Message Propagation in Vehicular Ad hoc Networks under free flow and congested flow Scenarios

Sara Najafzadeh, Norafida Ithnin, Shukor Abd Razak, Ramin Karimi

Faculty of Computer Science and Information System
University Technology Malaysia
Email :{ sara60, nithnin, sabdrazak, rakarimi1}@gmail.com

Abstract. *Vehicular Ad hoc Network (VANET), a subclass of mobile ad hoc networks (MANETs), is a promising approach for the intelligent transportation system (ITS). The key difference of VANET and MANET is the special mobility pattern and rapidly changeable topology. Temporary network fragmentation problem and the broadcast storm problem are further considered for designing Message propagation in VANETs. The temporary network fragmentation problem which happens in free flow caused by rapidly changeable topology influence on the performance of data transmissions. The broadcast storm problem in congested flow network seriously affects the successful rate of message delivery in VANETs. This paper presents a connectivity analysis under free flow and congested flow scenario in Vehicular Ad hoc Networks.*

Key words: *Vehicular Ad hoc Network, Message Propagation, free flow, congested flow*

1. Introduction

Vehicular Ad hoc Networks (VANET), a new technology to build a wireless network between vehicles (V2V). VANETs are based on short-range wireless communication (e.g., IEEE 802.11) between vehicles. The Federal Communication Commission (FCC) has allocated 75 MHz in 5.9 GHz band for Dedicated Short Range Communication (DSRC). DSRC was conceived to provide architecture for vehicles in Vehicular Network to communicate with each other and with infrastructure. In DSRC, subsequently specialized as Wireless Access in Vehicular Environment (WAVE), GPS-enabled vehicles that are equipped on-board units can communicate with each other.

VANETs are special class of Mobile Ad hoc Networks (MANETs).The major characteristics as compared to MANETs are following: components building the network are vehicles, dynamic topology, geographically constrained topology, vehicle mobility, frequently disconnected network and time-varying vehicle density [1]. VANETs could be playing an important role in future of vehicle communications. VANETs provide a variety of interesting applications like cooperative forward collisions, sharing emergency warning messages, weather and traffic data among vehicles. The past few years have seen increasing technological advances in Vehicular Ad hoc Network. There are some significant challenges in VANETs for broadcast protocol.

First, high mobility and dynamic topology of vehicles is one of the issues should be consider in VANETs. In order to high speed of vehicles, topology of VANET is sometimes changing. Due to the same reason the connection between nodes frequently could be changed rapidly and unpredictably [2]. So there is also a high degree of change in the number and distribution of the node in the network. Since vehicle mobility depends heavily on environment scenarios, the movement direction sometimes is predictable.

Second, high network density related to traffic density in Vehicular Network is the other challenge. Traffic density is high during peak hour in urban areas. Because of large number of vehicles , blindly flooding the packets which each node re-broadcast messages to its entire neighbor except the one it got the message from may lead to serious contention and collisions in transmission among neighboring nodes [3]. This problem is mostly referred to as broadcast storm problem [4].

Third, disconnection is another challenging issue in designing a data dissemination in Vehicular ad hoc network. Apart from the studies conducted in dense networks, there is a growing need to deal with disconnection in free flow conditions in Vehicular Ad hoc Networks. Where nodes are distributed sparsely, most of the time path between source and destinations may not exist. Traditional routing protocol can only transmit packet over end-to-end connected path so they would fail in such conditions. Although it is very hard to find end-to-end connection for free flow , the high mobility of vehicular networks introduces opportunities for mobile vehicles to connect each other during the movements. Connectivity has been studied for information dissemination in multihop networks [5].

2. Free Flow Scenarios

One of the most important limitations of V2V networks is end to end delay due to partitioning of networks. It is observed that carry-and-forward is the new and key consideration for designing all routing protocols in VANETs. With the consideration of multi-hop forwarding and carry and-forward techniques, min-delay and delay-bounded routing protocols for VANETs are discussed.
In this section, a connectivity analysis model has been employed. In this section vehicles categorized in two sections.

1) Informed vehicle:

This refers to the nodes which carries the information along a road.

2) Uninformed Vehicle:

Uninformed vehicles refers to the nodes which have not received information .whenever an uninformed vehicles enters to the radio range of an informed one, it becomes informed.

A distributed vehicle traffic model is used with the following assumptions:

- Poisson Arrival: Traffic moves on the road follows a Poisson process with an average rate equal to traffic flow rate(vehicles/time)
- Independent vehicle mobility: vehicle travels with a speed that follows a random distribution between [Vmin,Vmax].

Packets forward across a platoon via a single hop or multihop route, the number of middle hops depends on the number of vehicles in a platoon space of two adjacent vehicle named intra platoon spacing which calculate the Probability Distribution Function(PDF) of Sintra as follow:

$$fSintra = pr(q|q < R) = \frac{\lambda e^{-\lambda Sintra}}{1-e^{\lambda}R} \quad (1)$$

which R is the transmission range of equipped vehicles and λ is probability distribution of distance between equipped vehicles. By the assumption of undisturbed vehicle traffic model, vehicles passing a location (A) follows a Poisson process [6].
Assume n vehicles pass location A during (0, t].

$$P[X(t)<XIN(t)=n]=P[V*t<x]*P[v*(t-T)<X)^{n} \quad (2)$$

Where T and Ti has same distribution and V and has same distribution . Based on the assumption of poisson process .N(t) has Poisson distribution

(3)

Then we have

$$P[X(t)<X \text{ I } N(t)=n]=$$

$$P[V0*x, Vi *(t-Ti)<x \text{ for each } i=1,2,\ldots,n] \quad (4)$$

By the assumption of undistributed node traffic model, vehicle passing A follow Poisson process. Under this situation that n vehicles pass A during (0, t], the times at which these vehicles pass location A consider unordered random variables distributed both independently and uniformly in the interval (0,t],

Since T1, T2,…, Tn and V0, V1,…,Vn are (5)

$$P[X(t)< x \text{ I } N(t)=n] = P[V*t<x] * P[V*(t-T)<x]^{n} \quad (6)$$

Where T has the same distribution as Ti and V has the same distribution as Vi. Based on the assumption of Poisson process, N(t) has the Poisson distribution

(7)

Where λ is the traffic flow rate.

$$F_{X(t)}(x)= \quad (8)$$

Let V(t) be the message speed

(9)

E[V(t)], the average message speed is given in the above equation.(Figure 1)

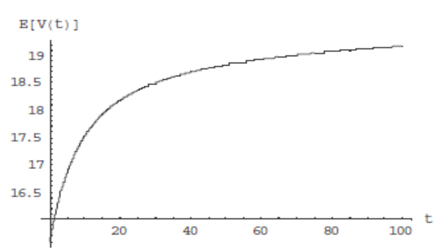

Figure 1- Average message speed

3. Congested Flow Scenarios

Besides, the temporary network fragmentation problem and the broadcast storm problem are further considered for designing routing protocols in VANETs. The temporary network fragmentation problem caused by rapidly changeable topology influence on the performance of data transmissions. The broadcast storm problem seriously affects the successful rate of message delivery in VANETs [7].

In this section a congested flow network will be modeled. For a given time t, we define Vp(t) to be the average message propagation speed during the interval[0, t] , p=X(t)/t. we define the long-term average message propagation speed vp to be

$$Vp = \lim_{t\to\infty} V(t) = \lim_{t\to\infty} x/t \quad (10)$$

So

$$Vp = \frac{E[Xt]+E[xf]}{E[T]+E[Tf]} \quad (11)$$

Where Xt (Xf) is the average distance traveled during forward phase and Tf is the time spent during forward phase. Figure 2 indicate numerical result related to average speed. we compare E[Xt] and E[Xf]. If the source and destination of a message are both within the same partition, there is an end-to-end (E2E) connection.

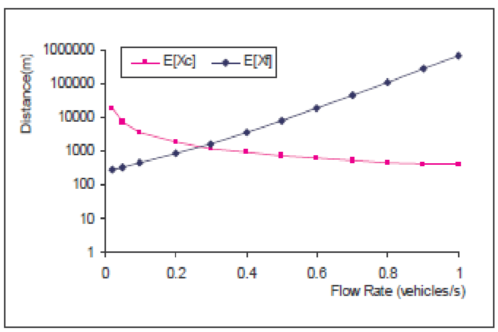

Figure 2- Numerical result

4. Conclusions

Besides, the temporary network fragmentation problem and the broadcast storm problem are further considered for designing routing protocols in VANETs. The temporary network fragmentation problem caused by rapidly changeable topology influence on the performance of data transmissions. The broadcast storm problem seriously affects the successful rate of message delivery in VANETs. To understand the characteristics of VANETs in different network densities we presented models for vehicle traffic where information is propagating in the direction of vehicle traffic flow. Then we develop a collection of models to study information propagation using V2V communications. These models can provide expected information propagation speed/distance over time.

References

1.Blum, J., Eskandarian, A., & Hoffman, L.:Challenges of inter-vehicle ad hoc networks,.*IEEE Transactions on Intelligent TransportationvSystems*, *5*(4), 347–351. doi:10.1109/TITS.2004.838218 (2006)

2. Chen, Y. S., Lin, Y. W., & Lee, S. L.: A Mobicast Routing Protocol for Vehicular Ad HocNetworks. *Mobile Networks and Applications(MONET).*New York: ACM/Springer. (2009)

3. Fukuhara, T., Warabino, T., Ohseki, T., Saito, K., Sugiyama, K., Nishida, T., & Eguchi, K. :Broadcast Methods for Inter-vehicle Communications System. *IEEE Wireless Communications and Networking Conference, 4*, 2252-2257. (2005)

4. Tseng, Y. C., Ni, S. Y., Chen, Y. S., & Sheu,J. P. :The Broadcast Storm Problem in a Mobile Ad Hoc Network. [WINET].*ACM Wireless Networks*, *8*(2), 153–167.doi:10.1023/A:1013763825347.(2002)

5. Naumov, V., Baumann, R., & Gross, T.:An Evaluation Of Inter-Vehicle Ad Hoc Networks Based On Realistic Vehicular Traces. In ACM International Symposium on Mobile Ad Hoc Networking and Computing, (pp. 108-119). . (2006).

6.Sara Najafzadeh, Norafida Ithnin, Ramin Karimi, “Analytical Analysis of sparse and Dense Vehicular Ad hoc Networks”, International Conference on Computer Science and Information Technology, Bangalore, India(2011)

7. Tonguz, O., Wisitpongphan, N., Bai, F., Mudalige, P., & Sadekar, V.: Broadcasting in VANET.*Mobile Networking for Vehicular Environments*,(pp. 7-12). (2007)