Demand-based Location Dependent Data Dissemination in VANETs

Susumu Ishihara
Graduate School of Engineering, Shizuoka University
3-5-1 Johoku, Naka-ku
Hamamatsu, Japan
ishihara@ishilab.net

Nobuhiro Nakamura
Graduate School of Engineering, Shizuoka University
3-5-1 Johoku, Naka-ku
Hamamatsu, Japan
nobu@ishilab.net

Yuya Niimi
Graduate School of Engineering, Shizuoka University
3-5-1 Johoku, Naka-ku
Hamamatsu, Japan
niimi@ishilab.net

ABSTRACT

We propose a framework for efficiently disseminating large data items associated to locations where they are produced by vehicles and desired by drivers of different vehicles in a VANET. The framework consists of a scheme for aggregating drivers' demand for location dependent data using soft-state sketches, a scheme for understanding the condition of data dissemination, and a strategy for selecting data to be transmitted according to the aggregated demands and the condition of the existence of neighboring vehicles which have the same data.

Categories and Subject Descriptors

C.2.2 [**Computer-Communication Networks**]: Network Protocols—*Routing protocols*

General Terms

Algorithms

Keywords

ad hoc networks, data dissemination

1. INTRODUCTION

If a driver can obtain a picture a place where he/she wants to go, he/she can easily know the current condition of the place and make a new driving plan to avoid traffic jams. Especially, if a service providing such an experience can be used in everywhere without relying on road and/or communication infrastructure, it will give much benefits to drivers. Using vehicular ad hoc networks (VANETs) will be a solution for the purpose since it does not rely on existing communication infrastructure.

Disseminating large image and video data to drivers using VANETs, however, is not easy. Of course, simply disseminating large picture data to all vehicles that are going to move to the position where the picture has been taken will incur large traffic. In addition, if multiple vehicles which have taken pictures send the different picture data to all vehicles which might need the pictures, the bandwidth of the VANET will be easily exhausted even if an effective data dissemination protocol is used. Thus efficient schemes to reduce traffic for disseminating images/videos which are produced by multiple vehicles is required.

In this paper, we propose a framework for efficiently disseminating large data items which are associated to locations where they are produced by vehicles and desired by drivers of different vehicles in a VANET (Figure. 1). We call such data *location dependent data*. In short, the proposed framework provides a way for demand-based many to many data dissemination. The framework consists of a scheme for aggregating drivers' demand for location dependent data, a scheme for understanding the condition of data dissemination, and a strategy for selecting data to be transmitted according to the aggregated demands and the condition of the existence of neighboring vehicles which have the same data.

Since the proposed framework disseminates only selected data according to aggregated demands from multiple vehicles and avoids duplicate transmissions of the same data from multiple vehicles, it can effectively use the communication resources in VANETs. Though effective schemes for many to many data dissemination in wide-area VANETs have been proposed, they are designed for smaller data such as traffic status and free parking lot information[1][2] compared with pictures and videos.

2. DEMAND-BASED LOCATION DEPENDENT DATA DISSEMINATION

The strategy used in the proposed framework is leveraging an efficient scheme for disseminating small data from multiple vehicles such as soft-state sketches[2] so that vehicles can understand the geographical distribution of demands to point of interest (POI) and who have the data related to the POI, and then disseminating location dependent data according to the collected information. The framework of the demand-based location dependent data dissemination consists of three components, *Demand Map*, *Supply Map*, and *Data dissemination engine*.

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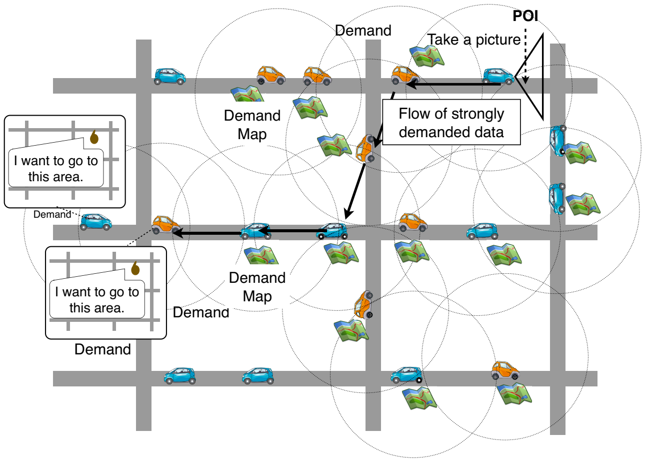


Figure 1: Demand-based location data dissemination in a VANET.

2.1 Demand Map (Dmap)

A demand map (Dmap) is a matrix that stores the strength of demands from a region to a POI. Figure 2 illustrates an example of a Dmap. Dmap is maintained at each vehicle. If a vehicle issues a new request to a POI, it updates its own Dmap so that the map reflects the new request, and the vehicle broadcast a portion of Dmap including the updated information by piggybacking it on a beacon. If a vehicle receives a portion of a Dmap from its neighboring vehicles, it updates its own Dmap according to the received information.

Each of requests issued by vehicles will lose its effect with time because the vehicle that has issued the request will leave the original position. Thus Dmaps have to support the temporal variation of demands. One of naive approaches for this purpose is to store the list of pairs of the ID of a vehicle that issued a request and its timestamp as an entry of the Dmap for each pair of a demand source region and a POI. However, it makes the size of the Dmap very large.

To effectively handle demand which lose its effect with time, we popose to use soft-state sketches proposed in [2] as a data structure for Dmap entries. The soft-state sketch is a data structure which has an ability to approximate aggregated values from different data sources instead of carrying specific values. In addition, it can handle the time to live of each data item.

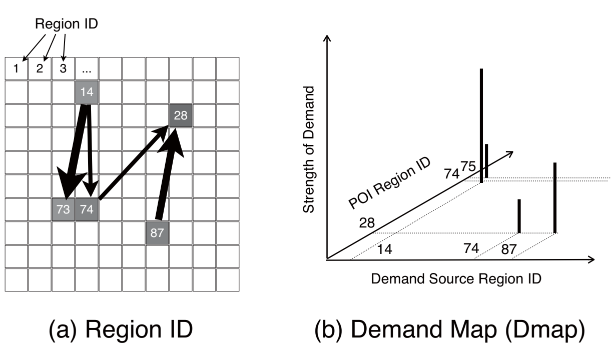


Figure 2: Demand map.

Note that the size of regions for demand sources regions and POIs do not have to be the same. If the size of a region for a POI is large, a data item which related to the region might be different from what the driver has requested to the POI. Thus, the size of regions for POIs should not be large. On the other hand, if the size of a demand source region is small, it will be difficult to aggregate multiple demands from different vehicles at different positions in the region. In addition, if the size is sufficiently large, a vehicle will be able to receive the requested data even if the vehicle has moved from the position where it has issued the request since the data should be disseminated within the region. Thus the size of regions for POIs should be small and one of demand source regions can be large.

2.2 Supply Map (Smap)

A supply map (Smap) is a table holding approximate numbers of vehicles that have copies of location dependent data items related to each POI. This information is used by each vehicle to determine whether it should send copies of location dependent data related to a POI if there is a strong demand to the POI. To share information for making supply maps, each vehicle periodically broadcasts a list of data items that it holds. Receiving the broadcasted list, each vehicle updates its Smap so that each entry of a POI hold the number of vehicles that have data items related to the POI.

2.3 Data Dissemination Engine (DDE)

Each vehicle has a data dissemination engine (DDE), which periodically selects and broadcasts a suitable data item from its local database of location dependent data items that it has received. According to the Dmap, the DDE on a vehicle assigns a high priority to a data item if the current position of the vehicle is on a suitable route between the position related to the data item and regions with strong demands in terms of multi-hop data transmission including store-carry-forward strategy. The DDE, however, lowers the priority if it knows there are many neighbors that have the same data item according to the Smap. As for concrete algorithms for data transmission, various effective schemes such as network coding based ones[3] and ones leveraging the road structure[4] can be used.

3. PRELIMINARY SIMULATION RESULTS

We conducted simulation of a simplified model of the proposed framework using a wireless network simulator, Sce-

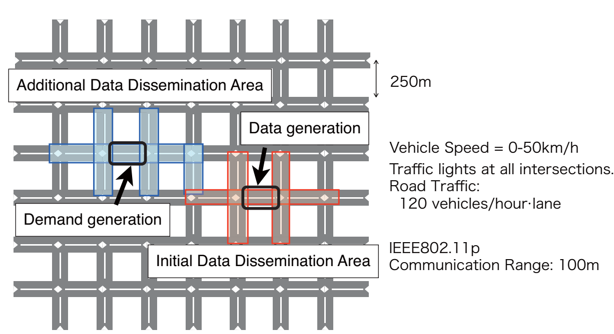
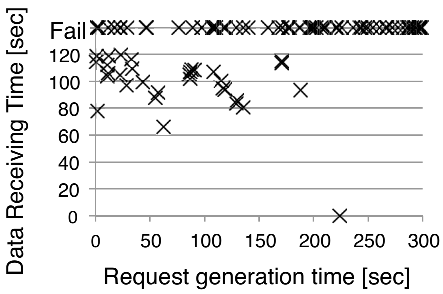
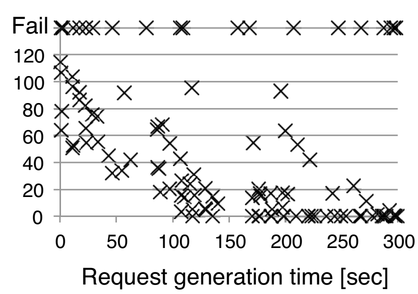


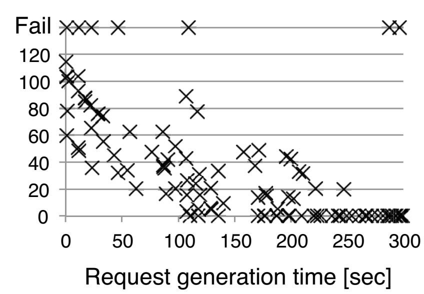
Figure 3: Road map used for simulations.



(a) No adaption of data dissemination area



(b) Data dissemination area is adapted to demands



(c) Data dissemination area is whole map area

Figure 4: Simulation results of a simple model of demand-based data dissemination

Table 1: Request success ratio and data traffic.

	Success Ratio	Traffic
(a) No additional data dissemination area	0.26	76
(b) Adaptipve data dissemination area (Proposed)	0.81	129
(c) Data item is disseminated to all the area	0.92	592

nargie by Space-Time Engineering[5] and a road traffic simulator, SUMO to illustrate the effectiveness of adaptively forming flows of delivering location dependent data according to the geographical distribution of demands. In the simulation model, we assumed that only vehicles passing through a road segment generate demands for data related to one location and only one data item related to the location is generated only once. The copies of data item are disseminated to the road segment where the data item has been generated and its neighboring segments using RD method[4], in which a copy of a data item is broadcasted at each intersection and at most one vehicle is delegated to broadcast the data item at the next intersection which the vehicle encounters within the term of validity of the data item. If a vehicle receives a demand piggybacked on a beacon, it enlarges the data dissemination area so that it can cover the road segment where the demand has been generated and the road segments between the original data dissemination area as shown in Figure 3. Vehicles broadcast the data item following the RD method. The size of the data item is 1kB. The beacon interval is 0.1 seconds.

Figure 4 (a)-(c) show the relationship between the time when a request generated by a vehicle and the time between the issue of a request and the reception of the requested data item. (a), (b), and (c) present the results of a case where additional data dissemination area is not used, a case where the additional data dissemination area is used (Proposed), and a case where the data item is disseminated to all the area even if no vehicle receives demands respectively. Table 1 shows the success ratio of requests and the number of transmissions of the copies of the data item. These results present the strategy (b) corresponding to the proposed framework effectively improves the success ratio compared with a case where no additional dissemination area is used and achieves sufficiently high success ratio with less data traffic compared with a case where the copies of the data item are disseminated to all the area (c).

4. CONCLUSION

The framework of demand-based location data dissemination in VANETs is proposed, and the simulation results of the simplified case of the framework present that the proposed framework suggest the potential to achieve high accessibility to location dependent data with small amount of data traffic. We are now working on developing detailed design of the framework and simulation models.

5. ACKNOWLEDGMENTS

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