ABSTRACT

Vehicular Ad Hoc Network (VANET) is a wireless network designed to provide safety, comfort, and other information needed by the drivers. VANET is an emerging technology with many innovative ideas to handle the vehicle traffic and road safety efficiently. Some of the key components governing VANET are Vehicle nodes, Smart Infotainment Devices, Global Positioning System, sensors, Road Side Units, and transceivers. IEEE 802.11p is the specific standard administering the vehicular communication systems in an intelligent manner, which is also called as Wireless Access in Vehicular Environments (WAVE) that potentially covers two modes of communication: Vehicle to Vehicle (V-V) and Vehicle to Infrastructure (V-I). One of the major issues with the VANET technology is the control of transmission data rate in the highly mobile and dynamic vehicular communication systems. Rate control algorithm or rate adaptation techniques provide adequate transmission data rate by assessing the channel conditions. This plays an important role in IEEE 802.11 wireless network and is widely used for static residential and enterprise network scenarios. Rate control algorithm assesses the channel condition to adjust the data transmission rate.

Rate control algorithms are based on two factors namely Signal to Noise Ratio (SNR) and statistical count. Some of the SNR based rate control algorithms are Receiver Based Auto Rate (RBAR), Opportunistic Auto Rate Media Access Protocol (OAR), and Rate Adaptive Framing (RAF). The rate control algorithms used in this research are based on statistical count. Auto Rate Fallback (ARF), Adaptive Auto Rate Fallback (AARF), Onoe, and Minstrel rate control algorithms are used and they are

active on Wi-Fi real time devices. The SNR calculation is infeasible in highly changing VANET environment, so the statistical count based rate control algorithms are preferred for VANETs.

The ARF rate control algorithm starts its transmission by lowest data rate through sender and triggers a timer. The sender increases its old data rate to new data rate once the sender succeeds in consecutive transmission of data for a constant threshold. If the new rate transmission fails due to loss of data or the timer expires suddenly after the increase in data rate, then the sender return or fall back to the old data rate. If the sender fails twice, then the data rate is decreased in ARF rate control algorithm.

In ARF rate control algorithm, the threshold constant is not adjusted by the rate whereas in AARF rate control algorithm, the threshold is adjusted. The old data rate increases into new data rate by a sender after N consecutive successful transmissions. The threshold increases or doubles into 2N, and if the transmission is not successful in new data rate, the sender falls back into old rate. The AARF rate control algorithm increases the time interval between rate changes over a stable channel and gives fewer fluctuations in rate compared to ARF rate control algorithm.

Onoe rate control algorithm associates the number of credits to the current transmission rate. It also finds best data rate with a loss ratio of not up to 10%. The data rate is adjusted by Onoe rate control algorithm at the end of each 1000 ms cycle depending on the collected transmission statistics.

Minstrel rate control algorithm adapts the data rate based on statistical table and the results of the sampling rate. Sampling rate that produced the best throughput and successful packet transmission rate is used for data transmission for the next packet transmission. The minstrel algorithm consists of retry chain mechanism, rate decision process, and statistic calculation.

Routing protocols employing Ad hoc On-Demand Distance Vector (AODV), Destination Sequence Distance Vector (DSDV), and Optimized Link State Routing (OLSR) that determine optimal communication paths between network nodes are used in this research.

AODV routing protocol creates routes to a destination on-demand basis and facilitates both unicast and multicast routing. The main feature of AODV is that, it does not provide additional space for unwanted traffic as the route is optimized based on the requirements of the nodes. This will further enhance the flexibility of the nodes as they can enter or leave the network based on their obligation. AODV also provides optimized network bandwidth and reduces excessive memory requirements and route redundancy.

DSDV is a table driven or proactive routing protocol that uses Bellman–Ford algorithm for path calculation. It uses hop count as a cost metric and it requires each node to periodically broadcast routing updates. Each node in the network will have entries such as destination node, sequence number, and number of hops required to reach them. Each DSDV node maintains two routing table, one for forwarding packets and another for broadcasting the incremented routing packets.

OLSR is a proactive routing protocol that uses an optimized link state algorithm designed by using the classical link state algorithm. The main concept used in this algorithm is MultiPoint Relay (MPR). The broadcast messages are forwarded by MPRs through the flooding process. Duplicate transmission and reception are eliminated by MPR flooding. The link state information is maintained only by MPRs which reduces the overhead. The link state information is shared only between the selected MPRs.

There are basically three categories of propagation models namely, abstract propagation loss model, deterministic path loss model, and stochastic fading model. Abstract propagation loss models do not represent the loss in real time propagation. In the deterministic path loss model, the loss takes place over the distance from the sender to the receiver. A stochastic fading model is applied on top of a path loss model in order to determine the non-deterministic consequences caused by moving objects.

Friis, two ray ground, and log distance propagation loss models are investigated in this research. Friis model is used to analyze the effect of propagation loss in free space. Two Ray Ground model is used to predict the reflection loss between the sender and the receiver. Log distance model is used to predict the path loss in dense environments. Stochastic Fading models are also equally important for the performance analysis and the design of VANET as it helps to include the changes in the signal transmission due to the presence of obstacles in the real time environment that affect the signal transmission. Nakagami-m fast fading model is studied and tested for the variations in signal strength due to multipath fading.

The objective of this research is to improve the performance of VANET by proposing hybrid methodologies and to identify the best combination of rate control algorithm and routing protocol based on the performance metrics such as Average Routing Goodput (*ARG*), MacPhyOverhead (*MPO*), and Packet Delivery Ratio (*PDR*). The best performing combination of rate control algorithm and routing protocol is

tested with propagation loss models such as Friis, log distance, two ray ground model, and Nakagami-m fading model.

The rate control algorithms such as ARF, AARF, Onoe, and minstrel are combined with AODV, DSDV, and OLSR routing protocols respectively. The performance is analysed for different densities of the vehicles for the real-time scenario in VANET. Real time scenario is selected from Google map and the vehicle traffic is generated using Simulation of Urban MObility (SUMO). Network Simulator version 3 (ns-3) is used for deploying the proposed methodology with the vehicle node densities of 20, 30, 50, and 100. The simulation results show that minstrel rate control algorithm with DSDV routing protocol performs better when compared with other combinations. Finally, the best selected combination of minstrel-DSDV is tested with propagation loss models such as Friis, log distance, two ray ground model, and Nakagami-m fading model for different densities of the vehicles. The results prove that two ray ground model with Minstrel-DSDV performs better than other two propagation loss models.