An Efficient Cluster-Based Dissemination Algorithm to Decrease Traffic Congestion and Delay in Vehicular Networks

Mildred Madai Caballeros Morales, Choong Seon Hong

Networking Lab. Dept of Computer Engineering, Kyung Hee University

madai@networking.khu.ac.kr, cshong@khu.ac.kr

Abstract

Vehicular ad hoc networks (VANETs) have recently caught the researcher's attention, due to VANETs promising impact regarding with the applications of Intelligent Transportation System (ITS). Currently, dissemination algorithms help to ensure the adequate performance of communication systems required by the applications of ITS. However, high mobility and constant changing topology in VANETs increase the congestion, which are challenges not fully addressed. Thus, we propose an efficient dissemination protocol based on an adaptable mobility-aware clustering algorithm, taking advantage of the mobility patterns and behavior of the vehicles to disseminate the information into the network through the cluster heads to reduce traffic congestion and communication delay.

1. Introduction

ITS applications are aimed to smart transportation, which are supported by VANETs. Consequently, the communication system within VANETs should be smart, being able to follow the patterns and behavior of the vehicles to disseminate the information at the appropriate moment, interest and geographic location.

Different data dissemination paradigms could be employed in VANETs, such as, flooding, epidemic, Event-oriented and Publish/Subscribe (Pub/Sub). Flooding strategy sends the messages to all the neighbors, often causing congestion in the network, an alternative solution to the congestion problem is the epidemic strategy, which informs only a certain peers, as the event-oriented (VESPA [1]) and the Pub/Sub strategies [2]. These algorithms disseminate the information mainly to subscribers, decreasing the congestion in the network and the amount of unnecessary copies. But, they do not take advantage of the patterns and behavior of the vehicles, such as the facts that the cars usually travel in groups, where the destination of the vehicles is a crucial factor to follow the group mobility and vehicular behavior. Thus, we propose an efficient cluster-based dissemination algorithm that takes into account the destination of vehicles, the current location, speed, relative destination and final destination of the vehicles as parameters to form the clusters and implements a Pub/Sub strategy to address the user's interest. Our algorithm disseminates the information through the clusters, delivering opportunely the information, avoiding bottlenecks in the Base Station (BS), enhancing the communication delay, reliability, low data delivery and congestion issues, making the vehicular networks more accurate and skillful.

The rest of the paper is structured as follows. Section 2 sums up approaches related to the dissemination algorithms. In section 3 we explain the scenario of the proposal. In section 4, the dissemination algorithm is described. Section 5 shows the Performance & Evaluation of the proposal. Finally, section 6 concludes the paper.

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2. Related Work

Flooding dissemination solutions re-broadcast the messages to all nearby vehicles making that the content servers become bottlenecks, increasing the congestion. A Hybrid Approach for content-based publish/subscribe in vehicular networks [2] is a protocol to disseminate information mainly to subscribers without affecting non-interested vehicles. It uses a Content-based Routing (CBR) and assumes that the final destinations of the vehicles are known. But it does not have an accurately mobility pattern to disseminate the information and assumes a storage space virtually unlimited, but, in reality the storage is limited. Similarly, VESPA [1] implements a system for data sharing to facilitate the information when the vehicles meet each other, sending the information only to the vehicles interested in certain events. The relevance of events is a key factor to disseminate data. However, this not considers the advantages of group mobility, when the cars travel together sharing the same geographic space and same interests.

3. Scenario

We consider an urban scenario with an Intelligent Transportation System (ITS) as shown in Figure 1, where vehicles share information about an emergency occurred in the main street. All the vehicles employ Global Position System (GPS) or Navigation System (NS). The vehicles are organized by clusters, where the cluster head (CH) is responsible of disseminate the information to the cluster members.

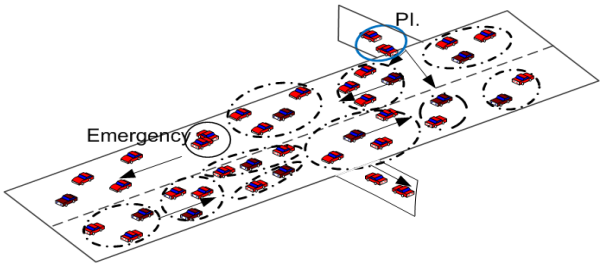

Figure 1. Urban Scenario

4. Dissemination Algorithm

The vehicles exchange periodically, each Δ t information to choose the CH and the affiliations to each cluster. The message includes vehicle's Id, current Location in terms of (x, y) position, speed, relative destination and the final destination in (x, y) positions. The dissemination algorithm works under the paradigm of publish-subscribe, employing meta-data to address the type and relevance of the publications [3] or priority data delivery [5]. The meta-data includes the home location, the creation time, time to live (TTL), the target location and the type of the publication, where the locations are managed by mapping the vehicle's latitude and longitude coordinates to points on the road. Moreover, the CHs have a list of other nearby CH, a list of its available publications and a list of the automatic subscription (generated automatically according to the current mobility) and custom subscription (generated according to the user´s interests).

The publications and subscriptions are constantly changing according with the current context or environment. Therefore, it is possible add and delete subscriptions and publications dynamically.

4.1 Dissemination Algorithm

Clustering formation considers the vehicle ' s destinations to follow the mobility patterns, solving the scalability, resource consumption, and load balance problem. The dissemination algorithm performs the next activities.

1. New Publication: When a CH has a new publication, it has to send the publication to its members first, checking the available subscriptions through the match function.
2. Match Function: This function compares the type, home location, TTL and the target location of the publication against to the subscription information. This comparison performs the verification of the TTL, verification of the diffusion area and the verification of the relevance.
3. Rebroadcast Publication: The CH spans the information to its CH neighbors. If any CH neighbor is interested in the information, the CH should be the carrier or custody [4] of the information unless the storage capacity of the CH is below the storage threshold. When the carrier is going out of the diffusion area (PI) has to forward the information to another CH, which is traveling towards the diffusion area.

5. Performance & Evaluation

To evaluate our proposal we implemented a simulation with 40 vehicles, in a space of 200 by 50 meters, where each vehicle belongs to a cluster, as shown in our scenario Figure 1. The simulation parameters were: transmission range of 50 meters and constant speed of 10 meters/sec. We simulated the spanning messages of one publication (an emergency Figure 1) until the publication reaches its target. Figure 2 shows the number of messages sent per second to different vehicles, comparing these results between the flooding technique and our solution. The results indicates that our cluster-based solution have better performance in terms of overhead; because, the information is sent only to the CH and it sends the information to its member only if they are interested. On the other hand, the flooding technique sends the information to all the neighbors. We compared our solution against flooding technique because VESPA [1] basically used this technique.

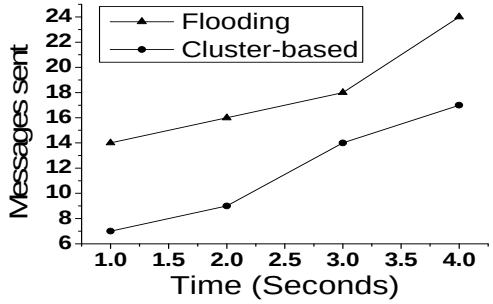

Figure 2. Overhead (Messages sent/sec)

6. Conclusion

The VANETs have to overcome the challenges related to communication delay, low delivery rate, reliability, scalability and congestion. Consequently, we propose an efficient dissemination algorithm based on clustering to take advantage of the fact that the vehicles form groups in the road and sometimes travel together long distance. This dissemination algorithm reduces significantly the overhead, because the communications within the network are through the CH, and the CH disseminates the information to its member or to other clusters. Our future work performs a large-scale simulation, using practical data.

7. References

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