Light Fidelity (Li-Fi) as an Alternative Data Transmission Medium in VANET

Sowmya Nayaki R

Abstract

VANET is a set of vehicles moving on the road, equipped with communication capabilities among one to another and with Road Side Units using wireless technologies such as Wi-Fi or WiMAX. The number of possible applications of VANETs is expanding. In addition to safety applications, vehicles are foreseen to support entertainment applications such as peer-to-peer applications and Internet connectivity applications. For all this, most mobile data traffic is consumed. Light fidelity (Li-Fi) which is related to visible light communication (VLC) offers many key advantages, and effective solutions. This paper presents some advantages that can improve performance of VANETs by using Li-Fi which is interesting to reach high speed data communication between vehicles.

Keywords: VANETs Vehicular ad hoc networks, Li-Fi Light Fidelity, VLC Visible light communication.

INTRODUCTION

Nowadays, the need of users to access Internet anywhere at any time is increasingly becoming a necessity. The exponential increase in mobile data traffic has led to the massive deployment of wireless systems. As a consequence, the limited available RF spectrum is subject to an aggressive spatial reuse and co-channel interference has become a major capacity limiting factor. Therefore, there have been many independent warnings of a looming “RF spectrum crisis” as the mobile data demands continue to increase while the network spectral efficiency saturates despite newly introduced standards and great technological advancements in the field. It is estimated that by 2017, more than 11 exabytes of data traffic will have to be transferred through mobile networks every month. Most recently, VLC has been identified as a potential solution.

Unlike other wireless environments that are mostly stationary or with low mobility, data transmission in VANETs poses more challenges to be resolved. Since the topology is constantly changing, vehicles could move away from their home network and cause connectivity breakage. In order to cope with this problem, a vehicle connected to the wireless network should be able to move using different access points available along the road. These access points could belong to different networks or wireless technologies like Wi-Fi, WiMAX or 3G. The performances are not enough good with the traditional RF technologies. In this paper we will show how in VANETs networks a Li-Fi wireless network would complement existing RF wireless networks, and would provide significant spectrum relief by allowing cellular and wireless-fidelity (Wi-Fi) systems to off-load a significant portion of wireless data traffic.

The reminder of this paper is organized as follows. We start in section II with describing VANETs architecture, characteristics, applications and their challenging issues. In section III, we introduce Li-Fi. In section IV, we discussed about Li-Fi integration into the vehicular Network. Then, we conclude the paper in section V.

Vehicular Ad hoc Networks

Vehicular communication networks have emerged as a key technology for next generation wireless networking. The main goal of these wireless networks consists in providing safety and comfort for
passengers by preventing vehicles crashes and traffic jam. Vehicular Ad-Hoc Networks: (VANETs) can be defined as a form of ad hoc networks to provide communications among nearby vehicles and between vehicles and nearby fixed equipments. VANET is a technology that uses moving vehicles as nodes in a network to create a mobile network. Vehicles which are members of a VANET share information about road conditions via Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) wireless communications.

**Architecture**

Each vehicle that is part of a VANET is equipped with an On Board Unit (OBU) and a set of sensors to collect and process information about road conditions, vehicle’s position, speed, direction, etc, then send it as a message to other vehicles or RSU through the wireless medium using broadcast communication.

VANETs allow vehicles equipped with OBUs to share information through Vehicle to Vehicle communications (V2V) and to perform communications between vehicles and Road Side Units (RSUs) through Vehicle to Infrastructure communications (V2I) (Figure 1). The RSU is equipped with one network device for a Dedicated Short Range Communication for Wireless Access Technology for Vehicular Environment (DSRC/ WAVE) , developed by the IEEE 1609 Group, which utilizes IEEE 802.11p, a modified version of IEEE 802.11 (Wi-Fi) standard.

![Figure 1: VANET Architecture](image)

**Characteristics**

VANETs have individual characteristics that are decisive in the design of the communication system.

These include: dynamic topology, large scale network, high computational capability, Impredictible mobility, infinite energy supply in order to provide real time message dissemination platform to share data between vehicles and guarantee reliable exchange of information.

**Challenges**

VANETs inherit from the wireless network shortcomings since they use radio frequency channel to exchange information between the different entities composing the network. These shortcomings consist on signal fading and bandwidth limitations.

Signal fading: This phenomenon is mainly frequent in urban regions. Buildings or other vehicles may constitute obstacles for nodes communications. These objects may cause transmitted signal fading or prevent it from reaching its destination.

Bandwidth limitations: as mentioned before, VANETs do not rely on any central administration. Consequently, this brings out problems about the management of nodes communication. In order to optimize vehicular communications, it is necessary to use the available bandwidth efficiently. The high density of vehicles in urban regions may increase the probability of channel contention. An efficient utilization of the available bandwidth influences the time delay of message dissemination. Channel contention increases data transmission latency. This has very negative impacts, especially for warning messages delivery in safety applications.
In addition there are some challenges which are specific for VANETs. Some of these challenges are time constraints, large scale of the network, high mobility of nodes, privacy and security.

**VANET Simulation Results**

**TABLE I: Results showing the number of failed broadcast messages per travel time**

<table>
<thead>
<tr>
<th>Time(s)</th>
<th>Broadcast Messages</th>
<th>Failed Broadcast Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>681</td>
<td>179</td>
</tr>
<tr>
<td>120</td>
<td>2556</td>
<td>765</td>
</tr>
<tr>
<td>180</td>
<td>4992</td>
<td>1393</td>
</tr>
<tr>
<td>240</td>
<td>7878</td>
<td>2011</td>
</tr>
<tr>
<td>300</td>
<td>11200</td>
<td>2738</td>
</tr>
<tr>
<td>360</td>
<td>15134</td>
<td>3656</td>
</tr>
<tr>
<td>600</td>
<td>18624</td>
<td>4460</td>
</tr>
<tr>
<td>720</td>
<td>19429</td>
<td>4606</td>
</tr>
<tr>
<td>840</td>
<td>20590</td>
<td>4876</td>
</tr>
<tr>
<td>900</td>
<td>22474</td>
<td>5325</td>
</tr>
</tbody>
</table>

Table I provides simulation results on data dissemination in vehicular network considering 5000 vehicles in Berlin.

The simulation was done using a VANET Simulator as shown in Fig 2. The simulation was aimed at determining the efficiency of information dissemination in a vehicular environment where the number of nodes communicating is large. The concentric circles represent the range of transmission and reception of the various nodes in the vehicular network. Fig 2 shows the simulation results for transmitted and failed broadcast messages for the 5000 nodes in the vehicular network considering an average travel time of 900s. It can be observed that there is an increase in the failed broadcast messages as the average travel time increases. Hence it is obvious that when the traffic density increases, there is an increase in broadcast message failures. This emphasizes the need for a better transmission medium which will be able to handle the huge data traffic generated in the vehicular environment.

**Li Fi**

Visible light communication (VLC), which uses a vast unregulated and free light spectrum, has emerged to be a viable solution to overcome the spectrum crisis of radio frequency. Light fidelity (Li-Fi) is an optical networked communication in the subset of VLC to offload the mobile data traffics. The vision is that a Li-Fi wireless network would complement existing RF wireless network.

Li-Fi uses white LED bulbs at the downlink transmitter. Normally, a constant current is applied across the LEDs. Varying the current at a faster rate will cause the optical output to also be very high. By varying the rate at which the LEDs flicker, the desired data can be encoded and transmitted very easily. The system can be improved by using an array of LEDs for parallel data transmission and or using a mixture of red, blue and green LEDs to alter the light’s frequency, with each frequency encoding a different data channel.
Li-Fi & VANETs

In this section we propose our VANET architecture based on Li-Fi. Users must be associated with one or some cars LED lamps for accessing and downlink transmission.

Enabling communications in mobile outdoor systems, particularly in dense, fast moving safety-critical automotive environments is one of the main benefits of VLC for VANETs. In vehicular applications, mobile communications are particularly suitable for adoption of directional communications using Line Of Sight (LOS) links.

As an instance, vehicles can be equipped with optical transceivers, such that they can communicate with other similarly equipped vehicles. Together with adaptive cruise control assisted by V2V communications, the problem of vehicle crashes due to human error can be alleviated.

Our attention will be focused on the use of Visible Lighting Communications (VLC) Li-Fi and how it can provide a valid technology for communication purposes in VANETs. The use of the visible spectrum provides service in densities exceeding regions. It represents a viable alternative that can achieve high data rates, while also providing illumination. This configuration minimizes packet collisions due to Line Of Sight (LOS) property of light.

CONCLUSION

In this paper we investigated main aspects of vehicular ad hoc networks. We discussed the state of art research on Li-Fi and its potential advantages that can make it supplement RF communications and improve wireless network performance wherever short range links are used such as Vanets for high speed and secure data transmission. However, there are still many problems that need additional study. The cooperative techniques and protocols between Li-Fi and the existing RF network need further study.
RF networks are widely used and gradually to be indispensable in our lives. Integrating Li-Fi into RF communications will not only accelerate the marketization of Li-Fi, but also offload traffic from the extremely crowded cellular networks. However, a large number of feedback packets and considerable delay may exist when performing handover between Li-Fi and RF network, which need to be investigated.

**References**


**Author’s Profile**

Department of Electronics and Communication Engineering, T. John Institute of Technology, Bangalore, India.