Application of Ad hoc Sensor Networks in VANETs (Vehicular Ad hoc Networks)- A Theoretical Approach

Anshika Upadhyay[1]

[1]Department of Electronics and Communication Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham Bangalore 560 035, India

***Abstract*—Ad hoc sensor networks are decentralized sensor networks in which every node can communicate with another without validation from any base device. An application of ad hoc sensor network is realized in VANETs which are vehicular ad hoc networks. It is unlike mobile networks and enables direct exchange of information among vehicles. It can support traffic efficiency and other safety related applications, thus, it can prevent life and injuries in the road traffic and can warn vehicles in dangerous locations such as an icy road and traffic jam. Hence, it is essential that the inter vehicle communication is reliable and robust.**

Index Terms* – *VANETs, Ad hoc networks, SNR

I. INTRODUCTION

Ad hoc sensor networks are essentially decentralized sensor networks in which each and every node can communicate with another without validation from any base device. An application of Ad hoc sensor networks is realized in VANETs. VANETs are vehicular ad hoc networks. The network follows a defined map and is not random (unlike mobile networks). Vehicular communication enables the direct exchange of information among vehicles. Such Vehicular Ad hoc Networks (VANETs) can support infotainment, traffic efficiency and, most important, safety-related applications. For example, vehicles can warn each other of dangerous locations like an icy road or the end of a traffic jam. Hence, saving life and preventing injury in road traffic is the driving force behind the development of inter vehicle communication. For these applications it is essential that the inter vehicle communication is reliable and robust.

Regarding the communication aspects, VANETs are confronted with diverse situations, ranging from very low vehicle densities up to very high vehicle densities. A lonely rural road, high speed autobahn as well as a congested metropolitan area are typical examples. In all of these situations, VANETs have to operate reliably.

The major challenges in VANETs are as follows:-

1) stringent power use restriction
2) stringent bandwidth restriction
3) inter symbol interference (ISI)
4) secure data transmission

Where the power and bandwidth restriction are taken care of by using orthogonal coding (OFDM), interference and security issues still prevail and by far are not absolutely addressed.

II. PROBLEM STATEMENT AND DISCUSSION

R. K. Schmidt, T. Kollmer, T. Leinmuller, B. Boddeker and G. Schafer [2] in their paper, have used the IEEE 802.11 standard and 5.9 GHz of frequency band so that external sources of noise are negligible except thermal noise and interference by other transmissions. They carried out extensive research work and analyzed the current state-of-the-art MAC protocol draft IEEE P802.11p which will be used in VANETs. They studied the reasons for packet loss and identified multiple causes belonging to both protocol and signal propagation issues. By an analytical discussion they pointed out the most severe ones. Afterwards, in a simulation study they conducted a quantitive analysis and evaluated the problem in dependence of particular parameters, i.e. beacon rate and packet size.

However, they made some observations as stated below that lack a clear reason:-

Interference of other vehicles has been found to be the main reason for packet loss. In situations where there is a high message density the effective reliable transmission range is reduced by up to 90%. It is also shown that the transition between stable communication to high packet loss occurs at particular slight increases of the offered load.

The significance of this problem is obvious: A reduction of transmission range, especially from an emergency vehicle results in a degradation of application performance. The lead time for a warning to driver is strongly reduced and hence is the benefit of such an application.

Also, In the paper, six possible reasons for packet loss are stated which are namely,

a) Fully Interfered Receiver : The SINR at the receiver is too low already from the beginning of transmission. The receiver may not even be able to sense the packet.

b) Classic Hidden Station : During the reception, the SINR deteriorates due to a colliding transmission. Packet loss occurs if the minimum SINR is not given anymore.

c) Far-Distant Hidden Stations : Many stations within interference range can together cause sufficiently high accumulated interference to result in packet loss.

d) Hidden Station in Time Domain : Regardless of the distance between two transmitters, a collision can occur if at least two stations have the currently lowest backoff slot. Hence, they start the transmission at the same time. This also allows for two colliding transmissions within receiving range of each other which is in contrast to the classic hidden station. This effect is called *Simultaneous Sending*.

e) Exposed Station : Packet loss implicitly occurs due to local message congestion if the medium can not be accessed in high-load situations.

f) Near Adjacent Station : Interference caused by out-of-band radiation from stations tuned to adjacent channels can also reduce the SINR below the minimum threshold.

They observe that the dominating reason for packet loss is increased interference level due to other vehicles. Thus they rule out the rest and figure only (a) and (b) as the dominating reasons for interference.
However, there is no study done on what exactly is the interference pattern and what are the specific reasons for such huge interference at the receiver that pushes SNIR below threshold and stops detection.
Also, other multi-carrier transmission effects such as doppler effect are not looked into.

In another paper by Mr. Rainer Baumann [1], he points out that the IEEE 802.11g protocol with 2.4 GHz frequency band with 108 Mbps speed can be well suited for VANETs. He uses the same for his simulation of VANET (using ns-2 software) and establishes that the packet loss is quite under control with maximum being little over 60% (with one physical layer and much lesser with other physical layers). However, this packet loss is again observed in high car density and mid car density. He also points out that the packet loss also happens when transmission from one vehicle to another is done when travelling in opposite directions. He points out that the reason for this can be logically deduced as link breakage and the need for a better broadcasting system.

Yet another paper [3] discusses the need for power transmission control for VANETs. They make use of 5.9GHz band to minimize the noise. They point out that maximum power (allocated from ITS) can be used to transmit only the beacons using direct hop and the other data can be transmitted using low power with multi hop. However, the mention that low power usage does not guarantee a near perfect transmission. Also, using high power for transmission of beacon at the time of channel congestion can make the scenario worse and can lead to overhead. Thus, they point out that dynamically controlling power (with beacon power control (BPC) protocol) by keeping track of channel congestion at every point of time can greatly reduce the overhead and thus can ensure message reachability to a great extent. They showed with the help of mathematical equations how channel congestion can be calculated dynamically and transmission power adjustments can be made.

III. SOLUTIONS SUGGESTED

With the help of all observations made, some logical solutions can be :

1) One possible reason for such abnormal packet loss can be a very high PAPR (peak to average power ratio) because of attempting to increase transmitting signal strength. Thus, to avoid it the crest factor (PAR (peak to average) ratio) must be reduced to keep PAPR under control. This reason may be attributed to the observation made regarding fully interfered channel receiver. The solution suggested in paper [3] regarding dynamic power control is a good solution, however, it is to be seen how well such an arrangement can work practically.

2) In the paper [1], they suspect that the sudden high packet loss due to slight increase in offered load is due to blocking of the receiver's decoding ability for channel assessment due to interference. However, how a slight increase in load causes huge interference is not studied. Even in paper [1], the packet loss is seen to be considerably high under mid and high car densities (keeping in mind that it is the result of simulation and not a practical model). Thus, a proper examination of all interference causing factors has to be done to model the interference patterns for different message densities and to reach the exact dominating factors for interference in VANETs.

3) The transmission, as stated in paper [1], when done in same direction works fine and when done in opposite direction breaks down. Also, he points out the problem of link breakage. This can be due to the lack of a good protocol. A good algorithm using principles of Sensor Convergence can be developed to eliminate the problem of such link breakage.

4) In the paper [2], they suspect that the sudden high packet loss due to slight increase in offered load is due to blocking of the receiver's decoding ability for channel assessment due to interference. However, how a slight increase in load causes huge interference is not studied. Even in paper [1], the packet loss is seen to be considerably high under mid and high car densities

(keeping in mind that it is the result of simulation and not a practical model). Thus, a proper examination of all interference causing factors has to be done to model the interference patterns for different message densities and to reach the exact dominating factors for interference in VANETs.

REFERENCES

[1] Rainer Baumann, Swiss Federal Institute of Technology Zurich, "Vehicular Ad hoc Networks (VANET)". Master's Thesis in Computer Science, 2004.

[2] R. K. Schmidt, T. Kollmer, T. Leinmüler, B. Boddeker, G. Schafer, Technical University of Ilmenau,"Degradation of Transmission Range in VANETs caused by Interference". *Venue:* PIK - Praxis der Informationsverarbeitung und Kommunikation (Special Issue on Mobile Ad-hoc Networks), 2009.

[3] Ghassan Samara, Sureswaran Ramadas and Wafaa A.H. Al-Salihy, National Advanced IPv6 Center, School of Computer Science, University Sains Malaysia Penang, Malaysia , "Safety Message Power Transmission Control for Vehicular Ad hoc Networks". Journal of Computer Science 6 (10): 1027-1032, 2010.