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2013 2015

A Novel Integrated Solution to Improve the Performance of Vehicular Content Delivery

A Novel Integrated Solution to Improve the Performance of Vehicular Content Delivery

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ITS Intelligent Transport Systems

With the develop of intelligent transportation systems and mobile networks, the vehicular networks have been paid much attend in both academic and industry field. In such kind of vehicular networks, how to spread contents including the urgent disaster warning and traffic information to drivers during driving becomes a new challenge.

We develop a novel cost model and design a content centric network architecture for vehicular networks to improve the load balance. Based on the analysis of access pattern and update, we show a proposal to control the consistency. In addition, we study the caching mechanism and present a new storage solution.

transportation systems vehicular networks multimedia contents

１．研究開始当初の背景

Nowadays, the intelligent vehicles have been widely used as an important tool and partner for us. With the rapid advance of intelligent vehicles, the vehicles are not the equipments just for transportation, it has been paid much attend in both academic and industry field.

It is reported that almost 90% of vehicles will be connected wirelessly by 2020. The vehicular networks have emerged as a promising research field to be applied to real life. The above challenges have attracted the attention from many researchers. Research groups from University of Southern California and MIT showed some of the latest results on the design of vehicular networks. TOYOTA and General Motors also make effort to develop real system applications and international standardization.

Especially, in the above vehicular networks, it has the need to spread multimedia content. Instead of the conventional data such as text-file, various content including pictures, audio and video need to be delivered over the vehicular networks, where the urgent disaster warning and traffic information can be delivered to drivers during driving. With the expanding scale of Social Networking Service (SNS) and Peer to Peer (P2P) applications, there is an increasing number of vehicular content to be delivered.

２．研究の目的

There exist Infrastructure to Vehicle (I2V) communication systems and Vehicle to Vehicle (V2V) communication systems in the existing vehicular networks, where the content is delivered based on IP address. However, with the advance of wireless communication, SNS area such as parking area becomes a possible unit to join vehicular networks.

For example, the walkers in the road can communicate with a roadside unit (RSU) to obtain the warning message by his mobile phone. The parked vehicles in the parking area can also help distribute content with RSU. Besides, the content centric architecture is also advocated to deliver vehicular content as the content can be controlled without relying the IP. Therefore, there come new issues for the vehicular networks to deliver content.

To design the efficient vehicular networks, there still lack of the integrated proposals. The related theoretical analysis, algorithms and implementation experiments have not been studied thoroughly. Therefore, an integrated and novel solution should be studied from the viewpoints of multimedia processing, mobile networks and vehicular communication.

Based on the theoretical analyses on the arrival of vehicles and mobility in social area, we study the characteristics of vehicles and vehicular contents. Next, based on the analyses, we propose an integrated and novel solution to design the vehicular networks to provide the requested content. In addition, we carry out experiments to show that the performance of the proposed solution can improve content delivery over the vehicular networks.

３．研究の方法

We consider a new network architecture to provide moving host/vehicles with contents by using the RSUs and social communities such as parking area. The RSUs are placed long the road to enhance the communication with moving vehicles and social communities. Based on the different access distribution and network topology, the relationships among the units in the vehicular networks are analyzed.

The cost model for content delivery in vehicular networks is developed based on the related parameters including the node density, vehicle distance, driving distance and available connection time. According the placement of RSU and parking area, the moving vehicles can request and obtain vehicular content through roadside unit and parking area.

Based on the cost model and the related parameters, our proposal can determine the

place to obtain vehicular content. The proposal can make decision for the content provider (roadside unit or parking area) to provide the requested moving vehicles with the wanted content.

Then, the proposal can construct the delivery route to deliver the content from the source to the destination of requester. If the replica in the parking area can provide moving vehicles with the satisfied content, the request needn't contact the RSU, where the load balance of the vehicular networks can be improved.

Vehicular networks improve the performance by keeping the vehicular content on a group of geographically distributed sites including RSUs and social communities such as parking area. With the development that vehicular networks can keep the dynamically changing contents, it is important to control the consistency of contents. For example, the vehicular networks need to keep the replicas of various contents including weather forecast, disaster warning and traffic status, to provide the moving vehicles when requested.

We study the consistency control of replicas on different sites based on the cost during the delivery of updated content among different units (roadside unit, moving host or parking area). After the optimization of the cost based on the related parameters including network topology and content properties, we evaluate our method and verify its efficiency.

The storage of cache is widely used by moving vehicles, RSU, and moving host, to store the frequently accessed content which may be used for the next possible request. However, Due to the limited cache capacity, it is difficult for the vehicular networks to keep caching all replicas of contents with the increasing number of content to be delivered. When the cache in the vehicular networks is fully occupied by contents, some replicas need to be removed to make room for new content.

Based on the analysis of content population and demands of quality of service, we study the hybrid caching methods. Both the characteristics of access frequency, period and fresh status are taken in consideration. If a given content is predicted to be interesting for a given requester, it can be stored in advance to reduce the response time when this content is requested.

We also introduce the content centric architecture to the vehicular network. The content store with the caching buffer is used to improve the caching performance. Base on the analysis of pending time and forwarding information, the content store can keep the replicas efficiently with the pending interest table and forwarding information base.

４．研究成果

We test the hit ratio by comparing the proposal with different methods. The hit means that the requested content can be provided by keeping replicas in vehicular networks when this content is requested by vehicles. Hit ratio is calculated by the ratio of hits to the number of requests in the vehicular networks.

From the result in figure.1, it can be known that the proposal can obtain better hit ratio than other conventional methods. It is because that the replicas in the parking area can be stored based on the access pattern and traffic status in the vehicular networks. The replicas in the parking area can be provided timely to the requesters.

Based on the theoretical analysis and experiment results, we can confirm that the proposed model and network architecture are efficiently for the vehicular networks. Instead of using the conventional Vehicle communication systems and Vehicle to Vehicle communication systems, our network architecture can apply the resource of social communities such as parking areas to join the delivery of vehicular contents. The presented method of consistency control can manage the replicas which are stored in different places in the vehicular networks. By using the storage in the vehicular networks, the caching mechanism can efficiently cache content and provide caching space for the newly coming content.

Based on the content centric mode, the caching methods are also studied by taking the status such as pending interests and forwarding information into consideration.

As for the future work, we will consider the extension of the proposal to the environment of Internet of vehicles towards the fifth generation (5G) networks. In such 5G scenario, as the requirement such as the data transmission is higher than the current vehicular networks, more discussions are needed.
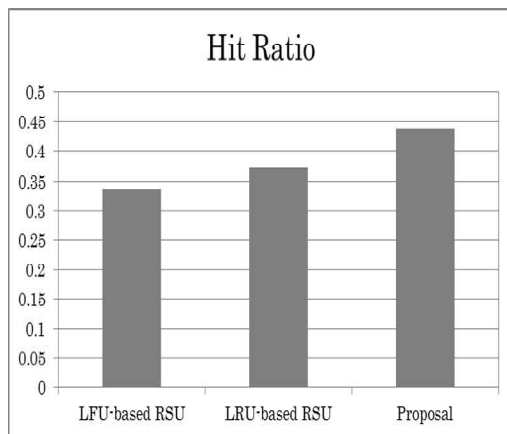

Figure 1: Comparison of Hit Ratio

５．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

合計　5件：

〔学会発表〕（計　4件）

① Suphakit Awiphan, Takeshi Muto, <u>Zhou Su</u>, Jiro Katto, "Outbound face selection considering response time and buffer usage for CCN adaptive video streaming". Proceedings of CSCN, pp.181-186, Tokyo,Oct.2015.（査読あり）
DOI：10.1109/CSCN.2015.7390441

② <u>Zhou Su</u>, Pinyi Ren, Xiaoying Gan,"A novel algorithm to cache vehicular content with parked vehicles applications",

Proceedings of IEEE ICC 2014, Sydney, Australia, Jun, 2014.（査読あり）
DOI：10.1109/ICC.2014.6884224

③ Danyang Zhang, Fan Li, <u>Zhou Su</u>,"A distortion estimation based packet scheduling strategy for H.264 video over wireless networks", Proceedings of ACM RACS, pp.267-272,2013, Montreal, QC, Canada, October, 2013.（査読あり）

④ <u>Zhou Su</u>, Yu Wang, Jiro Katto, "Content Caching using Parked Vehicles in Vehicular Networks", IEICE Society Conference, BS-7-38,Fukuoka, Sep, 2013.（査読なし）

〔雑誌論文〕（計　1件）

① Yichen Wang, Pinyi Ren, Feifei Gao, <u>Zhou Su</u>, " A Hybrid Underlay/Overlay Transmission Mode for Cognitive Radio Networks with Statistical Quality-of-Service Provisioning", IEEE Transactions on Wireless Communications Vol.13(3), pp.1482-1498, 2014.（査読あり）
DOI：10.1109/TWC.2013.010214.130797

６．研究組織

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