



Location-Based Hybrid Video Streaming Protocol for VANETs

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Abstract

The services and applications provided by video streaming over Vehicular Ad-hoc Networks (VANETs) have recently become very attractive to technology users. In VANETs, the moving vehicles on the roads take great advantage of this radio link by exchanging information with each other related to the safety, traffic jams, accidents, and condition of the roads via video streaming. On the other hand, this transmission domain poses many challenging issues like frequent disconnections due to fast-speed vehicles, longer transmission delays, and inefficient link consumption etc. numbers of routing strategies have been proposed in the literature that aimed to address these challenges of an Intelligent Transportation System (ITS). This article is based on a Location-Based Hybrid Video Streaming Protocol (LBHVSP) that has been proposed with the intent to minimize the challenges related to video transmission as well as the attainment of high network performance. The idea presented is a motivation from the dynamic nature of transceiver and receiver transmission power, accompanied by the range-based localization techniques for inter-space computation of vehicular nodes. LBHVSP is a 2-way protocol that works as a combination of infrastructure-based and infrastructure-less wireless networks that tends to minimize the average packet delay for efficient utilization of bandwidth. It is a two-phase solution, firstly frames are transmitted to the second hop node available in the direct range that minimizes the traveling path in terms of hop count and ultimately yields minimal delay. Secondly, this technique utilizes the Road Side Units (RSUs) having wired connectivity for a faraway destination. Experimental results using different transmission scenarios reveal its efficacy by attaining maximum average packet throughput, minimum average packet drop rate, and minimum average per-packet delay in Signal Transmission Power and Packet Reception Power Threshold values. The proposed scheme has outperformed the state-of-the-art transmission scenarios in terms of static parameters. Varying transmission and reception powers subject to the inter-distance have shown remarkable outcomes. In comparison to pre-existing VANET protocols like DyTE and DSR, proposed scheme has shown an average improvement of 30% in packet drop rate, and 80% rise in throughput, approximately. Besides, our scheme has shown a remarkable decline in transmission delay as well. On comparing the LBHVSP performance against recent VANET communication protocol, it comes out that it attains the maximum throughput and delay improvement. Furthermore, to cater the packet drop, a smart re-transmission strategy should be designed particularly for multimedia streaming and video message exchange.

Keywords VANETs · MANETs · RSUs · WSN · ITS · Throughput

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1 Introduction

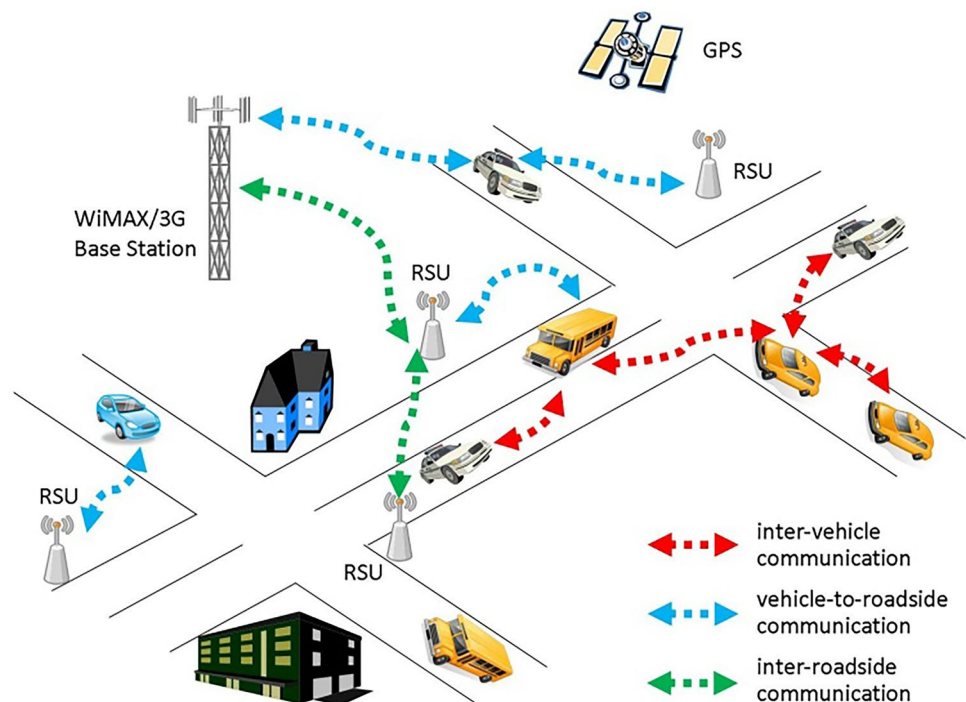
With the proliferation of digital devices and ease in an installment of radio links, internet connectivity has emerged as our basic necessity. Inter-networking has been visualized as the most probabilistic reality in all fields of life, no matter where you are and what you are supposed to do, it is always been well evident through various applications like ITS. ITS has emerged as an open-ended research area that efficiently addresses the challenging issues of the transport system. It is evident from recent surveys that traveling on the road is riskier and depicts an accident occurrence of 1 in 5000, as compared to air travel which exhibits an accident probability of 1 in 2 million. One of the major objectives of ITS is to provide safe driving.

In relevance to a network, ITS mainly consists of entities like vehicles (network nodes), RSUs, base stations, and infrastructure to facilitate the Global Positioning System (GPS), etc. VANETs are a subclass of the wireless networks technology i.e. Mobile Ad-hoc Networks (MANETs), where vehicles are equipped with On-Board-Units (OBUs) like GPS and Differential GPS (DGPS) receivers, the infrastructure for communication. These types of networks are characterized by moving vehicles (nodes) that are linked with each other probably in large networks to share information, like the exchange of messages among them as well as with other network infrastructural devices mounted on by roadside, named as Road-Side Units (RSUs). These categories of communication are

named as Vehicle-to-Vehicle (V2V) and Vehicle-to-RSU (V2R) communication, with the provisioning of various wireless technologies (Figure 1).

The nodes in these networks are specific to the patterns of the traffic and also to the roads. VANETs are considered the most important and efficient technology to provide numerous services in the transportation system. One of them is safety assurance since there is a broad range of applications in VANETs for which safety services are inevitable like Payment at the automated toll, management of the traffic on the roads, improved navigation system for the vehicle, and other location-based services like finding the nearby fuel station [1]. These services are implemented through recent telecommunication technologies like Cellular Ad-hoc Networks and (WSN) Wireless Sensor Networks, mainly used by the military for monitoring and security purposes as well as for remote sensing. Likewise, the support of the video streaming in the VANETs technology is used for effectiveness in a situation where emergency action is required i.e. when there is a car accident on the road that location can be seen. Another main advantage is in case of a collision when a driver may decide the routes by seeing the live video broadcasting of that specific accident area. For the estimation of the traffic conditions, drivers use the information gained from the live video streams of the streets and roads in that area, moreover, drivers may also decide the fastest way to their destinations. Likewise, vehicle tracking and entertainment applications also make use of video streaming to a major extent. But the caveat is that video streaming over VANET poses major challenges. Owing to massive video data and stringent

Fig.1 A Simple VANETs Scenario



on-time delivery requirements, video traffic greatly varies from general data sharing [2]. Likewise, other factors such as jitter and buffer control are also of utmost significance as they affect the Quality of Service (QoS) experience of the end-user. In VANET, the most challenging of all is to attain higher throughputs and delivery ratios, defined as the number of packets and/or frames received by destination nodes to the total number of unique packets/frames transmitted by the source node. However, the attainment of higher rates of delivery ratio in VANETs is a big question due to its rapidly changing topology, unguided transmission link, and frequently occurring disconnections. Besides, in the case of video data delivery ratio can be estimated for discrete packets or the whole video frames. So the loss of a network packet (containing video data) may result in the following consequences:

1. One packet drop event may lead to the contents loss of a whole video frame.
2. Sometimes, information in the data packet is used by the receiver to reconstruct multiple frames; thus, its loss prevents regenerating more than one frame.
3. In case a packet contains partial information of one frame, receivers could regenerate a lossy frame based upon other received packets. This proves a direct proportionate of packet loss to a frame loss and simply defines the quality of the received video. However, this relationship can be altered based on the distinguished significance of video frames affecting reconstructed video quality.

The loss of a data packet leads to a video frame loss, which ultimately defines the received video quality. This dependency can only be avoided by uneven treatment of packets containing information of distinguished importance that affects the quality of the video. Therefore, metrics e.g., PSNR, MOS, and MIV are used to estimate video quality by comparing frame fidelity to the original video. In addition to the delivery ratio, another challenging issue that is faced while experiencing video streaming in VANETs is the delay, measured as the latency between the transmission of the video and its reconstitution by the end user. This is attributed to the time to ensure the successful transmission of data through the network. However, various multimedia applications exhibit variable delay requirements; those storing video playback are delay-tolerant up to some extent (unless an excessive delay would lead to quality degradation perceived by the end-user). Besides, most of the VANETs applications are delay-sensitive means they demand real-time delivery of video content on the receiver side, which is characterized by the fact that end-to-end delays should not go beyond a few seconds [3]. And this becomes even more challenging for interactive multimedia applications

(e.g. video conferencing). Such services possess stringent delay requirements and cannot tolerate a delay of even a few hundred milliseconds. Although in the literature, some approaches might fulfill this low latency requirement but probably with a negative effect on reconstructed video quality. This change in the delay is measured by a metric, called jitter. However, it can be satisfied by opting for certain simpler methods like buffering.

Besides delay and packet loss events, an estimate of bandwidth consumption is a prime performance metric for video streaming applications. Video data is massive and requires higher data rates for exchange that ultimately consumes a major part of network resources generally. Therefore the solution to this problem needs to be attributed to scalability, concurrency, and resource management skills for the rest of the network nodes up to a major possible extent. On the other hand, since VANET supports wireless communication of nodes so issues like security are major concerns. Factors like abruptly changing speed and position of the vehicles, network topology, or vehicular inter-distance make routing entirely different in VANETs as it is in traditional networking [4], for instance, compared to unicast and multicast networks where the end nodes are identified by IDs or group IDs (IP addresses), VANET safety driving applications addresses entire geographical areas where packets require to be forwarded. Due to the frequently varying topology of VANET and moving vehicles, the connection between the vehicles exists only for a few seconds. And if vehicles on the roads move in an opposite direction, and then the connection between them is reduced only for a few microseconds. Therefore, proper communication is not possible in this connection. Other factors include the time-varying density of traffic which may be area-specific (e.g. urban or rural) and stringent QoS requirements of various security and real-time applications. Consequently, the provisioning of QoS support for such applications remains a great challenge.

Video transmission has been categorized as static and interactive video, the former is about the real-time transmission of contents (of a stored video e.g. TV shows or some live event e.g. traffic conditions) from one sender to one or multiple receivers. Whereas later consists of two or more streams of a video influencing each other; video conferencing is the best example where various users are in communication through a live video. Various studies have been conducted to explore network requirements of real-time video transmission applications, as in [5], a reliable guideline to define minimum requirements has been presented where these values may vary with different video coding techniques used. (Table 1) enlists the requirements of both categories of video transmission applications (aforementioned). However, the focus of this article is video streaming applications and their QoS requirements (shown in Table 1), which can be incorporated in to the design of a transmission scheme to

Table 1 Requirements of Video Transmission [5]

Parameter	Video-Streaming	Interactive Video
Delivery Ratio	< 5%	< 1%
Delay	< 5 s	< 150 ms
Jitter	N/A	< 30 ms

overcome challenges such as ever changing VANETs' topology, common transmission medium, unstable traffic density, and frequently-occurring disconnection to successfully deliver packets carrying video data without experiencing any delay as well as optimally utilizing the available channel bandwidth.

In light of this discussion, VANETs should implement a smart video streaming strategy that can provide the required QoS as well as safety assurance to vehicles, besides addressing the challenges of frequent disconnections, higher packet losses and larger delays. Proposed streaming strategy has overcome the highlighted challenges of vehicular radio network through deploying the advanced telecommunication technologies. Since these latest technological improvement has provided great opportunities for researchers to study the problem in the existing infrastructure and proposed more suitable solutions in different applications of the VANETs domain. For the dissemination of video content in streaming, infrastructure requirement is not unique. It can be communicated through V2V which is infrastructure-less or through vehicle-to-RSU (V2R) which is based upon wireless infrastructure communication. Infrastructure-based communication is provisioned with cellular access points and gateways of WLAN whereas infrastructure-less setup is truly an ad-hoc arrangement of entities, surely equipped with wireless devices that communicate through the Dedicated Short Range Communication (DSRC) technique [6, 7]. In addition, sometimes a hybrid mechanism i.e. a mix of wireless infrastructure and short-range communication technique is used as well. Depending upon the application all three types of communication are important for the dissemination of road accident related warnings and applications, V2V communication is best and for other applications like advertisements and broadcasting the news, vehicle-to-infrastructure (V2I) communication is well suited [8]. For V2V and at times V2I communication, the DSRC technique of IEEE 802.11 p standard is used that facilitate nodal communication up to a designated range. DSRC is operational in a 30–75MHz spectrum in 5.9 GHz and 5.8 GHz frequency bands in different regions across the globe. It provides connectivity services for both V2V and V2I communication up to a range of 1km, supporting data rates of up to 27Mbps. In DSRC, the RSUs and vehicles on the road communicate using either IEEE 802.11p or Wireless Access in Vehicular

Environment (WAVE) standards. DSRC and WAVE mean the same technology; however, DSRC includes the specifications of standards like IEEE 802.11p and an amendment of 802.11a MAC and PHY whereas the WAVE standard focuses on the upper layers of the network stack. DSRC can use the WAVE Short Message Protocol (WSMP) to support V2V and V2I safety applications.

Nodes in the VANETs are vehicles, equipped with devices to establish wireless connectivity among different nodes like antennas to operate the DSRC technique. The proposed communication strategy is based on a motivation from the idea of inter-vehicular distance measurement using Received Signal Strength Indicator (RSSI) method [9]. It is a 2-phase range-based technique, where the first phase is based on radio link communication facilitated by OBU of the vehicles in ad-hoc wireless networks. This is followed when the destination node is within transmission range of the vehicular node. However, the second phase is followed when the source node computes the range and the destination node is not directly approachable, RSUs are used that are mounted on the roadside to locate the target node. As evident from the literature [10–13], transmission power is directly proportional to transmission range so it should be kept dynamic for various transmission scenarios. Transmission and reception powers are changed based on the distance the signal needs to travel to reach the destination. This combination of network and link layer greatly improves the average throughput and minimizes transmission delay and packet drop rate. The main objectives achieved in this research are:

1. To propose a video streaming strategy for VANETs while addressing the challenging issues involved in transmitting video content over audio link in a frequently changing topology of vehicular networks. To achieve this goal efficiently, a two-phase transmission protocol has been proposed, simulated, and assessed with various performance metrics of the VANETs.
2. This protocol exploits the concept of vehicular node location to estimate the destination nodes that are indirect range or to do packet forwarding through the fixed RSUs otherwise.
3. Besides, this is an implementation of the idea that to get reliable communication and lesser delay, it is necessary to keep the transmission power of the vehicular nodes dynamic which can be varied based on the local traffic density and topology change information. Results depict the promising outcomes to achieve low latency, higher throughputs, and reduced packet drop rates at lower data rates.

This article is structured as comprising of 7 sections that start from Sect. 1 about introduction of VANETs and their

challenging requirements as well as research objectives are defined. Section 2 presents a survey of existing routing and communication techniques in VANET, accompanying a comparative analysis with proposed communication model. Furthermore, Sect. 3 gives design and algorithm descriptions, followed by a brief discussion about research novelty in Sect. 4. Results discussion is covered in Sect. 5. Section 6 highlights the performance comparison of proposed VANET model with recent state-of-art techniques. Section 7 describes the conclusion and future directions planned for extension of this work.

2 Literature Survey

Many researchers have worked on various challenges posed by VANETs; consequently, various informative surveys have come up to enlighten the basics of this domain [14]. Owing to the distinguished infrastructure of MANETs, protocols governing the routing tasks of legacy networks are not suitable for them. Many research studies have focused on MANET routing protocols, mainly consolidated into four variations as Destination-Sequenced Distance Vector (DSDV) [15], Ad Hoc On-Demand Distance Vector (AODV) [16], Dynamic Source Routing (DSR), and Location-Aided Routing (LAR). These routing algorithms have been adapted for various transmission schemes of VANETs, proposed by researchers in the past. VANETs exhibit abruptly changing traffic density on the road, dynamic network topology, and frequent disconnections. Ultimately, there is no single solution to address all these factors in all possible transmission scenarios. As a major proliferation of MANETs, routing strategies being used for these networks are generally considered for VANETs but due to performance challenges this application did not prove practical [17–19]. However, researchers have made use of these algorithms with appropriate adaptations and proposed new schemes in different eras. In addition to these network layer solutions, these schemes are based on the exploitation of video statistics as application layer modification, nodes localization techniques, and MAC layer solution etc. Researchers in [20], presented a comprehensive survey of the position-based routing protocols which are deliberately used for inter-vehicular communication scenarios in the city environment.

Urban vehicular communication is characterized by challenges like segmented network zones, periodic interconnections, route obstacles, and constantly moving nodes, which exhibit a major impact on the selection of routing schemes. Besides finding the least-cost route from sender to destination, packet loss event that occurs quite frequently in wireless communication also affects content quality. Network coding

is a video structuring technique that is used to address the events of packet loss in VANET video streaming applications [21]. The authors in [22] worked on a limited VANET scenario implementing multi-hop communication of up to three hops whereas RSUs are specialized for video transmission to vehicles. They implemented the provisioning of seamless handover between adjacent RSUs and avoidance of playback freezes. They adopted the Proxy Mobile IPv6 (PMIPv6) [23] accordingly to the specific characteristics of VANETs. Authors figured out the major challenge of retransmission, which ultimately adds to delay. The authors proposed a solution that is based on a multi-path and disjoint algorithm for the reduction of interference. Due to this, the transmission rate is higher and the delay is acceptable [24, 25]. In [26] the authors proposed a geometry-based protocol that makes use of the movement patterns of the vehicles and attributes of the road like the limitations of the different segments of the road to provide facilities for different topologies. This protocol provides buffering operation by analyzing different trace files the proposed protocol gains, the patterns of the mobility on the roads, and finding out the area, which is valuable. Likewise, Abbasi et al. [27], presented a survey of various position-based unicast routing protocols that are being modeled for V2V communications in the urban environment. In [28], a modern routing scheme named a Reliable Path Selection and Packet Forwarding Routing Protocol (RPSPF) has been presented by Abbasi et al. Their work was based on two parts; firstly it leads to optimal path generation for data packets sent by a vehicle to the respective destination. Secondly, a reliable forwarding scheme was proposed that guaranteed the prevention of packet loss in case of link breakage. Shin, Yongje, et al. [29], came up with an enhancement in video streaming technology typically for safety applications like making the drivers aware of accidents through video dissemination. They proposed a working mechanism that involved V2V and V2I communications. [30] Dynamic Tri-lateral Enrolment (DyTE) is a routing protocol, proposed for VANETs where selected nodes are allowed to participate in communication between source and destination nodes. This work shows an improvement in packet drop rate by 23% and throughput by 26%. Comparatively, our scheme exhibits an average improvement of 30% in packet drop rate, and 80% rise in throughput, approximately. Besides, our scheme has shown a remarkable decline in transmission delay as well. Recently, an innovative algorithm has been proposed that controls an unmanned vehicle based on the topology of VANET [31]. Likewise, block chain-based techniques are evident in literature to address the VANET challenges [32]. Bao et al. [33] describes a collaboration of Received Signal Strength (RSS) and Time Difference On Arrival (TDOA) to localize a vehicle. As compared to the proposed scheme, it is only applicable for indoor localization, and not suitable for

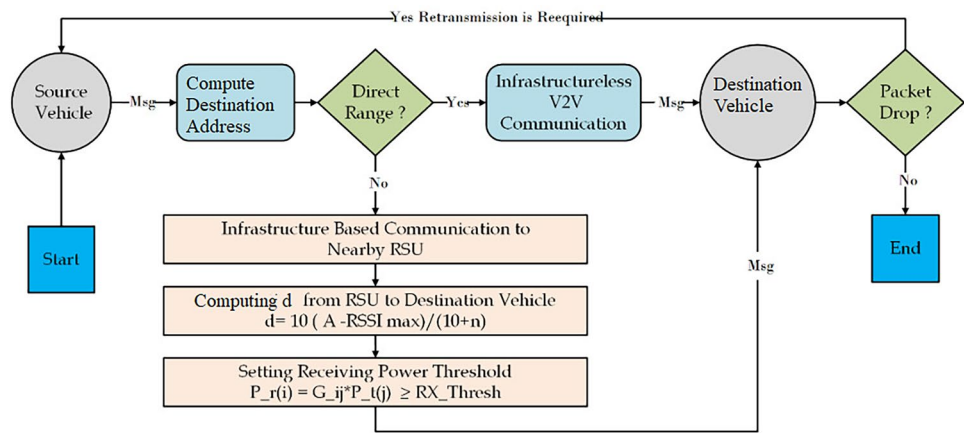
mobile localization. Bello-Salau et al. [34] improved Genetic Algorithm-based Route Optimization Technique (IGAROT) is a two-fold technique that shows an improvement of 4.24%, 75.7%, and 420% increment in routing in the low, medium and high car density scenarios, respectively. However, our proposed gains while keeping particularly the transmission power dynamic are outstanding equally for dense and sparse traffic density [35–37]. Idea is based on the carry-forward scheme of transmission to address rapidly changing topology. Consequently, as a comparison to our scheme, rather than reducing the delay factor, this results in increased end-end transmission time [38]. Changing mode of transmission based on traffic density. A neighboring node topology is worked out through sending beacon frames that induces extra overhead or these control frame processing. Our scheme achieves the high performance without any additional overhead. Road-based using Vehicular Traffic (RBVT) [39] is a combination of reactive and proactive routing schemes for VANET. However, due to certain constraints, it cannot be applied for streaming the video data [40, 41]. Rate-less network coding is used by RSUs to compose and send packets; however nodes carry this information through forward-carry mechanism when some RSU is not in range. In contrast to our proposed streaming scheme, this adds excessive delays due to high vehicle mobility. Numerous techniques in the literature, have proposed the idea of uneven processing of sensitive and non-sensitive video data [25, 42]. They identified the I, P, and B video pictures and devised different channels for the transmission of these frames. This has improved the packet drop rate and error somehow, but adds into the pre-processing of video data. In comparison to this, our scheme has improved packet drop rate up to a major extent without adding into the extra processing. Similarly, recent VANET communication and streaming protocols [43–47] have been compared against LBHVSP and it is evident that it shows improved performance in terms of maximum throughput and reduced latency. As, Taha et al. [43], have proposed a communication mechanism where edge servers of Content Distribution Networks (CDNs) are selected optimally through a redirection algorithm for information exchange. On comparing the performance gain with LBHVSP, model in [43] shows improved throughput however delay parameter is questionable because the algorithm used for edge server selection only shows a latency of 0.001–1 seconds, that is a fraction of transmission delay. Sarra et al. [44], have proposed a multi-path streaming protocol for vehicular fog computing environment to optimize QoE and QoS under dynamic and variable network traffic conditions. It leverages the potential of a vehicular fog computing architecture to ensure adaptive routing based on the

power of Ant Colony Optimization (ACO). Critical analysis of performance gain shows that our model shows higher throughput. However their model shows improved delay complexity. Ranjan et al. [45], proposed one automated method through VANET using location service-based routing for the location identification of a house. The proposed work involves searching for the location of a house using the open-source MongoDB database. On comparing the performance, LBHVSP has shown improved time complexity for small and large networks. Raza et al. [46] proposed P2P-CDN Framework for Live Video Streaming for improved QoE and reduced end-end latency. It showed an improvement in end user experience as well as edge server energy utilization.

3 Proposed Model

Deployment of video streaming applications in VANETs needs to provide the basic services as well as to address the challenges involved in radio link communication. This leads to an urge for an efficient and effective video dissemination method that can satisfy the Quality of Service (QoS) requirements like packet delivery ratio, transmission cost, delay, and bandwidth usage. Audio and video data generally improve the communication approach by providing more precise information than plain text messages. However, this initiates a new research paradigm based on the delivery of high-quality audio and video content without added latency. LBHVSP is the proposed routing protocol that tends to minimize the average packet delay for efficient utilization of bandwidth. It is a two-phase solution. In the first step, the transmission of frames to the second hop node available in the direct range is carried out. This will minimize the traveling path in terms of hop count and will ultimately yield minimal delay. In the second step, if the destination is far away then the technique will utilize the RSUs having wired connectivity. The destination location can be estimated by exploring the information on its connectivity to the RSU.

By using RSU from the predicted location, minimum delay and efficient utilization of bandwidth can be guaranteed, which results in delivery ratio improvement. (Fig. 2) shows the work mechanism of LBHVSP. The probability of location error may be minimized using the mobile (GSM) hand over technique. In addition to the above contribution, the proposed technique optimizes the re-transmission strategy through retransmitting the active frames only, consequently, the overhead will decrease and the overall efficiency of video streaming over VANETs is boosted. The working mechanism of LBHVSP is elaborated through the following pseudocode:

Fig. 2 Complete Flow Chart, Showing Work Mechanism of LBHVSP

Algorithm 1 Suppose Vehicle A wants to Communicate with Vehicle B

Input: Message m from source vehicle A to destination vehicle B

Output: Message m received at destination vehicle

- 1 **check_range** of vehicle B from vehicle A
- 2 **if** vehicle B is in direct range with node A
- 3 **Transmit** the Message m directly through second-hop
- 4 **Else**
- 5 **Transfer** packet to RSU
- 6 $i \leftarrow$ **Extract** vehicle B location
- 7 **Find** the RSU with vehicle B in direct range
- 8 **Compute** the distance d of vehicle B from RSU , $d \leftarrow 10 \frac{A - RSSI_{max}}{10 + n}$
- 9 **Compute** the required power P_r to transmit the packet based on d ,

$$\frac{P_r}{P_t} \leftarrow \left(\frac{K_r K_t}{d^2 \lambda^2} \right)$$
- 10 **Set** the receiving power P_r threshold ,

$$P_r(B) \leftarrow G_{BA} * P_t(A) \geq RX_Thresh_B$$
- 11 **Transfer** the Message m with P_r
- 12 **End**
- 13 **At** vehicle B , **if** Message m is dropped
- 14 **Retransmit** the Message m with m_ID
- 15 **End**

In step 9, X_r is the received signal power in dBm at a distance of 1 meter. d is the distance in meters and n is the path-loss exponent, $n+1$ shows the dynamicity of the system. After calculating the Received Signal Strength Indicator (RSSI) values we can obtain the maximum value of the RSSI which is known as RSSI_{max} out of all values [9]. The computation of the inter-distance of a transmitter and receiver based on the strength of the signal transmitted from sender to receiver is a range-based localization methodology. The motivation to select the RSSI method is that it is efficient without incurring an extra cost of hardware. Next, based on the distance, the required power to transmit the signal to node B is computed. This threshold value is defined as the minimum reception power node B must possess to receive a signal from node A having transmission power P_t (B) [9]. The received power at node B must at least be equal to its minimum receiving threshold i.e. RX-Threshold.

3.1 Configuration Parameters

NS-2 and SUMO have been used for the deployment and testing purposes of the mentioned technique. SUMO stands for Simulation of Urban Mobility which is open-source software, used to create multiple simulations. It can simulate any kind of traffic pattern, a network of roads, and vehicles moving on a given road. Moreover, we can create a model in which vehicles have their routes and move all over the network. NS-2 is used to create a topology, defined as interconnected nodes involving some links used to forward packets by making use of routing information. However, some of the nodes are mobile and thus not connected through links, making wireless topology. Packet forwarding between fixed and moving nodes is attained through a base station that is a kind of gateway in the wired-cum-wireless network. Vehicles equipped with On-Board Units (OBUs) constitute wireless vehicular networks on the highway. In VANETs, these mobile nodes are interconnected through OBUs that contain communication infrastructure like an antenna for message propagation. For better and more reliable communication,

these nodes are interconnected within the transmission range of each other. Transmission power (of the directional antenna) can be varied depending on the circumstances of the network. As the density of the network also changes on the course of the highway, it seems necessary to keep the transmission power dynamic to get reliable communication with lesser delay [10]. It has been observed through experimentation that to achieve higher throughput, transmission power should be kept dynamic ultimately decreasing the transmission delay. Furthermore, network performance can be optimized through dynamic control of transmission power in VANETs. The proposed model has been experimented with involving two traffic nodes; sender and receiver, with a total of 34 vehicles/nodes used for transferring packets, spans a simulation area of $220550 \times 20044 \text{ m}^2$ to perform the whole simulation of 1000 seconds and the speed of the mobile vehicles/nodes varies as 0–100 m/second, as shown in (Table 2). Two different types of simulation scenarios i.e. Packet Reception Power Threshold and Signal Transmission power have been simulated with three different parameters incorporated as the performance measure of the proposed model. Following table shows the configuration parameters for the experimental setup. The distance between the vehicles varies during communication, signal transmission and reception powers and vehicle inter-distance should also be kept dynamic. The existing VANETs use static transmission power and reception power thresholds during communication between the vehicles. The proposed protocol, LBHVSP makes use of all dynamic parameters. In this mechanism, the distance between the vehicles is measured before the data transmission begins. Further transmission is based on the inter-vehicular distance (computed) to select appropriate transmission parameters i.e. signal transmission power and packet reception power threshold.

4 Novelty of the Proposed Scheme

1. A video streaming strategy has been proposed that is a 2-phase data streaming Strategy:
 - (a) Where the first phase is based on radio link communication facilitated by OBU of the vehicles in ad-hoc wireless networks. This is followed when the destination node is within transmission range of the vehicular node.
 - (b) Whereas the second phase is followed when the source node computes the range and the destination node is not directly approachable, RSUs are used that are mounted on the roadside to locate the target node.
2. As evident from the literature [25, 28–30], transmission power is directly proportional to transmission range so it should be kept dynamic for various transmission scenarios. Transmission and reception powers are changed

Table 2 Configuration Parameters in NS-2

Parameters	Value
Total Number of Vehicles	34
Simulation Time	1000 Seconds
Area of Simulation	$22,055 \times 22044 \text{ m}^2$
Traffic Source	2 Nodes
Simulation Scenarios	1. Packet Reception Power 2. Threshold Signal Transmission Power
Performance Parameters	1. Average Throughput 2. Average Packet Drop 3. Average Per Packet Delay
Vehicle Speed	0 to 100 m/seconds

based on the distance the signal needs to travel to reach the destination.

3. This combination of network and link layer greatly improves the average throughput and minimizes transmission delay and packet drop rate.

5 Results and Discussion

To meet the QoS metrics in terms of packet delivery ratio, delay, and throughput there must be an efficient and effective protocol to support the dissemination of video. Experimental results have shown that LBHVSP is capable of providing an integrated solution while dealing with different VANET challenges simultaneously. Various experiments conducted include some simulation scenarios based on the implementation of the proposed streaming protocol. The state-of-the-art communication mechanism in VANETs that makes use of static transmission parameters has been simulated for different scenarios. And results have been compared with the novel protocol (with dynamic parameters) to analyze the QoS enhancements. Different performance parameters have been assessed to analyze signal transmission and reception powers e.g. average Per-Packet Delay (PPD), average Packet Drop Rate (PDR), and average throughput, where signal transmission and reception power are the strength of message signal fed into the transmitting antenna input terminals and available at receiving antenna output terminals, respectively.

Assessing the results in terms of all transmission attributes, it is well evident that LBHVSP outperforms all the state-of-the-art VANET transmission strategies. Due to dynamically changing traffic conditions, traffic densities, and vehicular speeds, it was difficult to implement the proposed strategy in the real world. A Simulation of Urban Mobility

(SUMO-based) simulation has been modeled to catch up with all possible transmission scenarios since SUMO is an open-source tool, characterized by different kinds of vehicles, multi-lane streets with several edges, and the possibility of lane change. Moreover, NS2 is used for backend WLAN implementation.

5.1 Signal Transmission Power Scenario

For a detailed analysis of the proposed transmission scheme, different scenarios are designed with dynamic and static signal transmission power for comparison, analyzed against three major attributes of wireless communication PDR, PPD, and throughput. The proposed 2-way streaming strategy is tested for two transmission scenarios where transmitted powers are varied depending upon transmission distance. Results of both scenarios are compared as signal transmission power i.e. 1.33826e-3dBm, 7.214e-3dBm, 0.2818dBm, 0.5636 dBm, and 1.1272 dBm are deemed sufficient for a communication range of 50m, 100m, 250m, 500m, and 1000m respectively. These Transmission power values are evident from the approved example worked out in network simulator-2 (NS-2) [10]. A comparison has been conducted concerning different parameters as below:

5.1.1 Average PDR in Signal Transmission Power Scenario

Average packet drop is a measure of the number of packets dropped at a given moment. The unit for the packet dropped is packets per second. Mathematically, it is given through Eq. (1) as a sum of all the dropped packets i.e. first to the last dropped packets, divided by total simulation time.

$$\text{Avg.PDR} = \frac{\sum_{i=1}^n \text{Dropped Packets}}{\text{Simulation Time}} \quad (1)$$

Fig. 3 Average Packet Drop in Signal Transmission Power Scenario

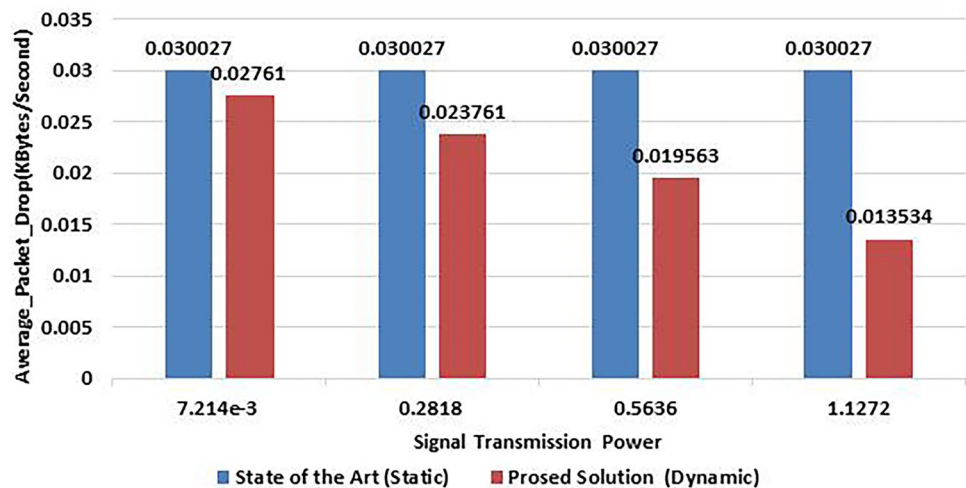


Fig. 4 Average per Packet Delay in Signal Transmission Power Scenario

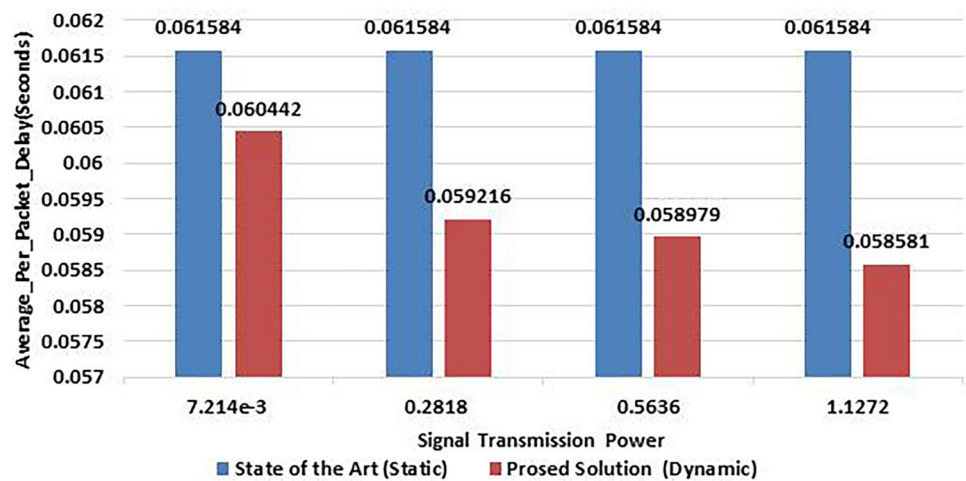


Figure 3 shows a comparison graph between static and dynamic transmission powers, it is observed that keeping the transmission power dynamic, greatly improves the packet drop rate. As an average PDR is measured as 0.02761 Kbytes/Sec, 0.023761 Kbytes/Sec, 0.019563 Kbytes/Sec, and 0.013534 Kbytes/Sec at dynamic transmission power i.e. 7.214e-3 dBm, 0.2818 dBm, 0.5636 dBm, and 1.1272 dBm. However, the average PDR for a static transmission power scenario is 1.33826e-3dBm, which is far higher than the dynamic scenario.

5.1.2 The average PPD in Signal Transmission Power Scenario

The average PPD is used to find out the time consumed by the packet to get transmitted from one node to another, measured in milliseconds. Mathematically, it is computed through Eq. (2) as summing up all the packet delays i.e. sending first

to the very last packet received at the receiver side divided by the total number of packets sent.

$$Avg.PDR = \frac{\sum_{i=1}^n End\ to\ End\ Delay}{1\ number\ of\ packets} \quad (2)$$

Like PDR, an improvement in PPD is evident in Fig. 4, it is detected that the average PPD of 0.060442 sec, 0.059216 sec, 0.058979 sec, and 0.058581 sec exhibited by using dynamic transmission power i.e. 7.214e-3dBm, 0.2818 dBm, 0.5636 dBm, and 1.1272 dBm is lesser as compared to 0.061584 Sec by using static transmission power i.e. 1.33826e-3dBm.

Fig. 5 Average Throughput in Signal Transmission Power Scenario

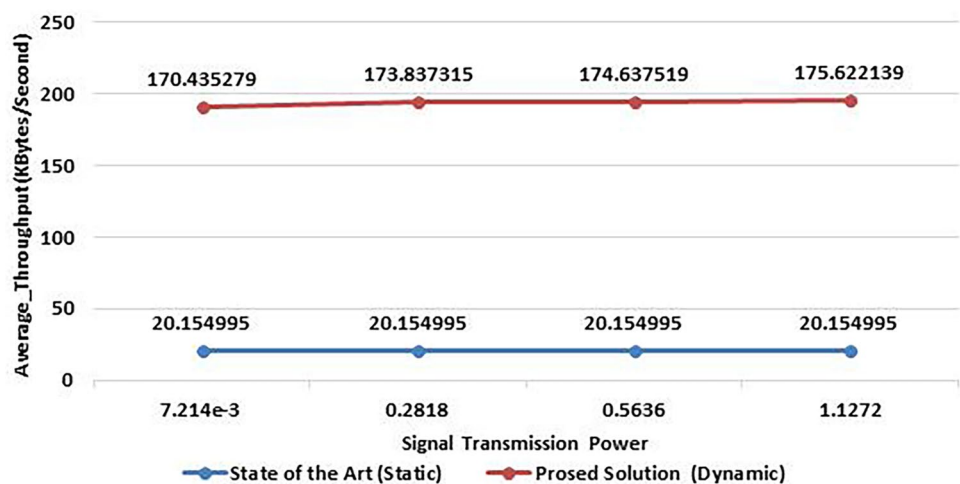
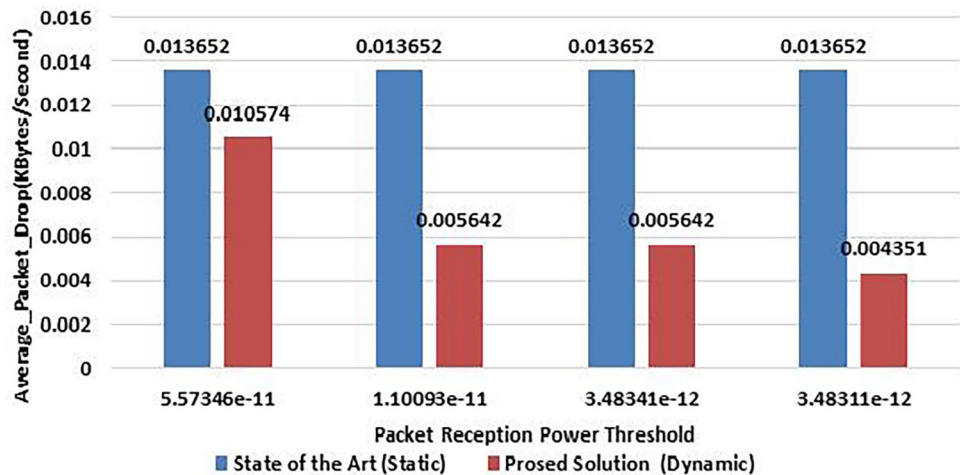


Fig. 6 Average Packet Drop in Packet Reception Power Threshold Scenario



5.1.3 Average Throughput in Signal Transmission Power Scenario

Average Throughput is the total number of packets delivered over the net transmission time, mathematically given as Eq. (3),

$$\text{Avg.Throughput}(TH) = \frac{I}{T} \quad (3)$$

Where TH, I, and T are defined as throughput, the total number of packets, and total time (that is required to complete the transmission task) respectively. In (Figure 5), it is observed that the average packet throughput obtained of 170.435279 Kbytes/Sec, 173.837315 Kbytes/Sec, 174.637519 Kbytes/Sec, and 175.622139 Kbytes/Sec is maximum by using dynamic transmission power as i.e. 7.214e-3 dBm, 0.2818 dBm, 0.5636dBm, and 1.1272 dBm respectively as compared to 20.154995Kbytes/Sec by using static transmission power i.e. 1.33826e-3dBm.

5.2 Packet Reception Power Threshold Scenario

To thoroughly analyze the proposed scheme, two different types of simulation scenarios i.e. Packet Reception Power Threshold and Signal Transmission power are used for comparison. Signal reception power i.e. 8.91754e-10 dBm, 5.57346e-11 dBm, 1.10093e-11 dBm, 3.48341e-12 dBm and 3.48311e-12 dBm is sufficient for a communication range of 200 m, 400m, 600 m, 800 m, and 1000 m respectively. These reception power values are selected based on the approved example in network simulator-2(NS-2) [10].

5.2.1 Average Packet Drop in Packet Reception Power Threshold Scenario

Like static and dynamic transmission power scenarios, signal reception power has also been assessed by analyzing the same performance parameters.

Fig. 7 Average per Packet Delay in Packet Reception Power Threshold Scenario

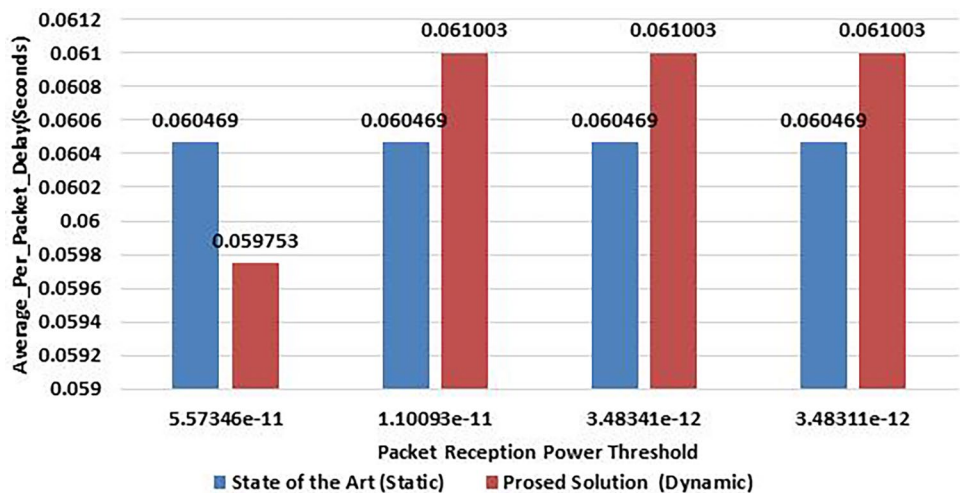


Fig. 8 Average Throughput in Packet Reception Power Threshold Scenario

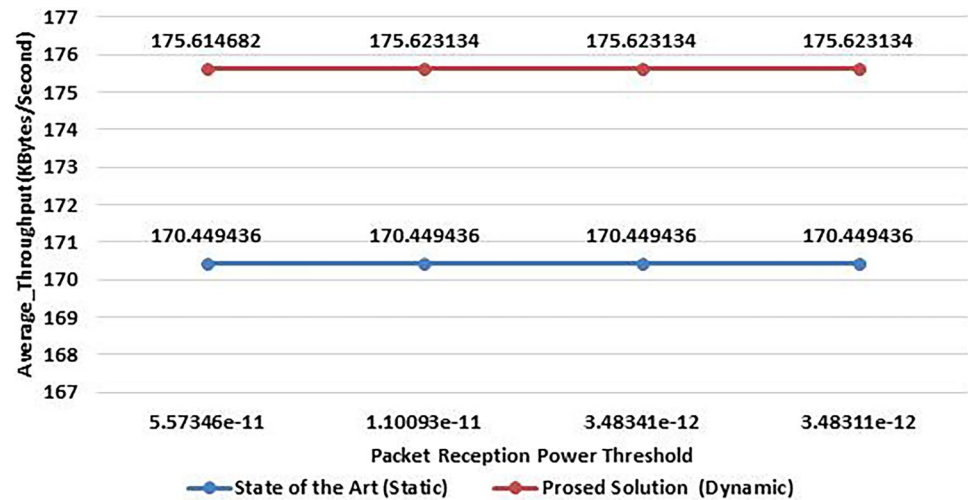


Figure 6 shows that the average packet dropped of 0.010574 Kbytes/Sec, 0.005642 Kbytes/Sec, 0.005642 Kbytes/Sec and 0.004351 Kbytes/Sec are the least exhibited using dynamic reception power threshold i.e. 5.57346e-11 dBm, 1.10093 e-11 dBm, 3.48341e-12 dBm and 3.48311e-12 dBm respectively. However, it is measured as 0.013652 Kbytes/Sec by using static reception power i.e. 8.91754 e-10dBm.

5.2.2 Average per Packet Delay in Packet Reception Power Threshold Scenario

In (Figure 7), it is observed that the average per-packet delay of 0.059753 sec experienced is minimum by using dynamic reception power i.e. 5.57346e-11 dBm as compared to 0.060469 sec by using static reception power i.e. 8.91754e-10 dBm. But there is little increase in packet delay i.e. 0.061003 sec, 0.061003 sec, and 0.061003 sec by using Reception Power Threshold of 1.10093e-11 dBm, 3.48341e-12dBm and 3.48311e-12dBm respectively. This is a major fact about dynamicity of the reception power that came out of these experiments.

5.2.3 Average Throughput in Packet Reception Power Threshold Scenario

(Figure 8), depicts that the average packet throughput of 175.614682 Kbytes/sec, 175.623134 Kbytes/sec,

175.623134 Kbytes/sec, and 175.623134 Kbytes/sec is maximum by using dynamic reception power i.e. 5.57346e-11 dBm, 1.10093e-11 dBm, 3.48341e-12 dBm, and 3.48341e-12 dBm respectively when compared to 170.449436 Kbytes/sec by using static reception power i.e. 8.91754e-10 dBm.

6 Comparative Analysis

VANETs exhibit abruptly changing traffic density on the road, dynamic network topology, and frequent disconnections. Ultimately, there is no single solution to address all these factors in all possible transmission scenarios. As a major proliferation of MANETs, routing strategies being used for these networks are generally considered for VANETs but due to performance challenges this application did not prove practical [17–19]. However, researchers have made use of these algorithms with appropriate adaptations and proposed new schemes in different eras. In addition to these network layer solutions, these schemes are based on the exploitation of video statistics as application layer modification, nodes localization techniques, and MAC layer solution etc. Table 3 summarizes the comparative analysis of these methodologies with our proposed technique.

On comparing the performance gain of the proposed communication model, Table 4 shows a comparative analysis with some state-of-art techniques from literature [43–45].

Table 4 shows that while comparing LBHVS against recent VANETs models, it has shown improved performance, either in terms of transmission latency or throughput. On comparing the performance gain with LBHVSP, model in [43] shows improved throughput however delay parameter is questionable because the algorithm used for edge server selection only shows a latency of 0.001–1 seconds that is a fraction of transmission delay. Similarly, performance analysis of [44] shows that our model shows higher throughput.

Table 3 Performance Comparison with Existing Approaches

Node Localization Techniques	Network Layer Techniques	MANET Routing Protocols	Video Data Processing
[35] Describes a collaboration of Received Signal Strength (RSS) and Time Difference On Arrival (TDOA) to localize a vehicle. As compared to the proposed scheme, it is only applicable for indoor localization, and not suitable for mobile localization [44] Improved Genetic Algorithm-based Route Optimization Technique (IGAROT) is a two-fold technique that shows an improvement of 4.24%, 75.7%, and 420% increment in routing in the low, medium and high car density scenarios, respectively. However, our proposed gains while keeping particularly the transmission power dynamic are outstanding equally for dense and sparse traffic density Taha et al.[47], have proposed a communication mechanism where edge servers of Content Distribution Networks (CDNs) are selected optimally through a redirection algorithm for information exchange. On comparing the performance gain with LBHVSP, model in [47] shows improved throughput however delay parameter is questionable because the algorithm used for edge server selection only shows a latency of 0.001–1 s, that is a fraction of transmission delay. Ranjan et al. [49], proposed one automated method through VANET using location service-based routing for the location identification of a house. The proposed work involves searching for the location of a house using the open-source MongoDB database. On comparing the performance, LBHVSP has shown improved time complexity for small and large networks	[37–39] Idea is based on the carry-forward scheme of transmission to address rapidly changing topology. Consequently, as a comparison to our scheme, rather than reducing the delay factor, this results in increased end-end transmission time [40] Changing mode of transmission based on traffic density. A neighboring node topology is worked out through sending beacon frames that induces extra overhead or these control frame processing. Our scheme achieves the high performance without any additional overhead Road-based using Vehicular Traffic (RBVT) [41], is a combination of reactive and proactive routing schemes for VANET. However, due to certain constraints, it cannot be applied for streaming the video data	[42, 43] Rateless network coding is used by RSUs to compose and send packets; however nodes carry this information through forward-carry mechanism when some RSU is not in range. In contrast to our proposed streaming scheme, this adds excessive delays due to high vehicle mobility [22] DyTE is a routing protocol, proposed for VANETs where selected nodes are allowed to participate in communication between source and destination nodes. This work shows an improvement in packet drop rate by 23% and throughput by 26%. Comparatively, our scheme exhibits an average improvement of 30% in packet drop rate, and 80% rise in throughput, approximately. Besides, our scheme has shown a remarkable decline in transmission delay as well	Numerous techniques in the literature, have proposed the idea of uneven processing of sensitive and non-sensitive video data [17, 36]. They identified the I, P, and B video pictures and devised different channels for the transmission of these frames. This has improved the packet drop rate and error somehow, but adds into the pre-processing of video data. In comparison to this, our scheme has improved packet drop rate up to a major extent without adding into the extra processing. Sarra et al.[48], have proposed a multi-path streaming protocol for vehicular fog computing environment to optimize QoE and QoS under dynamic and variable network traffic conditions. It leverages the potential of a vehicular fog computing architecture to ensure adaptive routing based on the power of Ant Colony Optimization (ACO). Critical analysis of performance gain shows that our model shows higher throughput. However their model shows improved delay complexity. Reza et al. [50] proposed P2P-CDN Framework for Live Video Streaming for improved QoE and reduced end-end latency. It showed an improvement in end user experience as well as edge server energy utilization

Table 4 Statistical Performance Gains

Models	Performance Measures	
	Delay(s)	Throughput (KBps)
[43]	–	500 (min)
	–	1000 (max)
[44]	0.003 (min)	1.7 (min)
	0.006 (max)	24 (max)
[45]	2.1 (min)	–
	6.5 (max)	–
LBHVSP	0.059 (min)	170 (min)
	0.061 (max)	176 (max)

However their model shows improved delay complexity. Model in [45] involves searching for the location of a house using the open-source MongoDB database of RSUs. On comparing the performance, LBHVSP has shown improved time complexity for small and large networks.

7 Conclusion and Future Recommendation

With the advent of variable features of ITS, there is an immense need for efficient and effective transmission of multimedia data in VANETs, services like provisioning of route information, awareness of accidents for drivers, and communication facilities for people in the vehicles demand research in this domain. However, video streaming is complex in VANETs, which demands extensive work for the attainment of better results. A Location-Based Hybrid Video Streaming Protocol (LBHVSP) has been proposed with the intent to minimize the average PPD for efficient utilization of bandwidth. The proposed scheme has outperformed the state-of-the-art transmission scenarios in terms of static parameters. The proposed scheme is analyzed through a comparative analysis using different transmission scenarios and the results reveal its efficacy. Future work aims to focus on improving the delay and packet drop rate by using more advanced technologies like Fog Edge Computing etc. as well as retransmission events of the dropped packets will be exploited. Furthermore, it is observed that when reception power is dynamically changed w.r.t destination distance, the delay is not improved so it can be improved and further investigated in the next work. Moreover, to cater to packet drop, a smart re-transmission strategy like [48, 49] should be re-designed that will be more appropriate for video data. In addition, a number of the survey papers [50] about VANET strategies exhibit that most QoS problems are due to the lack of coordination among the application, user, and MAC layers. This can be a motivation for a cross-layer methodology that analyzes video statistics and can make variations based on network topology or traffic density.

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