ENERGY COMPETENT TRANSMISSION MECHANISM BASED ROUTING APPROACH (ECTM-MRA) FOR RELIABLE VIDEO TRANSMISSION IN MULTIMEDIA VEHICULAR AD HOC NETWORKS

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ABSTRACT

Transmission of video without transmission errors is one of the key research issue in multimedia Vehicular Ad hoc NETwork (VANET). Multimedia VANETs are capable enough to capture and share environmental monitoring, surveillance, traffic accidents, and disaster-based video smart city applications. This research work aims in proposing energy competent transmission mechanism based routing approach (ECTM-MRA) for reliable video transmission in multimedia vehicular ad hoc networks. ECTM-MRA has two stages. The first stage of ECTM is data gathering that contains a video review table and the vehicle information table. The second stage of ECTM is associated to the video streaming method that obtains the parameters such as vehicle's degree, residual energy and transmission speed to determine low delay and resource responsive routes for streaming the video. Simulations are carried out and the results demonstrate that the proposed ECTM-MRA performs better in terms of route length, packet end-to-end delay, freezing delay, number of delivered packets and packet loss ratio.

Keywords: multimedia VANET, MANET, video transmission, residual energy, routing, packet end-to-end delay, freezing delay, number of delivered packets, packet loss ratio.

1. INTRODUCTION

An ad hoc network has wireless nodes that selflessly form a network devoid of any explicit management [5]. Each node that is present in an ad hoc network does routing information among its neighbor nodes. When nodes are free to move randomly and organize themselves arbitrarily, it is referred as Mobile Ad Hoc NETworks (MANETs) [6]. As an evolution of traditional MANETs, VANETs (Vehicular Ad hoc NETworks) [7] include communications between vehicles (Vehicle to Vehicle, also known as V2V communications) on the roads and with the road communication infrastructure (Vehicle to Infrastructure, also known as V2I communications). Vehicular ad hoc networks (VANETs) are temporal, self-organized networks where vehicles send and receive information to other vehicles (V2V communications) or to fixed infrastructure points (V2I communications). These communications are possible enough to evolve high number of potential applications [4]. Vehicular Ad Hoc Networks (VANETs) are aimed to provide Information and Communication Technology to lessen transportation problems. Vehicles that are present in VANET are possibly will exert together between themselves to pass error-free scalar data.

This VANET inspired vehicle industries to bestow with drivers and passengers with a wide scope of novel real-time multimedia services, ranging from safety and security traffic warnings to live entertainment and advertising video flows [1]. Among several Information and Communication Technologies (ICT) services, video surveillance is the key service for developing smart city scenarios which obtains an imperative notice from governments, car manufacturers, academia, and society [1]. At the present time, the allocation of real-time multimedia content over Vehicular Ad-Hoc Networks (VANETs) is flattering a realism and consenting to drivers / passengers for experiencing with on-road videos in smart cities [2, 3]. Multipath routing protocols even for energy efficient data transmission also discussed in the literature [10]. Multimedia VANETs are complementary for incarcerating and sharing environmental monitoring, shadowing, traffic accidents, and disaster-based video smart city applications. Live streaming videos makes available to end-users and authorities. The motivation of this research work is the existing protocols deem the Quality of Service (QoS) of the application layer. As a result, they are tactless to the applications requirements. They also judge no intact route lifetime required to deliver the whole data, such as video and it is possibly will show the way to packet drop after departure of the source or destination vehicles from the route which is in progress. Considering this scenario, discovering a new route or updating the route need to be done. Therefore, there is a wide scope of inheriting further techniques in order to make the protocol appropriate for video streaming. This paper is organized as follows. This section provides introduction to VANET. Section 2 reviews the related works / literatures. Section 3 presents the proposed work. Section 4 portrays simulation settings. Section 5 provides simulation results with discussion. Section 6 gives concluding remarks of the paper.

2. RELATED WORKS

The current consent of the new H.265 video compression standard [11] has been intentional to restore the broadly used and renowned H.264 standard [12], gives a new-fangled prospect for real-time video transmission in decisive circumstances. This new-fangled standard, which outperforms the old one by accomplishing the same video quality with only 50% of the bit-rate [13], is probable to turn out to be a facilitating technology when trying to offer real-time video transmission in VANETs. Cuomo *et al.* [14] put forward the making of a vehicular Backbone Network (VBN) for elevated throughput content distribution on thoroughfare roads. In difference their work spotlighted on distributing live video streaming between vehicles. Guo *et al*. [13] suggested several scenarios where live video streaming between vehicles is both practicable and enviable. Soldo *et al*. [15] presented the Streaming Urban Video (SUV) protocol, a distributed elucidation to broadcast video streams in VANETs. The protocol recommended dividing the neighbors into four sectors and selecting one node in every sector as a candidate for rebroadcasting; even though an out of the ordinary MAC layer is necessary to sustain TDMA scheduling. Such situation prevents its implementation on real IEEE 802.11p devices.

Piñol *et al*. [16] proposed the primary come up to a correct simulation setting competent enough to represent real-time video transmission in VANETs. The authors presented a simulation platform and PSNR results, following the guidelines presented by Seeling and Reisslein [17], thereby offering a constructive loom on the way to simulate video transmission exactly. Wu et al. proposed distortion-aware concurrent multipath transfer (CMT-DA) solution [18]. CMT-DA examined data distribution among more than one route to minimize the video distortion based on the utility maximization theory. Wu et al. also proposed a scheduling approach that uses frame splitting based on weibull distribution and graph theory to minimize the end-to-end delivery delay and reduce out-of-order reception [19]. Xu *et al*. proposed a quality-aware adaptive concurrent multipath transfer solution (CMT-QA) [20]. CMT-QA takes advantages of reordering delay reduction and unnecessary fast retransmission to alleviate out-of-order data reception. From the literatures, it is evident that more research scope exists in the field of VANET for reliable video transmission.

3. PROPOSED WORK

Energy Competent Transmission Mechanism (ECTM) takes vehicles' degree and the network capacity as parameters in order to lessen the signaling overhead and to curtail the streaming delay. ECTM deems data gathering method to carve up the video review tables and the vehicle information tables upon get in touch between vehicles. In ECTM, on every occasion two vehicles come within transmission range, each vehicle shares a portion of their video review tables along with the vehicle information table. The segment of the video review table is distributed based on the vehicles' degree and the videos' priority. For this reason, the first stage of ECTM is data gathering that contains a video review table and the vehicle information table. The second stage of ECTM is associated to the video streaming method that obtains the parameters such as vehicle's degree, residual energy and transmission speed to determine low delay and resource responsive routes for streaming the video.

3.1 Data gathering method

To gather the video and vehicles' information table, the preliminary loom is to flood the vehicles' video review tables and vehicles' information tables upon acquaintances. On the other hand, this results in increased signaling overhead. For this reason, a data gathering method is proposed in order to decrease the signaling overhead by prioritizing the vehicles using their video review tables. It is done by identifying vehicles that share the whole or just a small portion of a video review table along with the vehicles' information table to the next neighbor vehicle in the VANET environment. Initially, the overhead is measured when the network is fully connected. In this scenario, it is assumed that the links are bidirectional and flooding is used, the total number of links required to communicate are equal to,

$$\frac{n(n-1)}{2} \tag{1}$$

Here n denotes the number of vehicles in the network. Likewise, the number of review tables to be sent over each link is calculated by,

$$2n(n-1) \tag{2}$$

In another scenario where the network is not fully connected, the total number of links in which vehicles are connected equal to vehicle's degree (M) is calculated as

$$M = \left(\frac{\sum_{i=2}^{n} \varepsilon_i}{2} \right) \tag{3}$$

Here ε_i is the degree of vehicle i and n is the total number of vehicles that are present in the VANET. The number of tables transferred is 4M as every ad hoc vehicle contains two tables to distribute, when compared to fully connected network $4M \le 2n(n-1)$. The videos in the video review table are arranged in descending order depending on the priority which increases the possibility of admired videos information available at other vehicles. In the same way, when a vehicle is located in a high-density area, it has a higher degree seeing that it is uncovered to larger number of vehicles. This finding aids to transmit more content of video review tables to the vehicles that has higher degrees.

Every vehicle i under ECTM contains degree ε_i, ahead make contact between vehicles i vehicle j, vehicle i evaluates the ratio of its degree with respect to vehicle j's degree. On this fashion, a fraction of the video review table is forwarded along with the vehicle's information table. In particular,

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$$P_{i,j} = \frac{\varepsilon_j}{\varepsilon_j + \varepsilon_i} \times 100 \quad (4)$$

From the Equation (4) it can be observed that vehicle i will transmit $P_{i,j}\%$ of its video content to its video review table. As a result, in this proposed technique, each vehicle distributes a segment of its video review table with every met vehicle as per the Equation 4. On the other hand, when a vehicle also has the video review table of other vehicles that it met before and wish to transmit them to a newly met vehicle, then the Equation 4 is functional to all the tables for distributing the segment of these tables depending up on the degree of a new vehicle. Furthermore, when two vehicles are within the communication range of each other, they swap over their review vectors, that describe the new information to every vehicle. In view of that, a verdict is obtained for swapping this information, as portrayed in data vectors. This method is familiar among routing protocols. Besides this, when vehicles swap over the information, in the future, intrinsically entails that these vehicles have been in contacts since they carry the info that the other one is carrying. Consequently, when the two already contacted vehicles communicate each other another time, the vehicles bring up to date the video review tables by only distributing their new data vectors or update the vehicles' information table. The proposed data gathering method is efficient to distribute the video review table and the vehicle information table transversely every vehicle in the VANET so that the signaling overhead is lessened.

3.2. Energy and delay aware video streaming strategy

This part employs energy and delay aware video streaming strategy which help to stream videos for the desired destination such that minimum delay is achieved and energy consumption is balanced across the vehicles. When there is a link with a high data transmission rate, it is not required that all the data packets (video data) are needed to send through that link. Consequently, the VANET does not overlook the nodes swiftly due to lack of energy. Furthermore, the video's segments are streamed through different routes; usually congestion does not transpire across the high-speed links. That's why, for each discovered route, residual energy and time delay.

When a vehicle on the VANET requests a video, the first step is to determine the source vehicle. That's why; the destination vehicle floods the request throughout the VANET. Vehicles will make use of a route discovery mechanism (in this research AOMDV routing is used), for obtaining all the available routes from source to the destination. Additionally, based on the data gathering method, vehicles' information is notorious to all vehicles and the source vehicle will come to know that what other sources have a given video. In view of that, every source vehicle is capable enough to obtain the number of layers. Expressly, the effectiveness of every route i is computed by.

$$U_i = \frac{E}{E_{\max}} \times \frac{TR}{TR_{\max}} \quad (5)$$

In the Equation (5) E denotes the residual energy of vehicles involved in route i and TR is the transmission speed of the links in the route. Also E_{max} and TR_{max} denotes the maximum available energy and transmission speed.

Every source vehicle j that receives a video transmission request it will discover the available routes. For knowing which source vehicle already received the request, it is required to compute the delay based on the route's speed that could be obtained from the link capacity. This information helps to compute how many layers are already forwarded from other sources. Then, node j is capable enough to forward a proportional number of remaining layers based on the utility of the routes. In particular,

$$D_{j,v,s} = [U_i \ X \ L_t] \quad (6)$$

Equation 6 decides the number of layers that can be forwarded by each node based on the route utility. It is to be noted that for each second of a video, each source vehicle only forwards the corresponding layers once. While streaming, the source vehicle, for some reason such as; limited energy or high mobility pattern becomes disconnected, then the layers that are supposed to be streamed by the missed vehicle will not be delivered. In such a case, as the vehicles are always aware of the network topology, the source vehicles, which have recorded the video review table of the missed vehicle, will make a decision to forward the layers, which were supposed to be forwarded through the missed vehicle. In the case of live videos streaming, a loading time LT is presumed that denote the time that a receiver need to wait since the first layer of a video is received. As a result the quality of video is improved that implies that if loading time decreases, the downloaded video will have fewer gaps with respect to the live. Conversely, this may reduce the quality of video.

The above said strategy is depicted in the Algorithm - 1.

VOL. 13, NO. 5, MARCH 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

$begin$

$for\ every\ vehicle\ n_i\ that\ meet\ node\ n_j$

$$P_{send} \leftarrow \frac{\varepsilon_j}{\varepsilon_j + \varepsilon_i} X\, 100$$

$send\ P_{send}\ \%\ of\ U_i\ \ to\ vehicle\ n_j$

$end\ \ for$

$for\ every\ request\ made\ by\ n_i\ \ for\ video\ v$

$d \leftarrow Floodrequest(v)$

$n_j \leftarrow \mathrm{Re}\,ceiverequest$

$for\ source\ vehicle\ n_j\ do$

$d_{ji} \leftarrow delaycalculation$

$l_t \leftarrow numberoflayers$

$d \leftarrow destination$

$$U_i = \frac{E}{E_{\max}} \times \frac{TR}{TR_{\max}}$$

$D_{j,v,s} = [U_i\ X\ L_t]$

$l_{send} \leftarrow D_{j,v,s}$

$end\ \ for$

$end\ \ for$

end

4. SIMULATION SETTINGS, RESULTS AND DISCUSSIONS

Simulation settings are presented in Table-1. The performance metrics such as route length, packet end-to-end delay, freezing delay, number of delivered packets and packet loss ratio are taken into account. The proposed ECTM-MRA is compared with AMGR protocol. The network region consisting of 1000 vehicular nodes are presented in Figure-1. As per the network topology, when the route length is increased the quality of video transmission also increases. From the Figure-2 it is evident that the proposed ECTM-MRA has better route length than that of AMGR protocol. It is noteworthy that when the end-to-end delay is reduced it results in better video transmission speed. Figure-3 portrays the results of simulation time versus packet end-to-end delay. From the obtained results it shows that the proposed ECTM-MRA acquires less packet end-to-end delay than that of AMGR protocol [9]. Freezing delay also taken into account in order to witness the quality of video transmission. Less freezing delay results in better video quality. Fig.4 presents the simulation results in terms of simulation time versus freezing delay. From the results it is obvious that the proposed ECTM-MRA consumes lesser freezing delay when compared to AMGR protocol.

Throughput or number of packets delivered is the measure used to evaluate the performance of the protocol by which the total number of successful packets reached towards the destination. Figure-5 shows the performance comparison of the protocols in terms of simulation time versus number o delivered packets. It is evident that the proposed ECTM-MRA attains better throughput than that of AMGR protocol. Figure-6 presents average packet loss ratio of the protocols and from the results it can be perceived that the proposed ECTM-MRA has less packet loss ratio that ensures better video transmission. The result values are presented from Table-2 to Table-6.

Table-1. Simulation settings.

Parameters	Values
Simulation area	2.5 km x 3.5 km
Number of nodes	1000
Number of intersections	250
Number of streets	513
Vehicle speed	3 – 13 meter/second
Transmission range	250 meters
Minimum data rate	6 Mbps
Simulation time	12 seconds
Beacon interval	5 seconds

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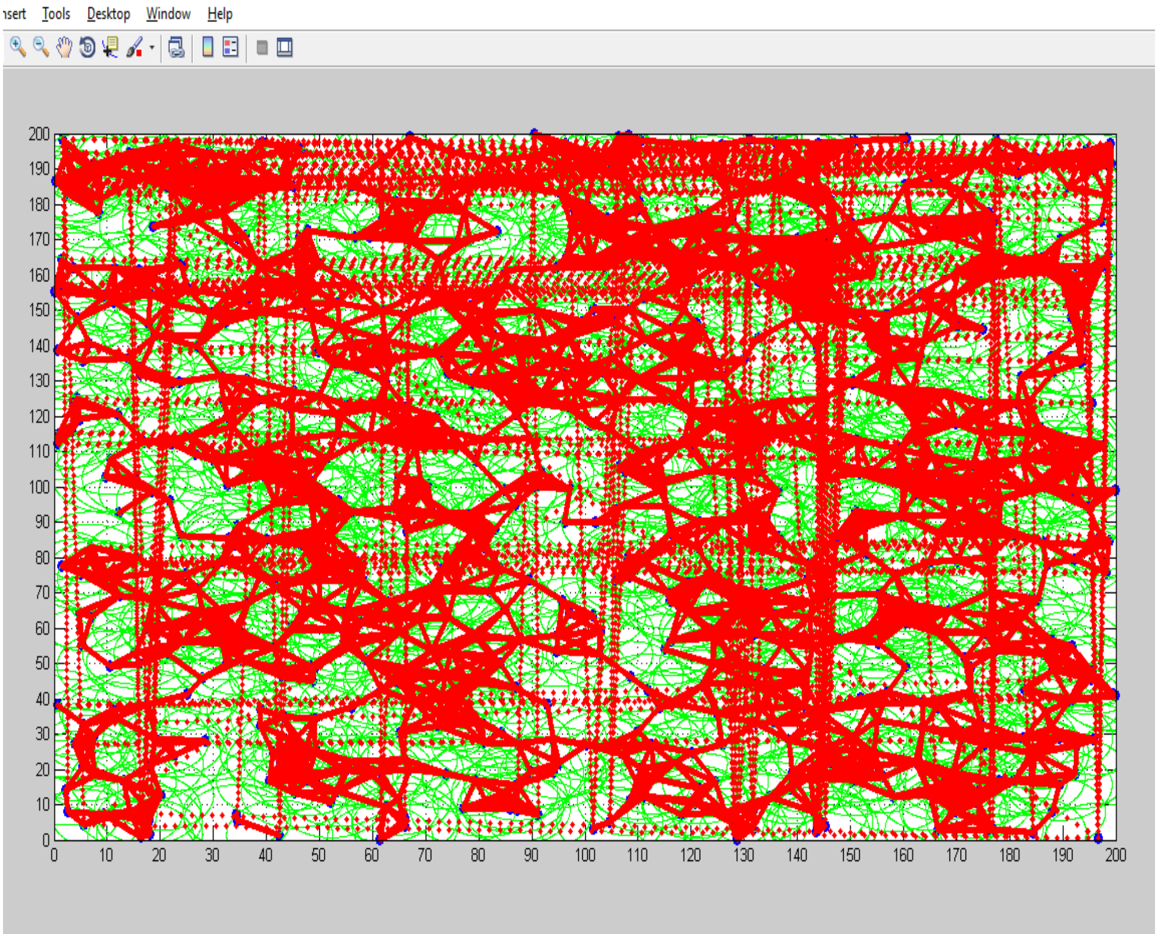

Figure-1. Network setup.

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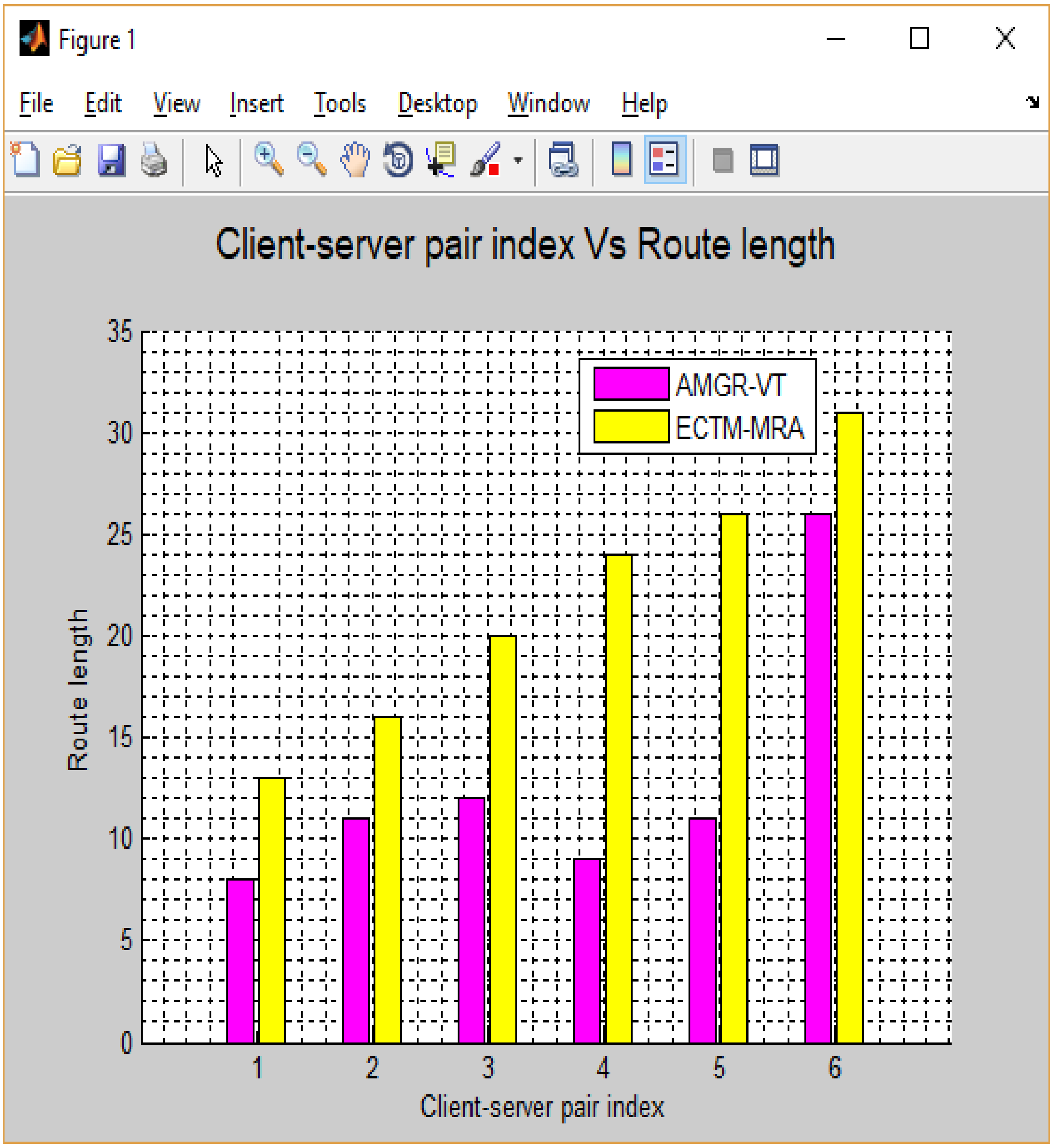

Figure-2. Client - Server pair index vs route length.

Table-2. Client - Server pair index vs route length.

	Route length (count)	
Pair index	**AMGR-VT**	**ECTM-MRA**
1	8	13
2	11	16
3	12	20
4	9	24
5	11	26
6	26	31

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ARPN Journal of Engineering and Applied Sciences

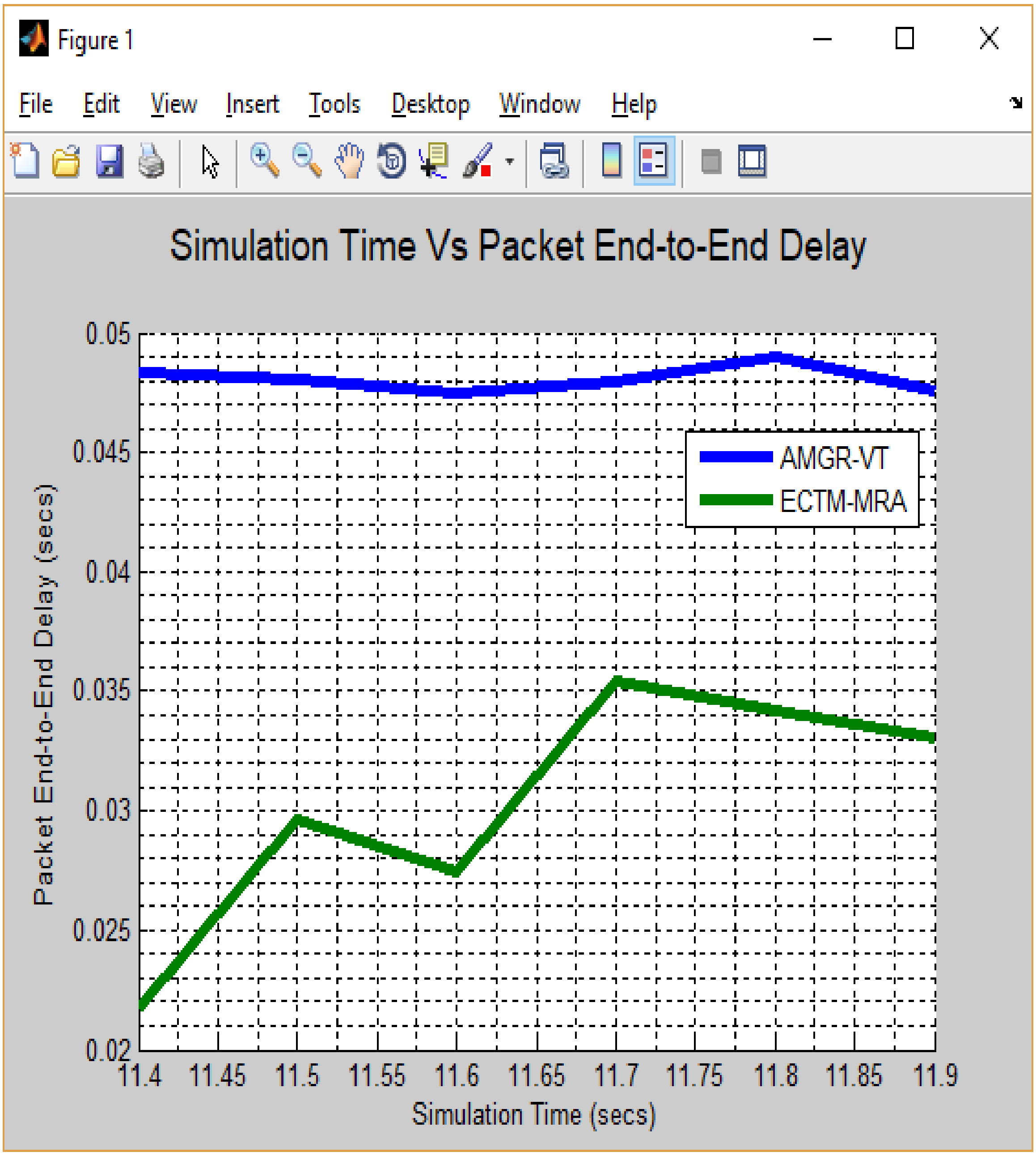

Figure-3. Simulation time vs packet end – to – end delay.

Table-3. Simulation time vs packet end-to-end delay.

	Packet end-to-end delay (seconds)	
Simulation time (seconds)	**AMGR-VT**	**ECTM-MRA**
11.4	0.0483	0.0218
11.5	0.0481	0.0296
11.6	0.0475	0.0275
11.7	0.048	0.0354
11.8	0.049	0.0342
11.9	0.0476	0.0331

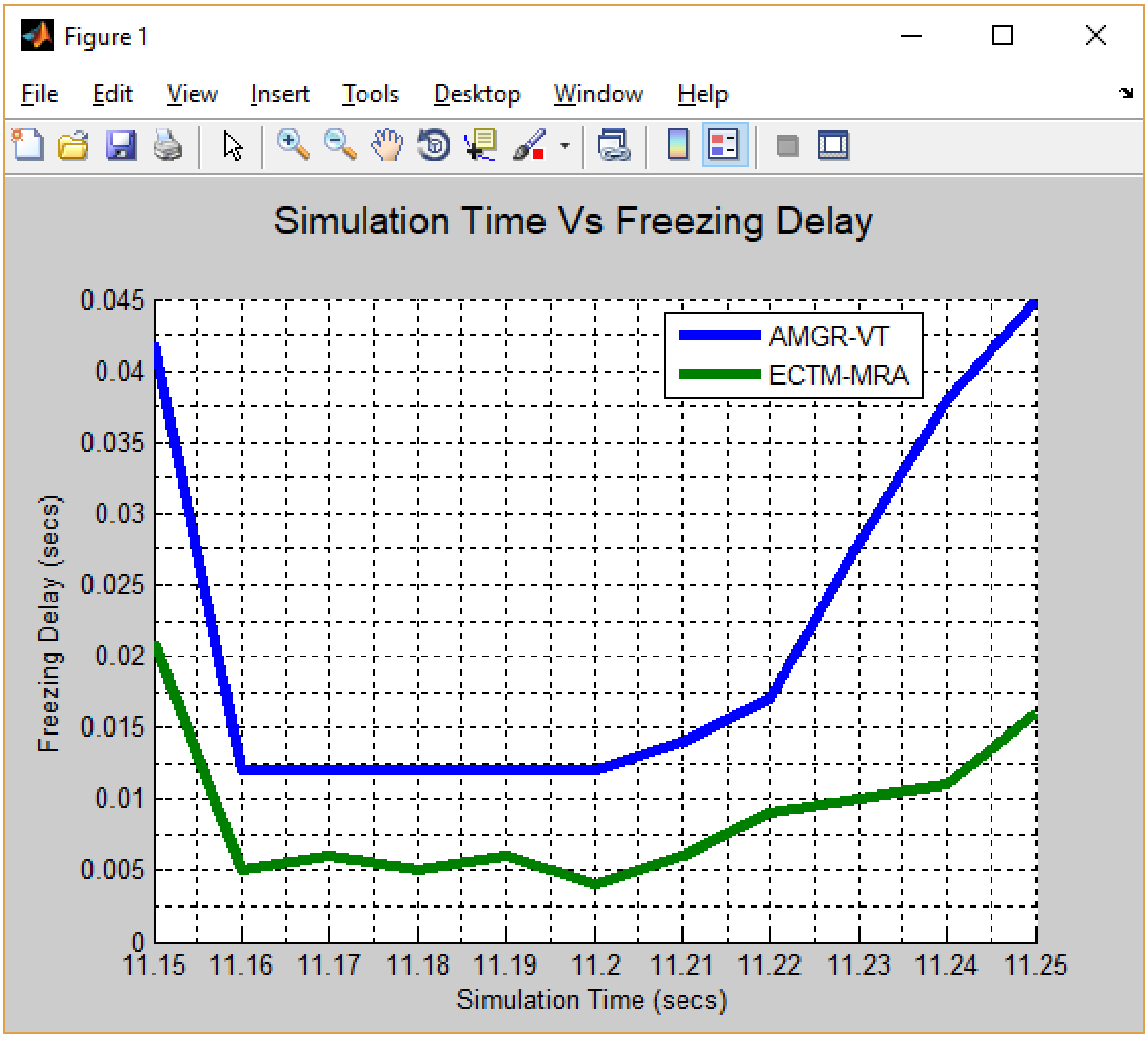

Figure-4. Simulation time vs freezing delay.

Table-4. Simulation time vs freezing delay.

	Freezing delay (seconds)	
Simulation time (seconds)	**AMGR-VT**	**ECTM-MRA**
11.15	0.042	0.021
11.16	0.012	0.005
11.17	0.012	0.006
11.18	0.012	0.005
11.19	0.012	0.006
11.2	0.012	0.004
11.21	0.014	0.006
11.22	0.017	0.009
11.23	0.028	0.010
11.24	0.038	0.011
11.25	0.045	0.016

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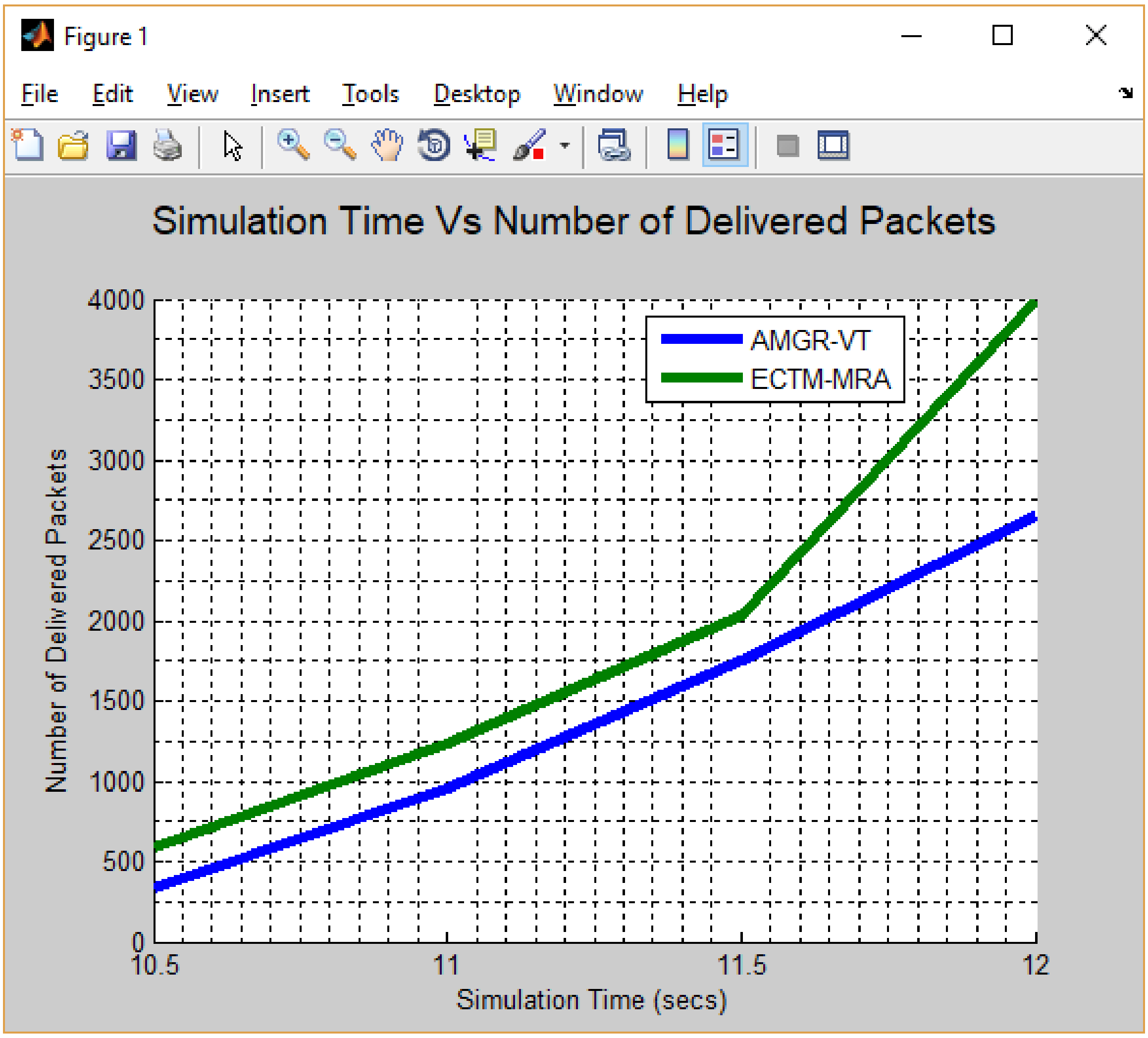

Figure-5. Simulation time vs number of delivered packets.

Table-5. Simulation time vs number of packets delivered.

	Number of packets delivered (packets)	
Simulation time (seconds)	**AMGR-VT**	**ECTM-MRA**
10.5	332	591
11	958	1229
11.5	1759	2033
12	2658	3991

Table-6. Packet loss ration of protocols.

Packet loss ratio (count)	
AMGR-VT	ECTM-MRA
8.65	1.01

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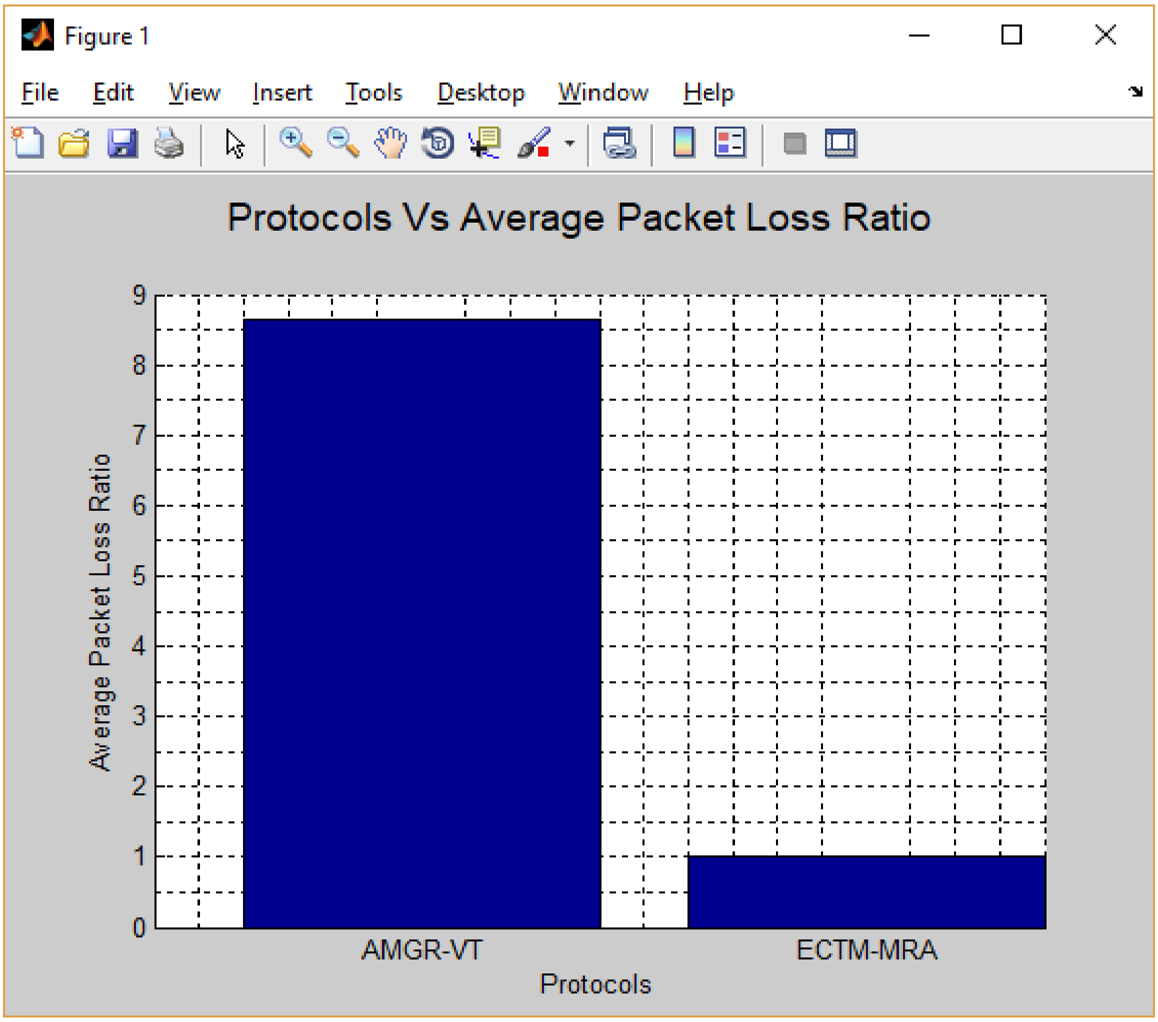

Figure-6. Protocols vs average packet loss ratio.

5. CONCLUSION AND FUTURE WORKS

VANET is one of the primary applications of ad hoc network. Transmission of video and live streaming is a challenging research issue. This paper proposes energy competent transmission mechanism based routing approach (ECTM-MRA) for reliable video transmission in multimedia VANETs. The proposed ECTM-MRA has two stages. The first stage of ECTM is data gathering that contains a video review table and the vehicle information table. The second stage of ECTM is associated to the video streaming method that obtains the parameters such as vehicle's degree, residual energy and transmission speed to determine low delay and resource responsive routes for streaming the video. Simulations are carried out and the results projects that the proposed ECTM-MRA performs better in terms of route length, packet end-to-end delay, freezing delay, number of delivered packets and packet loss ratio.

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