A QoS-Sensitive Video Uploading Scheme with Economic Perspective in VANET

***Abstract*—Video streaming uploading applications will be more and more important in Vehicular Ad Hoc Networks (VANETs). The fundamental challenge is how to provide service efficiently with the constraints of limited resources, high mobility, and opportunistic contact, while satisfying the application with quality-of-service (QoS) and system charge requirement. To address this issue, a QoS-sensitive video uploading scheme with economic perspective is proposed. In this scheme, the vehicle-to-infrastructure communications and vehicle-to-vehicle communications are cooperated to forward video streaming continuously from the moving vehicles to a fixed network. We make use of vehicle mobility prediction for the vehicles to find the best relay node in order to improve the QoS, and an optimal selection for RSU clusters and gateway-vehicles is used to reduce the charge for video uploading. Experimental results show that the proposed scheme achieves good performance for the startup delay, video packet loss and interruption ratio, while keeping a low application charge.**

Keywords—vehicular networks; video streaming uploading; quality of service; application charge

I. Introduction

Vehicular ad hoc networks (VANETs) are considered to be a promising techniques during the last decade for its capability of supporting many interesting applications, varying from driver assistance, vehicle collision warning, cooperative cruise control, etc [1][2]. Among all these applications, video streaming uploading applications will attract more attentions in the near future. It allows users, like traffic controllers, to better understand the nature of appointed vehicles and conditions surrounded. Video uploading can also be very useful in other fields like remote emergency treatment, crime scene tracking and social network information sharing, making it very useful in city intelligent systems.

Since video streaming over VANETs requires a stable streaming rate to keep a fluent playback, the packet loss rate and data delivery delay should be low enough to fulfill this requirement. However, due to the high mobility, channel fading and opportunistic contact of vehicles, packet loss and delay in VANET is a frequent phenomenon [3]. This situation would become even worse in streaming applications as the relay decision is based on beacons. Beacons are periodical messages carrying vehicle's information (e.g. velocity) useful for relay decision. While beacons are time-discrete and the data delivery for streaming is continual, the problem arises. As the continually transmission are based on information in beacons which keep changing and the up-to-date one will only comes till the next period, the relay decision will often be short-sighted. Even if we can invoke the relay algorithm when we find the path is broken, the video playback in server may be already frozen, thus the user will experience an interruption.

Another problem we need to consider is the charge for application. Multimedia streaming services often occupy most of the traffic comparing with other applications in VANET. Even though the charge for using RSUs (e.g. WLAN) is cheaper than that for cellular networks (e.g., 3G), streaming services over VANETs would still cost more since video uploading applications often last for a long period of time even for several hours. Since different Network Service Providers (NSPs) bring different cost, an optimal selection for vehicles covered by cheap RSUs will reduce the total cost.

It should be noted that video streaming uploading applications are different from strict real-time video services used for safety applications such as overtaking assistance system in [4], as the latency constraints of video uploading services are usually not as tight as those safety services, which usually require a strict delay limited into hundreds of milliseconds from end to end. In our application, if the video streaming can be forwarded to the destination before the settled deadlines of presentation and the QoS metrics are satisfied, the service will be accepted.

In this paper, we propose a QoS-sensitive video uploading scheme with economic perspective, where the vehicle-to-infrastructure (V2I) communications and vehicle-to-vehicle (V2V) communications are cooperated to upload the video streaming continuously from a moving vehicle to the fixed network. We use vehicle mobility prediction for the vehicles to find the best relay to improve the QoS, and an optimal selection for RSUs and gateway-vehicles is made to reduce the total charge for application. This novel vehicles relay prediction and selection scheme for video streaming uploading services will be useful for analyzing the optimal decisions of designing the streaming services in vehicular networks from both the system QoS and economic perspectives.

The rest of the paper is organized as follows. Section II describes the network scenario and system model. In section III, the proposed video uploading scheme is presented. In Section IV, the simulation results of the proposed scheme are discussed in full details. Finally, we conclude the paper in section V.

This work has been supported by the National Natural Science Foundation of China under Grant No.60803138 and National Basic Research Program of China (973 Program) under Grant No.2011CB302505.

II. NETWORK SCENARIO AND SYSTEM MODEL

A typical video streaming uploading scenario for vehicular networks is shown in Fig. 1. We consider a VANET deployed in an urban environment. Roadside units (RSUs) owned by different NSPs are deployed along sides of the roads. Due to the relatively high deployment cost of roadside units and each RSU's limited communication range, the entire road cannot be fully covered by RSUs. In addition, RSUs will usually be deployed in places which have a high population density such as near commercial centers, so they will be situated adjacent to each others as a *RSU cluster* which contains several RSUs owned by different NSPs.

On-board-units (OBUs) are installed on the vehicles, which are equipped with positioning systems and wireless communication devices, so they can exchange their locations and accurately synchronize in time. The camera continuously captures the video streaming and encodes them into frames. After formatted into packets, they are transmitted into the server via V2V and V2I communications. A vehicle could access the RSUs via direct V2I or via multi-hop V2V communications depending on the RSU's coverage. A moving vehicle can also carry the packets for a short time and forward it to the next vehicle if none of the relay vehicles is found around. Considering the deadlines of presentation and routing overheads, there could only be limited hops of connection between the RSU and the source vehicle for video uploading. As the RSU coverage rate and the vehicle density are both high in urban environment, we set the maximum hop not exceed three to contact with the RSU before the deadline.

Each vehicle periodically broadcasts the beacon message, which carries the sender's ID, GPS position, current velocity and direction. The RSUs also periodically broadcast the beacon messages with vehicles in coverage. All vehicles know the position of RSUs as it is fixed. In our model, in order not to bring too much performance cost, the beacon intervals are set to three seconds. Considering there are limited hops of connection between the RSU and tagged vehicle, by exchanging the beacon messages periodically, each vehicle can therefore keep an updated list and synchronize for each one between the RSU and tagged one.

We assume the V2I communications use an IEEE 802.11 radio, and V2V communications use a Dedicated Short Range Communications (DSRC) radio. As in [5], we define the node transmission range as the maximum distance at which the expected packets error and lost ratio is still acceptable, and we denote the corresponding received power level by P, which is measured in dBm. In this paper, we set the maximum effective distance for V2I as 300 m, and for V2V is 150 m.

We denote the last hop vehicles which upload packets directly to RSUs as *gateway vehicles*, and transmission time between RSUs and video streaming server is ignored as the RSUs are often connected to the video server with high speed communication links. We only focus on the transmission procedure between the source vehicle and target RSU in our research. The multimedia content is considered to be a video sequence in the server, so once enough packets are received, the video will start and continuously playback.

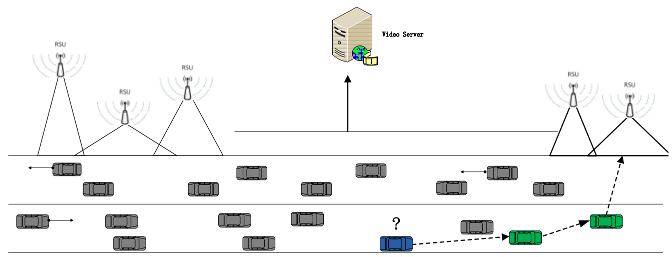


Fig. 1. Scenario of video streaming uploading for vehicular networks

We select Car Following Models (CFMs) to describe the vehicles' motion. CFMs are probably the most popular microscopic flow models in urban environments with many research works on it [6]. CFMs adapt a following car's mobility according to a set of rules in order to avoid any contact with the leading vehicle. In this mobility model, the acceleration a_n of a following vehicle n at any time t should be proportional to the perceived relative speed between leading and following vehicle, with the equation:

$$dv_n/dt = \gamma \cdot (v_{n+1} - v_n) \quad (1)$$

where γ is weight parameter representing the *sensitivity* of a driver, which can be acquired according to [7].

This mobility model is used to calculate the probability of connectivity between two vehicles, so as not to choose the relay vehicle which will often get out of the maximum effective distance during the transmission period. A precise description for the relay selection in this mobility model will be shown in details in section III.

III. VIDEO STREAMING UPLOADING SCHEME

In this section, we present our video streaming uploading scheme. We first present the metrics for application, and then the uploading scheme will be described in details with three steps. We focus on the protocols on the straightway and the intersection mode will be discussed by revising the protocol from the straightway mode.

A. Metrics definition in application QoS

We define four QoS metrics to quantify the performance of our proposed scheme.

- Packet loss rate: Let n be the total packets number received in video server while N is the number of all packets generated in source vehicle. The packet loss rate will be n/N. A low packet loss rate will bring a higher quality video. Note that both the overtime and disconnection of network will bring the packet loss.

- Startup delay: The startup delay is defined as the time interval between the generation of the first packet and when enough packets are received for playback in video server, both the packet loss and data delivery latency will influence the startup delay. Startup delay is a common metrics for video streaming applications in many researches as it reflects the time lapse before the users experience the services [8].

- Interruption ratio: Let t be the total interruption duration time while T is the entire service time of the application in playback. The interruption ratio will be t/T. The interruption ratio reflects the fluency of video playback in users' perspectives.
- Application charge: The application charge is defined as the total expense charged by all RSUs which are used by vehicles to upload the video streaming during the entire service period, where the RSU may belong to different NSPs.

B. Forwarding direction policy

Before we find the relay vehicle as the next hop to forward the video streaming, the preferred forwarding direction of packets must be decided first. If the expected packet forwarding delay and charge for RSU clusters at each direction could be obtained, each direction will be assigned a priority, where a smaller value has a higher priority. The tagged vehicle will then forward packets to relay nodes in the outgoing directions with the highest priority and applies forwarding scheme continually toward the target RSU to pass the packets.

The packet forwarding delay to the destination is not only related to the distance, but also to the vehicle density. For example, a low density may make the relay selection missing and increase the delay too. According to [9][11], we assume the inter-vehicle distances between the tagged vehicle and the gateway vehicle follow an exponential distribution, with a mean distance equal to 1/ρ, ρ denote the vehicle density in this region. The expected packet forwarding delay T between them will be expressed as:

$$T = (1-e^{-r\cdot\rho}) \cdot (s \cdot d)/r + e^{-r\cdot\rho} \cdot s/v \,. \qquad (2)$$

Where s is the distance between the tagged vehicle and the gateway vehicle, r is the maximum effective distance for V2V communications, d is the average one-hop packet transmission delay, and v is the average vehicle velocity on s. As gateway vehicle cannot be obtained at this stage, we select the one on the RSUs cluster edge which is nearer to the source vehicle in our estimation.

The direction with smaller expected delay is preferred as video streaming can be quickly forwarded to destination with more probability, which is important for video uploading QoS.

For charge estimation for RSU clusters, we divide the road within the communication range of RSUs into a number of segments. Suppose the RSU cluster coverage range is L along the road and the average speed is V in cluster area, we set the segments number m as:

$$m = \mathrm{L/V}. \qquad (3)$$

Each segment here means the distance where a vehicle moves along in one second. The expense vector of each RSU_i can be expressed as:

$$E = [e_{i1}, e_{i2}, e_{i3}, \ldots\ldots, e_{im}]^T. \qquad (4)$$

We assume wireless connectivity for RSU is in on-demand mode so the expense e_{ij} can be measured by cost/megabyte. If the segment j is not covered by RSU_i, e_{ij} will be set as ∞. For each gateway vehicle u, the traffic vector requirement can be expressed as:

$$S = [s_{u1}, s_{u2}, s_{u3}, \ldots\ldots, s_{um}]. \qquad (5)$$

Note that s_{uj} means the traffic transmitted in one second for each vehicle u, and the cost will only be produced in this V2I procedure. If a candidate gateway vehicle will not pass segment j in its transmission period, s_{uj} will be 0.

According to (4), assuming that the cluster has N RSUs, we can get the average expense C as:

$$C = \frac{1}{m}\sum_{\eta=1}^{m} \min\{ e_{1\eta}, e_{2\eta}, e_{3\eta}, \ldots\ldots, e_{N\eta} \} \quad (6)$$

As video streaming uploading applications are time-sensitive, the delivery delay must be fulfilled first, which should be assigned a highest priority. If T in both directions is less than the deadline t_{max}, then the charge will be considered and a cost-effective direction is selected to forward the packets.

C. Vehicles relay scheme

In relay selection process, for every video packet generated, the vehicle undertakes the path selection with identifying up to all possible relay nodes around. The same action is then undertaken by each of the relays to forward the streaming to destination. Each newly selected relay repeats the procedure until it is asked to forward the packets to the gateway vehicle which is in the coverage of the RSUs.

We modify tradition greedy geographic routing protocols [10] which are commonly used in VANETs for our relay scheme. In greedy mode, the packets move hop by hop through the network, at each node, a local decision is made to forward the packet to the neighbor geographically closest to the destination. We incorporate the vehicle mobility prediction into greedy geographic routing protocols to construct a *stable area* in which the vehicles can continually connect with the sending one for a longer time, and then the proper relay will be selected from it. To reduce the system overhead, we switch the relay node only when the selection algorithm can get a better path over which the QoS increases largely.

We used CFMs introduced in section II to describe the vehicle motion. As we can only get the instantaneous velocity at each clock end of interval by the periodic beacon, we make a prediction shown below to get the dynamic motion of vehicles and reduce the jitter of connection.

During each beacon interval, we predict for the acceleration a varying with time t following three conditions shown below:

$$a_t = \begin{cases} a_n + \lambda\ t & \text{if } v_{n+1} - v_n \geq \varphi_2, \\ a_n & \text{if } \varphi_1 < v_{n+1} - v_n \leq \varphi_2, \\ a_n - \lambda\ t & \text{if } v_{n+1} - v_n \leq \varphi_1 \end{cases} \qquad (7)$$

where a_n can be obtained according to (1), λ is a positive constant depending on the current distance to the leading vehicle, φ_1 and φ_2 are thresholds.

Suppose the vehicle n which would like to forward the packet has the velocity v_n at the beginning of beacon interval T, and the initial distance between the vehicle and its relay node is

Δd_{Tj} for every one hop neighbor *j*, we calculate the connection variance of them between the beacon interval t_T and t_{T+1}.

The moving distance for vehicle *n* can be expressed as:

$$d_n = \int_{t_T}^{t_{T+1}} (v_n + a_t t)\, dt \qquad (8)$$

From (7), a_t is also a function of *t*, so we can predict the moving distance in each beacon interval for both forwarding vehicle and all of its candidate relay nodes.

In each beacon interval, the distance between of the vehicle and its relay node will be:

$$\Delta d = \Delta d_{Tj} + (d_j - d_n) \qquad (9)$$

With (8) and (9), we get:

$$\Delta d = \Delta d_{Tj} + \int_{t_T}^{t_{T+1}} \left(\Delta v_{jn} + \Delta a_t t\right) dt \quad (10)$$

Note that Δd is dependent on the velocity difference. For example, if $v_{n+1} - v_n \geq \varphi_2$ and $v_{j+1} - v_j \leq \varphi_1'$, vehicle *j* is at front of vehicle *i*, then

$$\Delta d = \Delta d_{Tj} + \int_{t_T}^{t_{T+1}} \left((\lambda_j + \lambda_n) t^2 + (a_j - a_n) t + (v_j - v_n) \right) dt \; (11)$$

As we need to know the distance change with the time going on, we solve the inequality:

$$\Delta d_{Tj} + \int_{t_T}^{t_{T+1}} \left(\Delta v_{jn} + \Delta a_t t\right) dt \leq d_{max} \quad (12)$$

Where d_{max} means the maximum effective distance for V2V communication. By solve (12), we will get the duration time of connection, denoted as Δt, and the proportion of connection time will be:

$$P(\Delta d_j) = \Delta t / (t_{T+1} - t_T) \qquad (13)$$

We get a vehicle group in which each one fulfills $P(\Delta d_j) \geq \varepsilon$ for every possible relay vehicle, where ε is the threshold. If we set $\varepsilon=1$, it means the relay vehicles in this group are always in effective connection with the forwarding vehicle during the transmission period.

As the nodes near the tagged vehicle will always fulfill the inequality above, among this group, we selected the vehicles moving towards to the target RSU and geographically far from the forwarding vehicle, with a distance of lower threshold *d* to build the stable area, where *d* is decided by the vehicle density. The field outside of stable area could cause a frequent disconnection although it may be selected in greedy mode and the area nearer than stable area will bring a high delay. Finally, among the vehicles in stable area, the one with the maximum speed will be chosen.

To avoid the routing loop, we record the previous hops information to break the loop as in [11]. Before choosing a vehicle as the next hop, we check the record and select the one not used before. As there are limited hops during the transmission, it will not bring too much performance overhead.

The intersection mode will bring new problems as vehicles may turn a corner near the intersection. We revise the relay scheme in straightway mode to design the relay in the intersection. We give an example to illustrate the scheme in Fig.2. Vehicle A selects the vehicle B as the relay node and sends the packets to it, however, vehicle B turn right during the transmission. Hence, we make B forward the packet received from vehicle A to vehicle C when it turns, and it sends a message to A to inform this event. Then vehicle A forwards the packets to C if they are connected or start a new relay selection if not. The intersection mode can be very complex as there are some extreme cases. Due to the space limit, we will leave these optimizations as future works.

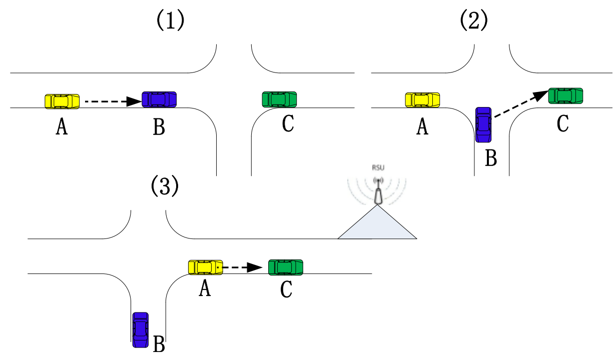


Fig. 2. Relay in intersection mode

D. Gateway vehicle selection

The objective of gateway vehicle selection is to minimize cost when forwarding the streaming packets to internet. While the expense only happens in the V2I communications, the gateway vehicles will bring different cost as they are covered by RSUs owned by different NSPs. If the RSU charges the vehicle for a high price, the cost will increase, so an optimal gateway vehicle selection scheme needs to be proposed.

We have formalized the charge for RSU clusters and traffic requirement for each gateway vehicle as vectors in (4) and (5), suppose there are *M* vehicles covered by RSU clusters which contains *N* RSUs, then the charge matrix for RSU clusters will be:

$$X = [E_1, E_2, E_3 \ldots\ldots, E_N]. \quad (14)$$

The traffic requirement matrix for vehicles will be:

$$D = [S_1, S_2, S_3 \ldots\ldots, S_M]^T. \quad (15)$$

Here, D is a $M \times m$ matrix and X is a $m \times N$ matrix, *m* is the segments number described in (4). We set the *vehicles charge matrix* as *Y*, and obviously we can get *Y* by:

$$Y = DX \qquad (16)$$

Y is an important matrix as each row in *Y* denotes the cost of a vehicle passing each RSU, and then the gateway vehicle we select to upload the video packet to RSU will be the one who has the minimal element in the matrix *Y*, while the connected RSU can also be gotten in this matrix from the column. Note that if the element is ∞, it means the vehicle cannot transfer all packets to a single RSU during its moving as it may be on the edge of the RSU and need a switch, which will not be selected here to avoid the switching cost.

A brief algorithm for video streaming uploading scheme is given in table 1 divided by three steps as description above. Computations for priority and metrics are not included in this table.

TABLE I. ALGORITHM FOR VEHICLES RELAY SCHEME

1. Forwarding direction policy

For each direction D, get the expected packet-forwarding delay T, t_{max} is the deadline for playing back in the application

```
if max{T_front, T_back} ≤ t_max
    get the RSU clusters' average expense C in each direction
        if C_front ≥ C_back
              D = D_back
        else
              D = D_front
        end if
else
    D = D_i , where T_i = min{T_front, T_back}
end if
```

2. Vehicles relay scheme

For the selected direction D, get the proportion of connection time $P(\Delta d_j)$ for vehicle j.

ε is the proportion threshold of connection in each beacon interval

d is the threshold of current distance between the vehicle and relay node

```
v_max = 0
for i=1→ Max Hop Num. do
      for Each vehicle j in one hop  do
      Check the current location of v_j.
        if v_j is in RSU's communication range
            Break the loop
        else
          find the vehicle always in connection during the transmission period
          if P(Δd_j) ≥ ε
             Check the location of v_j to get them near the destination
             if Δd_j ≤ d
               looking for the relay vehicle with the fast speed
               if  v_j ==v_max
                 Best Candidate ID = j
                 The relay is found, break the loop
               end if
             end if
          end if
        end if
      end for
end for
```

3. Gateway vehicle selection

For each gateway vehicle as the next hop, find the minimal element in the vehicles cost matrix Y

```
if y_mn is the minimal element in Y
      v_gateway = v_m
      RSU_best = RSU_n
end if
```

IV. PERFORMANCE EVALUATIONS

In this section, we analytically evaluate our integrated scheme and simulate the video streaming uploading in urban environment. To evaluate the performance of the uploading scheme, we compare our scheme with traditional greedy geographic routing in terms of the startup delay, the packet loss rate and interruption ratio. In the greedy geographic routing we compared, we suppose the vehicle will always choose the forwarding direction where the source vehicle has the smallest Euclidean distance to the RSUs clusters, and the packets will be always forwarded to the neighbor which is geographically closest to the destination until it reaches the RSU. We also evaluate the charge policy for our application.

To represent our vehicle prediction and charge optimization effect, we randomly select a vehicle to be the tagged vehicle and encoded a 3600 seconds CIF video sequence Foreman into MPEG4 data format at 30 fps. Each frame is packetized into packets of 1024bits and sent to the network hop by hop. As in [12], we use a variable bit rate (VBR) data source as video frames usually have different size in MPEG encoding scheme.

Let RSUs clusters be located with 1.5Km from each other. In each cluster, there are three RSUs deployed randomly owned by different NSPs. The roads are bi-directional, and each direction has two lanes. We consider three traffics density situations, which are sparse (180 cars/Km), medium (240 cars/Km) and dense (300 cars/Km). As it is in urban environment, we set the maximum speed as 60km/h, and we test seven different velocities, which are 30 km/h, 35 km/h, 40 km/h, 45 km/h, 50 km/h, 55 km/h and 60 km/h for each density. Simulations will run with different combinations of density and speed. Each vehicle selected at the intersection may turn left or right with probability $p = 0.1$. Other settings in our experiment are described in system model of section II.

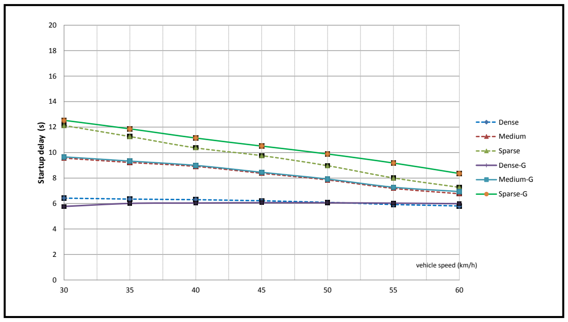
The performance results are shown in Fig. 3.

From Fig. 3(a), we find that with vehicle speed increasing, the startup delay will decrease slightly as the vehicles can carry and forward the packet more quickly. We notice that our scheme is better than greedy forwarding in high and medium speed, which means our method works well for the startup delay in an unstable environment. We also notice the low density will bring a high startup delay as fewer vehicles can be selected to forward the packets thus the delay will be larger. In addition, a random selection for tagged vehicle also plays an important role as far RSUs will increase startup delay largely in sparse condition.

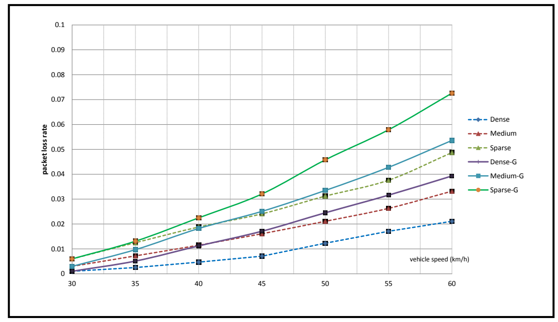
In Fig. 3(b), we compare our relay scheme with greedy geographic forwarding in terms of packet loss rate, and we notice that our scheme is better than greedy forwarding, especially in sparse scenario. The gap between two schemes also becomes larger with the speed growing similar to Fig. 3(a), as in high velocity the vehicle will easily move out of the transmission range, thus the prediction will be necessary.

The interruption ratio evaluation is shown in Fig. 3(c). We notice that with different combinations of density and speed, the interruption ratio will be always fewer than 3% using our scheme, which means our uploading service offers a pleasant user experience. Note that the interruption are not corresponding to the packet loss rate directly, as the loss may outbreak for a short time and lead a serious interruption while the total loss rate is still low. These relationships for quality-of-service requirements are discussed in [13].

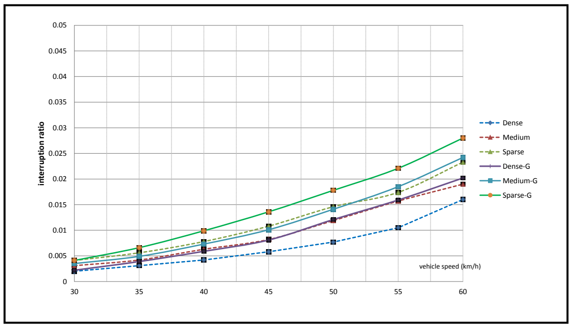
The charge comparison for service is shown in Fig. 3(d) where the data is normalized, and we observe the cost increases with the time lasting for one hour. It can be seen that with our scheme, the charge will reduced about 25% compared with uploading without economic perspective, which is very attractive for users.



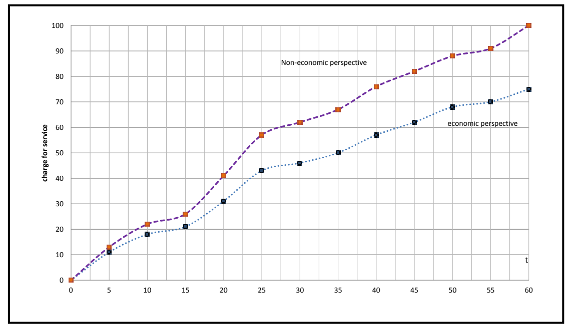
(a) Startup delay



(b) Packets loss rate



(c) Interruption ratio



(d) Charge for service

Fig.3. Simulation result for the video uploading scheme ("-G"means the Greedy forwarding mode)

V. CONCLUSION AND FUTURE WORK

In this paper, a novel QoS-sensitive video uploading scheme with economic perspective in urban VANET scenarios has been proposed. We use vehicle mobility prediction to find the best relay node to reduce the startup delay, packet loss rate and interruption ratio, thus improving the QoS of the application, and an optimal selection is made to find the best RSU cluster and gateway-vehicles to reduce the charge for video uploading. Experimental results showed that the proposed scheme achieves good performance, while the total application charge is also reduced largely.

As future work, we will focus on a more precise prediction for the relay of vehicles, with considerations of buffer management, transmission rate and encouragement factor. In addition, routing loops and relay in intersection mode will be solved with a comprehensive method to cover the whole condition.

REFERENCES

[1] X. Yang, J. Liu, F. Zhao, and N. Vaidya, "A vehicle-to-vehicle communication protocol for cooperative collision warning," in Proc. Int. Conf. MobiQuitous, Aug. 2004, pp. 114–123.

[2] Y.-C. Chu and N.-F. Huang, "Delivering of Live Video Streaming for Vehicular Communication Using Peer-to-Peer Approach," Proc. IEEE Mobile Networking for Vehicular Environments (MOVE Workshop), pp. 1-6, May 2007.

[3] W. Chen, R.K. Guha, T.J. Kwon, J. Lee, and Y.-Y. H. Wirel, "A Survey and Challenges in Routing and Data Dissemination in vehicular ad-hoc networks" IEEE Int. Conf. on Vehicular Electronics and Safety, Sept.2008. pp.328 - 333.

[4] Vinel, Belyaev, Egiazarian, and Koucheryavy, Y. "An Overtaking Assistance System Based on Joint Beaconing and Real-Time Video Transmission." IEEE Trans. Veh. Technol,Jun. 2012, pp.2319 -2329

[5] P. Barsocchi, G. Oligeri, and F. Potortı`, "Frame Error Model in Rural Wi-Fi Networks," Proc. IEEE Int'l Symp. Modeling and Optimization (WiOpt), WiNMee/WiTMeMo Workshop, Apr. 2007,pp. 41-46.

[6] Panwai S and Dia H "Comparative evaluation of microscopic car-following behavior." IEEE Trans. on ITS vol.6(3), 2005 pp.314–325.

[7] Brackstone M and McDonald M "Car-following: A Historical Review. Transportation" Research Part F: Traffic Psychology and Behaviour vol.2(4), 1999, pp.181–196.

[8] Mahdi Asefi, Jon W. Mark, and Xuemin (Sherman) Shen "An Application-Centric Inter-Vehicle Routing Protocol for Video Streaming over Multi-Hop Urban VANETs." IEEE International Conference on Communications (ICC), June,2011 ,pp. 1-5

[9] G.H. Mohimani, F. Ashtiani, A. Javanmard, and M. Hamdi. "Mobility modeling, spatial traffic distribution, and probability of connectivity for sparse and dense vehicular ad hoc networks." IEEE Trans. Veh. Technol, vol.58(4), 2009. pp.1998–2007.

[10] Brad Karp, H. T. Kung."GPSR: Greedy Perimeter Stateless Routing for Wireless Vehicular Ad Hoc Networks," Proceedings of the 6th annual international conference on Mobile computing and networking (MobiCom), 2000,pp. 243 – 254.

[11] Jing Zhao and Guohong Cao, "Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks." 25th IEEE International Conference on Computer Communications. Proceedings(infocom), 2006,pp. 1 – 12

[12] F.H.P. Fitzek, B. Can, R. Prasad, and M. Katz, "Traffic Analysis and Video Quality Evaluation of Multiple Description Coded Video Services for Fourth Generation Wireless IP Networks," Wireless Personal Comm., vol. 35, nos. 1/2, pp. 187-200, 2005.

[13] T. Luan, L. Cai, and X. Shen, "Impact of Network Dynamics on User's Video Quality: Analytical Framework and QoS Provision," IEEE Transactions on Multimedia, vol. 12, Jan. 2010., pp. 64 –78.