A Novel Krushkal's Algorithm Approach to Ensure Quality of Service Enabled Data Dissemination in Hierarchical Vehicular Ad-Hoc Network

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Abstract— Vehicular ad Hoc Networks (VANETs) is a collection of vehicular nodes that perform as a mobile hosts form a temporary network without aid of any centralized infrastructure, so it is a sub class of ad hoc network. Most of the VANET applications are delay sensitive application. Hence, guarantying the Quality of Service (QoS) plays a significant role in VANET application. The routing protocols obtainable for MANET can also be applied to VANET but they do not work out better under the dynamic scenario of VANETs like fast mobility and frequent link disconnections in the network. Research has reveals that Hierarchical routing schemes has numerous benefits over the traditional ones. Stable cluster formation and maintenance with guarantying QoS in intra cluster communications has always remained as a great challenge. Thus, this paper proposes a QoS Enabled Data Dissemination using Kruskal's algorithm to provide efficient data dissemination and quality of service in Hierarchical VANET. This approach constructs the minimum spanning trees using Kruskal's algorithm in every road segment, where the vehicle has been clustered by considering the intra-cluster QoS. It is the responsibility of the cluster head present in spanning tree to collect the data from the leaf nodes and distributing the data to other coordinator nodes and vice versa. The simulation results show that the proposed approach performs better than the existing routing approach in terms of delay, throughput, and packet loss. ***(Abstract)***

Keywords - VANET, Kruskal's Algorithm, QoS, minimum spanning tree, coordinator nodes, mobility models, routing

I. INTRODUCTION

Nowadays, the interest rates towards the Vehicular Ad hoc Network (VANET) has been trending up in the research communities because it has been characterized as very active area of research and development. VANET characterizes a special type of mobile ad hoc network. The communication has been enabled among the vehicles through Inter-Vehicle Communication and between the vehicles and the road side unit [15]. It is a distributed ad hoc network described by high mobility of vehicles, great speed difference of vehicles and limited freedom on the mobility patterns. This circumstance results in rapid change of network topology. Road safety, multimedia, infotainment, and intelligent transportation are some of services supported by VANET. Certain services are crucial such as collision warning, accidents; other services such as multimedia require bandwidth. Provisioning of QoS is difficult in VANET's because of their frequent disconnection in their routing path [1].

Most of the routing protocols proposed for MANET are also tried for VANET such as Ad hoc On-demand Distance vector (AODV), Destination Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR). However, the VANET can be differentiating from MANET by dynamic topology changes because of high mobility of the vehicles. Likewise, studies relied upon simulations that have been performed to access the performance of the routing protocols in VANET under different traffic situations proved that several MANET routing protocols performance is poor in terms of bandwidth and route convergence.

Moreover, due to rapid change of VANET topology, to keep the communication between the vehicles all nodes must transmit the broadcast packets periodically that results network congestion and it leads to bad assurance in the QoS. The research on the concern of network connectivity with scalability, it has been shown that the clustering scheme is a feasible solution to these issues [3]. But the traditional clustering schemes used in VANET lacks in supporting QoS and create it challenge to attain the stable network.

Thus, this paper proposes a QoS Enabled Data Dissemination using Kruskal's algorithm to provide efficient data dissemination (QoS-EDDKA) and quality of service in VANET. This approach constructs the clusters aid of minimum spanning trees in every road segments by considering the intra cluster QoS. Each spanning tree will have a cluster head that is responsible to collects or disseminates the data from the leaf nodes and to other coordinator nodes and vice versa.

The rest of the paper is organized as follows: section II describes the recent related works. The proposed algorithm has been given in the section III & IV with detailed description. The mobility model and the simulation results have been discussed in the section V. Finally, section VI renders the conclusion.

II. RELATED WORK

QoS routing scheme motivated by bee communication has been proposed in [4] to enhance the throughput and minimize the packet loss in VANET. The concept of mobile agent is taken from the mobility manner of the bees for exchanging the traffic information among the vehicles targeting for quality support data transmission. This is attained by computing the respective QoS provision values relied upon specific QoS metrics threshold to find a feasible route between the source and destination.

An Intersection relied routing with guarantying the QoS in VANET (IRQV) [16]. The IRQV composed of three procedures relied upon the Ant Colony Optimization (ACO), i) terminal intersection choice method, ii) method for network exploration, i.e., applied utilizing the QoS of road segment in local and endwise intersection in global, and iii) feasible route selection method. While forwarding session of data packet has been initiated, this scheme selects the feasible next intersection dynamically to transmit the data between the nearby intersections.

Furthermore, the mathematical models for both transmission delay and connectivity has been presented for a 2-lane road segment situations to compute the local QoS. The Multiprotocol Label Switching (MPLS) has been adopted as a forwarding technique in [6] that can be well-suited with the layer 2 technology has been utilized in road side backbone network to enhance the QoS.

Intersection-based Geographical Routing Protocol (IGRP) has been proposed in [7] for city environment based VANET. IGRP chooses feasible road section that guaranties the QoS with great probability, network connectivity. The geographical forwarding has been used to transmit the data packets between the intersections on the route, minimizing the sensitivity of the path to every movements of node. The genetic algorithm has been used further to solve the issue of optimization.

In [8], the authors compare the routing protocols in a self-organizing infrastructure as accessibility of infrastructure is not pervasive. The IEEE 802.11p standard is used to perform the intensive simulation in the existence of realistic propagation model. And the behaviors have been studied in terms of QoS[ ] factors such as load, delay, packet delivery ratio and throughput. In [9], the author introduces geographical QoS routing that offers optimal routes between the source and destination pairs. The cluster based scheme [18] has been adopted to improve the performance of this protocol.
In [10], the authors proposed a location based clustering approach, where the road has been partitioned in to numerous cells with containing an anchor point in each cell. In the cells, the vehicle nearest to the anchor points has been elected as the CHs. In [17], the author presents a distributed algorithm to build a spanning tree relied upon the Dynamicity Aware Graph relabeling that creates an extreme spanning tree so as to minimize the rebroadcast number and time of data dissemination. The neural adaptive resonance network algorithm [2] can be used to achieve improvised clusters. In case of both biological and artificial neural systems [14], since time delays due to amalgamation and communication are everywhere and frequently become a source of instability neural networks can be used for problem solving. In the field of artificial intelligence [5] new paradigms have been developed in which neuro-fuzzy systems [11] have an excellent learning capacity and an ability to represent human thought and robustness.

A cluster on demand minimum spanning tree with prims algorithm has been proposed in [12] for VANET. In this approach the vehicles has been clustered by accounting the intra-cluster QoS. An extended Kruskal algorithm has been proposed in [13] to support QoS. This approach construct the multi cast trees and consist of unique characteristics composed of a superior management of Kruskal's priority queues and in the facility of edge priority collection.

III. SYSTEM MODEL

The proposed system model consists of n number of vehicles, Road Side Unit (RSU). Each vehicle is fitted out with the On-Board Unit (OBU). The OBU is comprises of sensors, memory storage and processing unit. Every vehicle can communicate with other vehicles and also with RSU using OBU. The vehicles are aware of their location information with GPS positioning system. A communication link between the nodes will be exist if they present in their communication range The vehicles present with in the radius of the intersection point are not allowed to form the clusters. Figure 1 shows the clustered based VANET with the proposed technique. The vehicles which are away from that region can form and join the clusters. It has been assumed that if the road contains any of the Road side unit then it will act as the cluster head for that region.

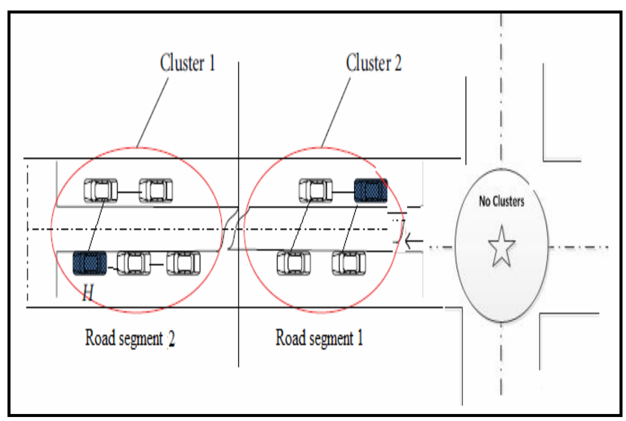

Figure 1Clustered based VANET

The number of clusters can be formed on a road segment can be determined as follows

$$\text{No of clusters} = \frac{(1-3xTR)}{3xTR} \quad (1)$$

Here l is the length of the road segment measured in meters; TR is the Inter-cluster communication range of the nodes. According to this the Road has been segmented and the cluster head has been selected in each segmented road. Figure 2 shows the segmentation of road in the proposed approach. The clusters will be formed for the nodes which are travelling on the same direction.

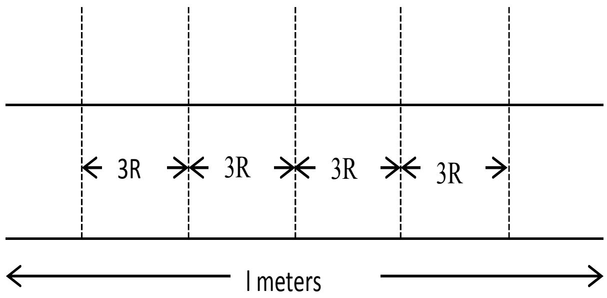

Figure 2 Segmentation of road

IV. QOS ENABLED DATA DISSEMINATION USING KRUSKAL'S ALGORITHM

In QoS-EDDKA, the vehicles present in a particular road segment are required to compute the probability density function (PDF) with respect to the node stability ratio. The node stability has been computed based on the Time to Live (TTL) and the acceleration of the vehicle. The moving vehicle calculates the TTL i.e., the remaining time to cross the road segment and it has been computed as follows

$$TTL = \frac{D_n - rs}{S} \quad (2)$$

Where D is the distance between the node and the road segment, S is the speed of the node

The stability of the nod e can be given as follows

$$NS = \frac{TTL}{\alpha} \quad (3)$$

The probability density function (pdf) has been calculated for every node relied upon the NS value.

$$Pdf = \frac{1}{\sigma\sqrt{2\pi}} e\left(-\frac{1}{2}\right)\left[\frac{S-\mu}{\sigma}\right]^2 \quad (4)$$

Here μ is the mean of the NS value gotten from the nodes in the road segment, σ is the standard deviation valued to the particular mean. The node with the highest pdf will be elected as the cluster head. The node with next highest pdf will be termed as vice CH, whenever the CH moves away from that region at great mobility, the vice CH will take that place. For the remaining node in the road segment, a weight will be allocated between the links based on the node stability and the signal interference ratio. The node stability between the nodes can be calculated using the equation 3 but the distance is between the node i and node j.

The signal to interference ratio between a node i and node j can be given as follows

$$y_{i,j} = \frac{pt_{i,j}}{\sum_{K=1}^{N} pr_{j,k}} \quad (5)$$

Here, N is the number of channels available between the node I and node j, p_{tx} is the transmitted power between the two nodes i and j. $Pr_{j,k}$ is the measured received power at the node j on the channel k. The weight for each link based on NS and can be given as follows

$$W_{i\to j} = \alpha \text{ x } NS_{i,j} + \beta \text{ x } Y_{i,j} \quad (6)$$

Using Kruskal minimum spanning tree algorithm, a list of vehicles has been chosen to form a cluster with great connectivity. The minimum spanning tree clustering algorithm has been widely adopted in practice. The issue of determining a minimum spanning tree for a connected network was initially solved by Kruskal algorithm. After that the Prims algorithm and Dijikstra algorithm suggested algorithm for MST problem. Until now every problem correlated with spanning trees are solved utilizing either Dijkstra's or Prims algorithm. Meanwhile, the recent research suggests that the appropriate use of Kruskal's algorithm is more effective in terms of computation in a number of cases, while in the sparse network. The Kruskal's algorithm constructs the feasible spanning tree from non-empty set by adding a single link at every time.

Initially, in the proposed approach, the links are sorted in the increasing order of their weights. The algorithm determines minimum spanning tree with the connected weighted graph with a function

a. Begin with every vertex being its particular component

b. Merge two components repeatedly into one by selecting the minimum edge connecting them

c. A set of edges has been scanned monotonically ascending order by weight

d. Find if an edge connects vertices in various components by using the disjoint-set data structure

Let consider a graph G composed of moving vehicles in a road segment here v is the vertices i.e the total number of vehicles present in the road segment and travelling in a same direction. Therefore the number of edges is $e = v - 1$. W is the weight associated for each link. The minimum spanning tree must be generated for the cluster formation which satisfies the desired QoS. Delay from the source to receiver in a real time situation is the essential QoS metric considered during the evaluation of the routing protocols. So the average queuing delay has been considered as a QoS parameter that has to be satisfied by the Minimum spanning tree. The average queuing delay QD between the none i and node j can be computed as follows

$$QD_i = \alpha\, QD_{j-1} + (1-\alpha) QD_j \quad (7)$$

$$\alpha = \frac{\text{size of the queue} - \text{length of the queue}}{\text{size of the queue}} \quad (8)$$

Where size of the queue is the present size of queue at node i, length of the queue is the queue length between the node i and j. The algorithm for the cluster formation with Kruskal's algorithm has been given in the algorithm1.

Algorithm 1 Hierarchical VANET MST graph using Kruskal's algorithm

1.	**Input: graph G for the vehicles present in a road segment**
2.	**Output: Cluster graph T**
3.	**For every vertex v in V[G]**
4.	**Label set** $S(v) \leftarrow \{v\}$
5.	**End for**
6.	**Set a priority Queue Q which composed of all the edges of G, aid of the weights**
7.	**B←{}// B is the MST starting with empty set**
8.	**While B< n-1 edges**
9.	**Set S(v) comprises v and S(u) comprises u**
10.	**If** $S(v) \neq S(u)$
11.	**Add edge (u,v) to B if it satisfies the QoS**
12.	$S(v) \cup S(u)$ **in to one set**
13.	**End while**
14.	**Return B**

V. SIMULATION AND RESULTS

A. Simulation

In this paper, a setup has been made for a situation of transmitting video data over a 4 km road with two or more lanes produced by VanetMobiSim. Vehicles are distributed randomly by means of linear node density. The traffic environments have been made for distributed traffic situation randomly. The NS2 simulation has been used to evaluate the video quality disseminated under the three various routing protocols such as QoS-EDDKA, Cluster demand MST prims with prims algorithm (CDMST-prims), location based clustering algorithm (LCA).

The Revival Mobility model (RMM) has been used to simulate the mobility pattern of the vehicles on roads defined by Google maps from the vehicles equipped with GPS. Two or more lanes have been comprised in the Revival Mobility model (RMM). Every vehicle can travel in altered speed. This mobility model permits the drive of vehicles in both directions. i.e. north or south (vertical roads) and east or west (horizontal roads). A minimum distance has been maintained between two consequent vehicles in a lane. Table 1 shows the simulation parameter to evaluate the routing protocols. The performance metrics such as delay, throughput, and packet loss has been used to evaluate the performance.

Table 1 Simulation Parameters

Parameter	Value
Simulator	NS2.2.28
Simulation Area	1200-1200 meters
Number of vehicles	30-120
Average vehicle speed	0-25m/s
Communication range	300m
Packet size	1024 bytes
MAC Protocol	802.11 DCF
Bandwidth	6Mbps
Video file	Foreman.yuv

- **Performance metrics**

Delay

Delay is the time duration taken by the data packet to reach the destination. It includes the waiting time of the packet in queue, propagation delay and processing delay

$$\text{Delay} = \text{Queuing Delay} + \text{Processing Delay} + \text{Propagation} \quad (9)$$

Throughput

Throughput is the data rate where a network can transmits or receives data. It is a measure of the capacity of the channel exist in the communication link and links to the internet are generally valued in terms of how much number of bits flow per second (bits/s)

$$\text{Throughput} = \frac{\text{Number of frame transmitted}}{\text{Time Interval (bps)}} \quad (10)$$

Packet Loss Rate

$$\text{Loss rate} = \frac{\text{Total number of dropped packets}}{\text{Total number of sent packets}} \quad (11)$$

The loss rate is the ratio between the total amounts of packet loss by the total amount of input data traffic over a particular time period.

B. Discussion

The foreman.yuv video file has been used in the test, where it contains 200 frames, that the average PSNR is 35.89. Figure 2 shows the delay with respect to number of frames. The speed of the vehicle has been changed and the video quality transmitted under various routing protocols. Figure 3 shows the average end to end delay with respect to number of frames.

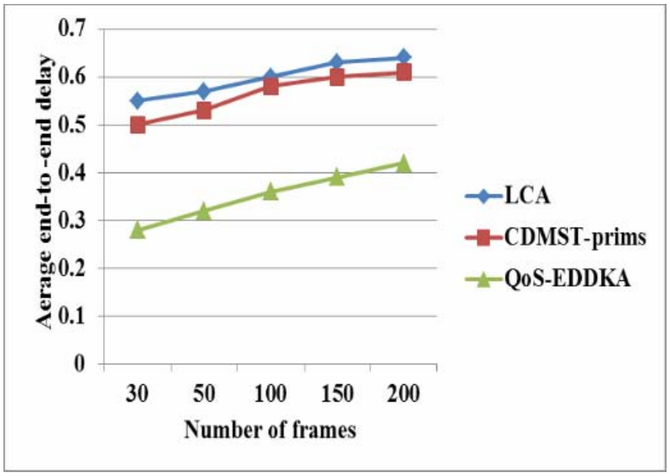

Figure 3 Delay with respect to number of frames

As the frame size increases, the average end to end delay has been increasing gradually. In the proposed QoS-EDDKA, the cluster will be formed by considering the average queuing delay constraint, where it can minimize the delay of the packet to reach the destination.

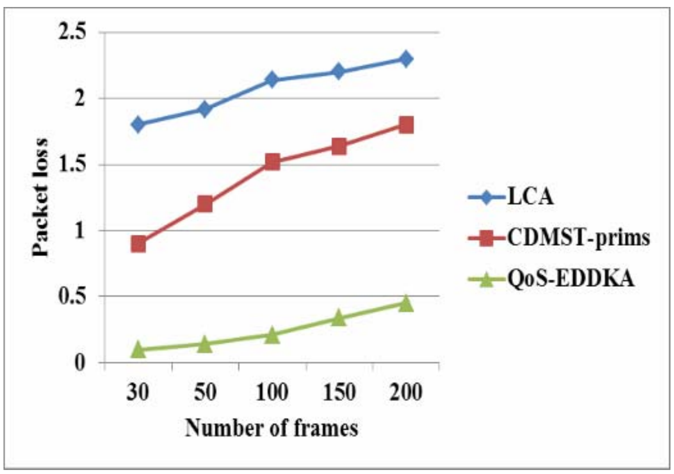

Figure 4 Packet losses with respect to number of frames

The QoS-EDDKA incurs 0.42 s of average delay for delivering 200 frames, while CDMST-prims, LCA incur 0.64 s, 0.61 s respectively.Figure 4 shows the packet loss with respect to number of frames. When the frame size increases, the capacity of the network may be overloaded that leads to congestion in the network. During congestion, the packet can be loss at the network. Since the weight metric considered the SIR, node stability in the proposed QoS-EDDKA and additionally the delay metric for assure the QoS gives stable clusters with high connectivity.

The QoS-EDDKA acquires the packet loss of 0.45 for 200 frames, while the CDMST-prims, LCA acquires the packet loss of 1.8, 2.3 respectively.

The average throughput for the network with respect to number of frames has been shown in figure 5. The throughput has been increases when the frame size increases. With 200 frames, the throughput attained by the QoS-EDDKA is 1.43×10^3 kbps, while the CDMST-prims, LCA attain 0.86×10^3 kbps, 0.74×10^3 kbps respectively.

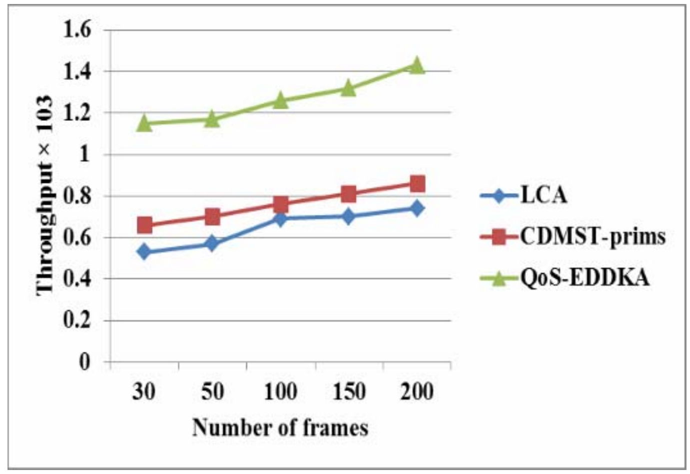

Figure 5 Throughput with respect to number of frames

VI. CONCLUSION

This paper proposes QoS Enabled Data Dissemination using Kruskal's algorithm (QoS-EDDKA) for hierarchical VANET. The probability distribution function has been used to select the cluster heads by considering the node stability. The weight metric to constructs the spanning tree with Kruskal's algorithm considers the node stability and SIR metric which gives an efficient link for data transmission. The average queuing delay has been considered as the desired QoS. While constructing the cluster tree with Kruskal's algorithm, the link should satisfy the desired QoS then only the link will be added to the tree. The QoS-EDDKA constructs the clustered minimum spanning tree with great connectivity also with assured QoS. A real time Foreman.yuv video has been used to evaluate the performance of the proposed QoS-EDDKA. The simulation results show that the QoS-EDDKA performs better than the existing LCA and CDMST routing algorithm in terms of delay, packet loss, and throughput.

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