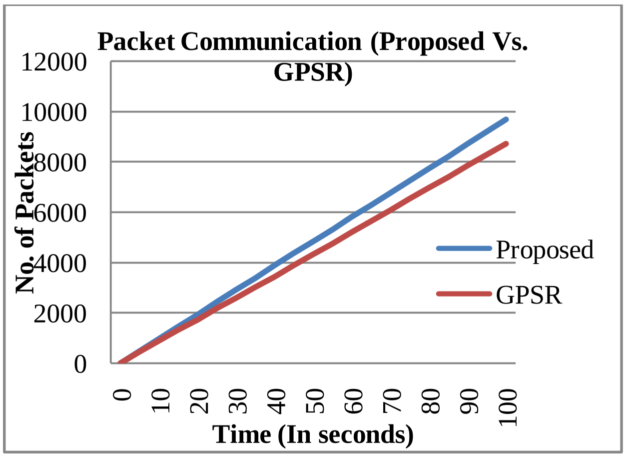

Fig. 4 : Packet Communication Analysis (Proposed Vs. GPSR)

Another analysis provided in this research work is in term of packet loss parameter. Figure 5 is showing the comparative analysis of the proposed work in terms of packet loss occur over the network. The leser the packet loss more effective the protocol is considered. In this figure x axis shows the simulation time and y axis represents the packet loss. The line graph clearly shows that the number of packets lost in case of proposed protocol is much lower than existing protocol. The lesser loss for proposed work shows the higher reliability is achieved.

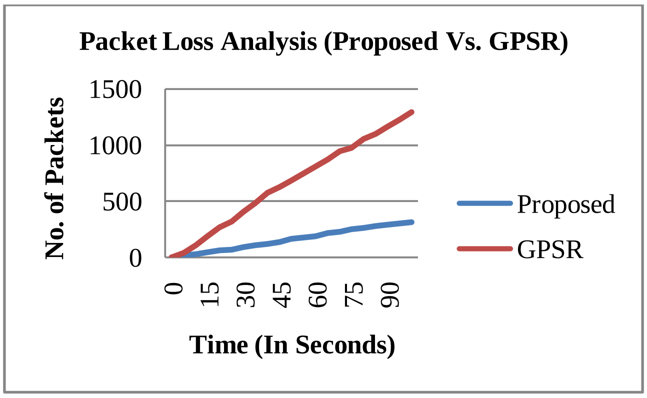

Fig. 5: Packet Loss Analysis (Proposed Vs. GPSR)

The communication effectiveness of the proposed prioritization based protocol is done in terms of throughput parameter. The throughput ratio based comparative analysis is shown in figure 5 in the form of bar graph. The figure 6 shows that the throughput achieved for proposed protocol is over 96% whereas in case of existing GPSR protocol the throughput is upto 87%. It shows a significant improvement of 9% is achieved from the work. The communication effectiveness of the proposed protocol is improved.

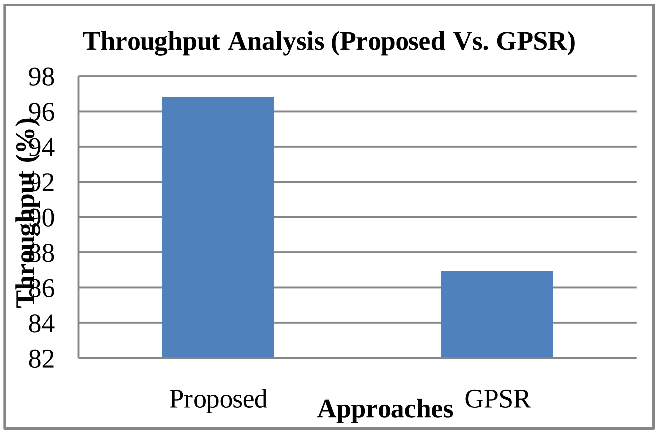

Fig. 6: Throughput Analysis (Proposed Vs. GPSR)

The packet delivery ratio (PDR) is another factor considered in this work for computing the effectiveness of proposed protocol shown in figure 7. The number of packets successfully delivered is identified by this parameter. The PDR ratio obtained fo proposed protocol is about 98% whereas the PDR ratio for existing protocol is 88%. It shows the significant gain is achieved for the proposed protocol.

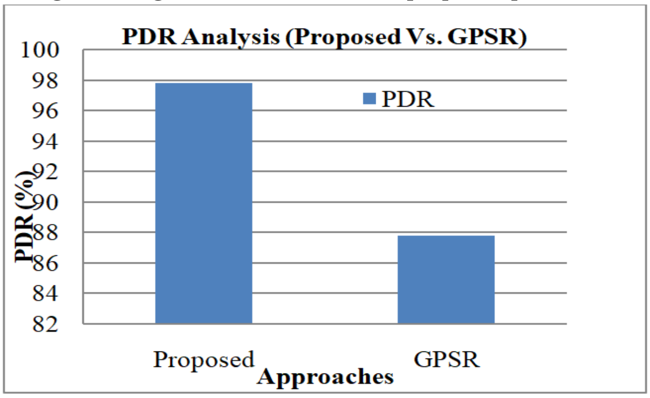

Fig. 7: PDR Analysis (Proposed Vs. GPSR)

The packet loss ratio based comparative analysis is shown in Figure 8. The figure shows that the packet loss ratio for the proposed protocol is 3% whereas the packet loss ratio for existing protocol is 13%. It shows the proposed protocol reduced the communication loss effectively and overall reliability of the proposed protocol is improved.

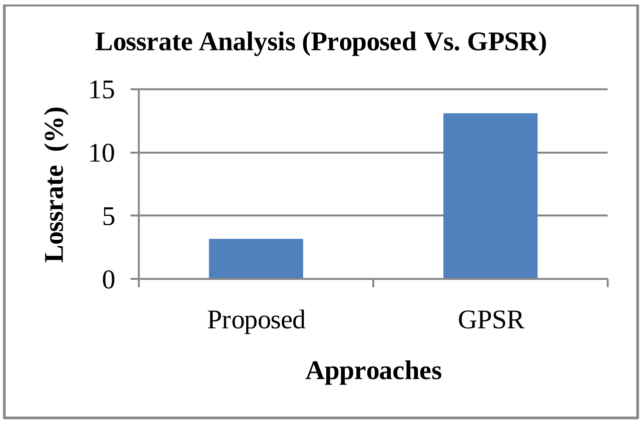

Fig. 8: Loss rate Analysis (Proposed Vs. GPSR)

V. CONCLUSION

In this paper, a prioritization based method is defined for effective V2V and V2I communication in vehicular network. The work is defined as an improvement to the existing GPSR protocol. The proposed work is divided in two main stages. In first stage, the vehicle, node and communication traffic based analysis is performed for assigning the priorities to the vehicle nodes. Once the priorities are assigned, the rules are defined for effective route generation. The proposed protocol is simulated in NS2 environment and comparative results are generated against the GPSR protocol. The comparative results show that the packet communication and throughput is improved and packet loss is reduced significantly in this proposed protocol.

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