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Live Media Streaming in VANETs using Traffic Flow

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Abstract

Multimedia streaming is a trend in VANETs infotainment service with establishment of infrastructure and communication standards. This paper considers the scenario of live multimedia streaming multicast to vehicles. We propose the relay selection scheme to deliver media streaming with stable link to improve QoS (quality of service). Through evaluation, our proposed scheme is able to have video delivered with a satisfying delay and acceptable loss ratio.

***Keywords**: Multimedia, VANETs, Stable link, QoS*

1. Introduction

Recent progress in academic and industry makes VANETs (Vehicular Ad Hoc Networks) feasible: the establishment of Intelligent Transport System (ITS) infrastructure, availability of on-board units (OBUs) for vehicles, and communication standards such as IEEE 802.11p and IEEE 1609.1-4 for inter vehicular communications. Through inter-vehicle communications, vehicles can exchange data with each other, including multimedia data.

It is a very attractive service to stream live video contents to driving vehicles. Such service can provide opportunities to benefit many applications in VANETs. (i) Driving assistance and safety applications: when a car accident or road work happens and live video about this area can reach vehicles approaching this area so the drivers can drive cautiously or simply choose another route. (ii) Business or entertainment applications: road-side businesses, such as hotels and restaurants, can use content-rich video streams to broadcast advertisements to nearby drivers. (iii) Military or scientific applications: vehicles on duty can broaden their view by receiving video from other vehicles' video cameras.

The current approach to broadcast traffic conditions to driving vehicles is to deploy bulletin boards on roadside, and several lines[1] of text is displayed about traffic conditions. This approach can provide traffic information to some extent, but it is far from satisfactory for the following reasons: (i) it may suffer extensive delay; (ii) it is not customizable for different drivers on the road; (iii) it can only provide very brief information; (iv) very limited coverage area, this service can only reach vehicles that drive past these bulletins.

Imagine a scenario where a vehicle is equipped with an LCD screen at the front panel which displays video information of the remote region. This screen serves similar functions as the rear view mirror, but it can display traffic conditions from any spot on the road. With a glimpse of this screen, the driver can obtain desired information without

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interrupting normal driving. We use video instead of text for the following reasons: (i) video provides content rich information; (ii) text needs human intervention as it often needs people to capture, organize and summarize to generate descriptive text information; (iii) video needs shorter time to understand, a glimpse of the video screen is enough to grasp the road conditions, while reading information takes significantly longer time.

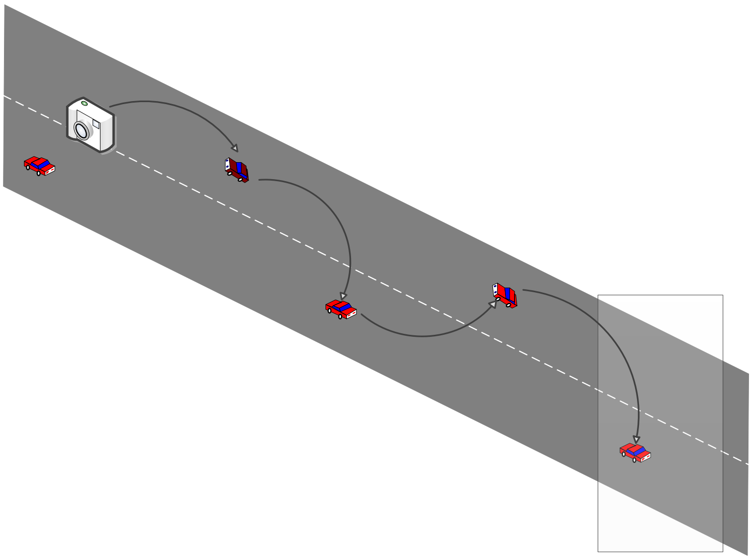

Figure 1. Scenario

In this paper, we propose an approach to select forwarders considering the traffic conditions such as velocity, density of neighbor vehicles. Our method ensures stable links to deliver media data and quality of service. Figure 1 illustrates scenario for our method to streaming media. The video camera is set on attractive places such as intersections on urban, roadwork on highway. The camera captures traffic and sends them in media data. The bypass vehicle carry those media data to the area where drivers can obtain some information about current traffic from those media data, and then take action. That not only benefits driver to save time on diverse traffic, but traffic safety to avoid the second disaster.

The rest of this paper is organized as follows: Section II introduces relation work. In Section III, we describe the design of our system. In Section IV, we propose a media-streaming scheme. Then, extensive simulation results and comparisons are provided in Section V. Section VI concludes this paper.

2. Related Work

There are researches about media streaming. In SMUG (Streaming Media Urban Grid) [1], a media access point and the stream is fed to SMUG-capable nodes and is distributed across a VANET [1]. Each node may dynamically be selected as a forwarder, and its transmissions are scheduled according to a TDMA scheme. Each forwarder is scheduled in a certain time slot to transmit, and neighboring forwarders would be assigned different time slots according to the proposed graph coloring technique so as to minimize the chance of collisions in adjacent areas [1]. However, if SMUG-capable nodes are not dense enough, it would result in high packet loss, due to hard to meet any forwarder around. Besides, SMUG can only be applied in TDMAbased ad hoc networks, and it requires all nodes to follow its specific TDMA channel access scheme.

NCDD (Network Coding based Data Dissemination) [2] utilize random network coding techniques for data dissemination in VANETs. Each group node broadcasts its resource information to its one-hop neighbors periodically. In addition, group nodes exchange coded pieces instead of original pieces. If a coded piece is linearly independent of the coded pieces in a nodes local memory, then the node stores it. A node has to collect enough pieces then for decoding [3]. Note that network coding based approaches require group nodes periodically broadcast its collected pieces' information and retrieves uncollected pieces. Broadcast packets are not always received by neighbor nodes, and the concurrent transmitting nodes may suffer from severe collision [4].

V3 [5] provides a scheme to retrieve the scene of a certain area to an interested vehicle. The application scenario of V3 is that for a certain region on the road, the scene can be captured by one or more video sources, such as pre-deployed stations or vehicles passing by. The interested vehicles, called receivers, continuously trigger the video sources to send the videos back. However, this scheme is not suitable for group communications, because each receiver establishes a path to a source, which is inefficient. Besides, the packet forwarding protocol in V3 only considers vehicles in a straight road, such as a highway. Therefore, V3 is not feasible to urban scenarios where a road map has many road intersections. Stream is generated from a certain point (e.g. a roadside access).

Both VAPER (Vehicles Adaptive Peer-to-peer Relay Method) [6] and ZIPPER (Zero-Infrastructure P2P System) [4] form clusters among vehicles, and multimedia stream are relayed between clusters. Every vehicle periodically sends a beacon to neighbors to form clusters. There are a cluster head and also a cluster tail in a cluster. Each vehicle in the same cluster is one hop neighbor to each other. The main difference between VAPER and ZIPEER is that VAPER pushes a multimedia stream, while ZIPPER pulls a multimedia stream. In VAPER, the cluster head broadcasts a multimedia stream to its cluster members, and then the cluster tail relays the multimedia stream to the cluster head of the subsequent cluster. ZIPPER assumes a multimedia stream is composed of blocks, and a vehicle can retrieve blocks from other vehicles if available. If a required block were found, the block would be sent back. However, both clustering schemes require all vehicles to form clusters and maintain the clusters all the time, regardless of whether cluster members want to receive multimedia stream. And both clustering schemes consider only straight roads, such as highways. They did not consider urban scenarios where the map has many road intersections. That is, the clustering schemes cannot be directly applied to urban VANETs.

However, those methods above to choose next forwarders do not take into account the current traffic flow. We propose an approach to select forwarders considering the traffic conditions such as velocity, density of neighbor vehicles. Our method ensures stable links to deliver media data and quality of service.

3. System Design

We assume vehicles carry GPS and obtain real time information about physical position. The memory in every vehicle is assumed to be unlimited. Table 1 illustrates our system. In network part, we propose multicast framework to deliver media streaming, the goal of which is to achieve high speed and reliability. In application, we propose data management scheme to enable media data to achieve data replication and fault tolerance. However, the design and implementation of application layer is beyond the scope of this paper.

Table 1. System Architecture

Application/ Data Management
Network/ Multicast Framework

4. Multicast Framework for Media Streaming

In our multicast framework, there are three roles: source/camera, forwarding vehicles, and vehicles in destination area. The following will describe them in details.

4.1. Source/Camera

We regard a source as a static vehicle, a stopped police car for example. A source can obtain information about bypassing vehicles through Hello messages and maintain a neighbor list. When capturing media, the source will send those media in format shown in Table 2. Timestamp is the time stamp of media when camera captures it and is used to control the media into special time interval since we are not interesting on outdated media data. Destination is physical coordination of area where media data will be delivered and is used to indicate the direction of forwarding media and control the range where media data will stay. Media data refers to real media data captured by the source.

Table 2. Format for Media Data

Timestamp	*Destination (x, y)*	*Media Data*

4.2. Forwarding Vehicles

Forwarding vehicles refer to those vehicles between source and destination area. They use carry-and-forward to spread media data. The forward strategy is as following. Forwarding vehicles multicast media data to their neighbor vehicles with longer link duration. Those neighbors store media data and then multicast the media data again. There is a case needed to consider: if the traffic is low, vehicles will broadcast rather multicast to increase the change of delivering media data. When vehicles with media data find their transmission range overlap the destination area, they will broadcast media data to vehicles.

4.3. Vehicles in Destination Area

When vehicles in destination area receive media data, vehicles are to process media data. Vehicles need to sort those media data according to time stamp. Those outdated media data will be filtered. Vehicles in destination area will exchange media list in Hello message and obtain new media data from neighbors. That will make vehicles collect more media data.

5. Evaluation and Performance

5.1. Experiment vs. Simulation

The first method we can do is practical experiment. We can install a video camera on traffic light and Wi-Fi device on each vehicle. Obviously, it’s not easy to implement. So we choose to use simulation. We can use traffic simulator to generate vehicles movement trace and use network simulator to do communication.

Since our long-term purpose is to employ this protocol in the realistic vehicle network, we should prove the feasibility of our simulation. We have to solve these issues when evaluating from simulation to practical experiment. First is vehicle ID. In simulator, we can easily get each vehicles ID, because in our simulator SUMO, every vehicle is identified by a unique unsigned integer. In practical experiment, we can use MAC address to identify each vehicle. For location and speed, they can be got easily by using GPS and speedometer. Also, the code of some network simulators can be deployed on the hardware. Based on these factors, we can do more realistic practical experiment, which will make the result more convinced.

5.2. Simulator Developing

To evaluate the performance of the proposed multimedia transfer protocol, we have designed and implemented our proposed framework in a vehicular traffic simulator and a wireless network simulator. The vehicular traffic simulator we used is the SUMO (Simulation of Urban Mobility) [7], which is a space continuous microscopic simulator for vehicular traffic. The SUMO simulator is a C++ based, highly portable, microscopic road traffic simulation package designed to handle large road network. It is open source and licensed under the GPL.

For wireless network simulator, we choose to use NS-3, which is a discrete event-driven network simulator for Internet systems, targeted primarily for research and educational use. It is being developed under GNU GPLv2 license and it is freely available for both use and development. It is not an updated version of NS-2, but a totally new simulator. Besides that it has more effect and save more time in simulation, it also has those differences from NS-2: (i) python bindings in replacement of OTcl in the simulation configuration; (ii) possibility to analyze simulation traces in Wireshark; (iii) possibility to integrate with real systems in order to provide better support for researchers to transition from simulations to real tests; (iv) inclusion of well documented attribute system.

5.3. Simulation Setup

As the Figure 2 shows, our simulation scenario is an urban road with an intersection, which assuming there is a video camera on it. This video camera is responsible to take the whole view of the traffic information for each direction. In the simulation, we choose a targeting area on the road to the intersection, in which all vehicles require the video captured in the intersection.

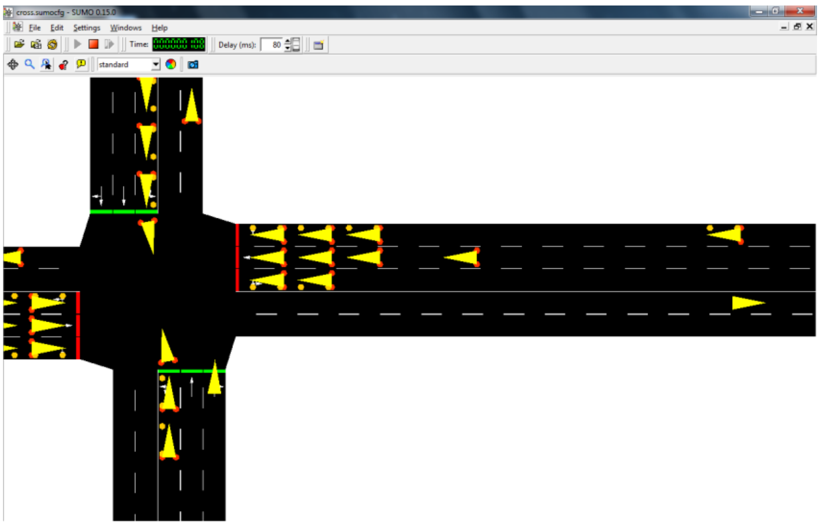

Figure 2. Simulation Scenario: Urban Road

For comparison, we use three kinds of cases according to different number of vehicles: 50 vehicles for sparse traffic case, 80 vehicles for normal traffic case and 120 vehicles for dense traffic. Table 3 is the configuration of simulation in SUMO and NS-3.

Table 3. Simulation Configuration

Parameter	Value
Vehicle Number	50(sparse), 80(normal), 120(dense)
Topology Size	1000m × 1000m
Targeting Area Size	200m × 200m
Acceleration	1 m^2/s
Deceleration	5 m^2/s
Speed Limit	10 m/s
Lane Number	2, 3
Minimal Gap	2 m
Transmission Range	110 m
Send Interval	2 s
Video Packet Size	20 MB
Simulation Time	2000 s

5.4. Evaluation Metrics

We define three QoS (Quality of Service) metrics to quantify the performance of the proposed protocol.

- **Startup latency.** The startup latency is defined as the time from the start of media stream to the time the first receiver begins to play the media. Smaller startup latency results in better QoS.
- **Average play delay.** This metric is defined as the average delay for stream playing compared to the original stream in the source.
- **Loss ratio.** We define loss ratio to describe the average quality for stream playing. It is the percentage of the lost video pieces during the transmission.

5.5. Results Analysis

We test three vehicle density cases: sparse, normal and dense, with the number of vehicles is 50, 80 and 120, respectively. For each case, we repeat the simulation for 10 runs to get the average.

Figure 3 gives the video startup latency as the simulation running. We found that as the number of vehicles around the intersection increase, the startup latency becomes less. In addition, in the case of sparse traffic, the video startup latency can still be less than 5 seconds. Even though drivers receive out dated video data, it is still useful to aid to make driving decisions.

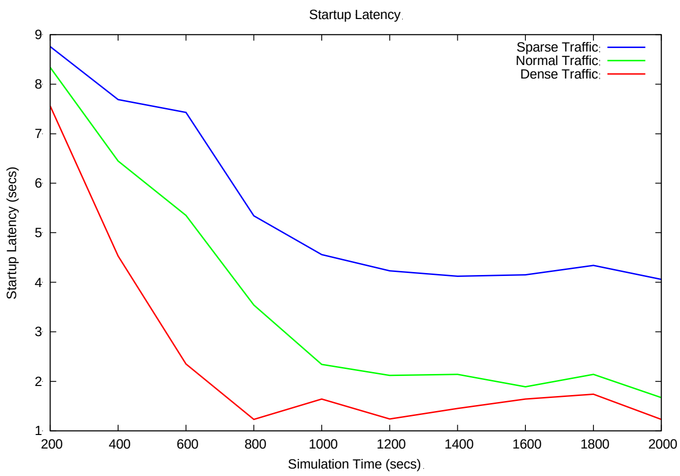

Figure 3. Startup Latency

Figure 4 shows the average play delay of each video piece as the advance of simulation running. We found that after warm up time, the play delay is keeping same around 0.5 second, which is an acceptable value for most applications in VANETs.

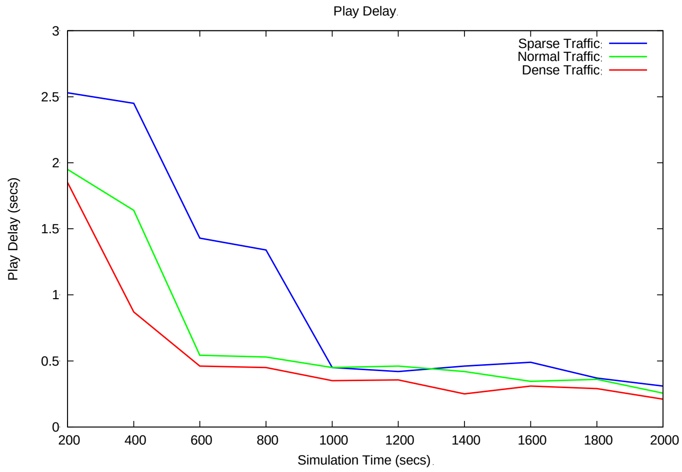

Figure 4. Play Delay

Figure 5 indicates the trend of loss ratio with each traffic density. We found that normal traffic density has smallest loss ratio. The other two situations have higher loss ratio because that sparse traffic density results in losing connectivity at most time and transmission collision in dense traffic.

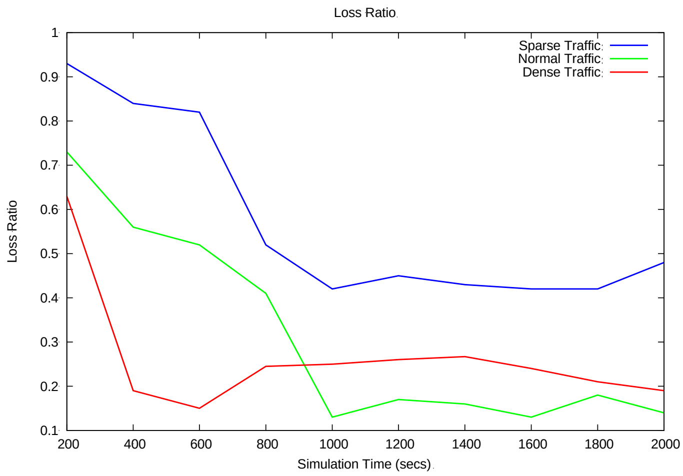

Figure 5. Loss Ratio

6. Conclusions

This paper explores the feasibility of live multimedia streaming by using traffic flow in urban VANETs. First, to enlarge the coverage and increase the video download speed, we have proposed a simple yet effective relay selection algorithm to facilitate inter-vehicle relay. Second, through exchange of media data message between vehicles in destination area , media data can be replicated and consistent. Through simulation, we found that our proposed scheme for multimedia streaming is able to deliver media data in a satisfying delay and acceptable loss ratio.

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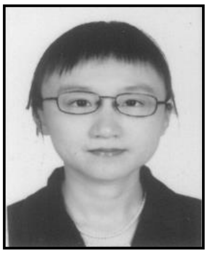

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