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Vehicle Telematics and its Applications

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Abstract
Vehicle technology has evolved by an incredible margin in the past three decades. With the increasing improvement of wireless communication standards, we are now able to implement communicational abilities into vehicles. 'Vehicle telematics' refers to all technologies which enable a vehicle to communicate. The communication can be of two types: vehicle-to-vehicle or vehicle-to-infrastructure. The following paper explores this interesting sphere. In particular, someapplications of vehicle telematics have been discussed-

a) Infotainment Systems
b) Telematics-based Insurance
c) Wireless Traffic Management System for Emergency Vehicles.

The paper also enlists the advantages of the technology and provides outlook on the impact of the implementation of the same with reference to the Indian automotive scenario. The challenges associated have also been briefly discussed.

Keywords-Telematics, Vehicles, Automotive, DSRC

I. INTRODUCTION

Over the past three decades, the electronics used in vehicles have vastly matured. In the beginning, the nature of communication within in-vehicular systems was point-to-point[1]. This meant that every system had its own wiring and controller. With time, the demand of electronics systems increased and the systems became more complex. They became more difficult to design, implement and maintain while compromising on reliability[1].Eventually, discrete wiring systems were replaced by newer technologies. The paradigm shift happened in 1986-1987 when Bosch launched the Controller AreaNetwork (CAN) Bustechnology.

With CAN Bus, discrete wiring was replaced by multiplexed wiring. This enabled companies to put even better electronic systems in their vehicles without having to deal with the disadvantages of the older design methodology[2]. The CAN Bus has since been the go-to standard for in vehicle systems.

A In-Vehicle Systems:

Most modern vehicles feature the following technologies-

1. Engine Control Unit (ECU)
2. Anti-lock Braking System (ABS)
3. Electronic Stability Control (ESC)
4. Airbags
5. Collision detection and avoidance systems
6. Comfort systems such as air conditioning, lighting, power seats, locks and windows etc.

These systems usually involve a microcontroller, sensors and actuators. A general representation would be as follows-

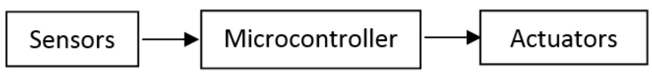

Fig. 1. In-Vehicle Systems

These systems are 'real time' systems (RTS). They are called so because of their ability to control their environment given their fast response time: usually within microseconds. RTS can be classified into two types. i) Hard RTS-Systems which must adhere to a deadline absolutely failing which catastrophic losses may occur. E.g. ABS, airbags. ii) Soft RTS-Systems which adhere to a deadline failing which system performance will degrade but no serious harm will occur. E.g. A/C and climate control.

A combination of both types of these systems co-exists within modern vehicles.

B In-Vehicle Networks:

CAN Bus enabled development of advanced electrical and electronics systems called in-vehicle networks[1][14]. The various systems could now be interlinked to create a hybrid

system where the information is shared by all member systems.
It led to a decrease in the physical amount of electrical wiring and enabled car-makers to implement more versatile systems. 'Telematics' is a new innovation in the automotive sphere.

C Vehicle Telematics :

As the technology of in-vehicle networks matured, the automobile gained the ability to communicate not just within its systems, but also with systems outside the vehicle. An umbrella term for this ability is 'Vehicle Telematics'[10].

II. DEDICATED SHORT RANGE COMMUNICATIONS DEVICES(DSRC)

The modern automobile can commutate with the outside environment in two ways-

1. Vehicle-to-vehicle (V2V) communication-The ability of a vehicle to communicate with another vehicle falls under this category. By sharing information, vehicles can create an environment where in every vehicle is 'aware' of another's presence[7]. For example-The latest BMW i8 hybrid uses a system to find other i8 drivers in its vicinity.
2. Vehicle-to-infrastructure (V2I) communication-The ability of a vehicle to communicate with its environment such as buildings, road signals, power grids and so on falls under this category[8]. A vehicle equipped with advanced systems can perform sophisticated communication with infrastructure, to create a truly connected environment around itself[5].

In both cases, the devices used are termed dedicated shot-range communications (DSRC) devices[19].A pair of these devices are needed to establish communication. The following diagram explains their relationship-

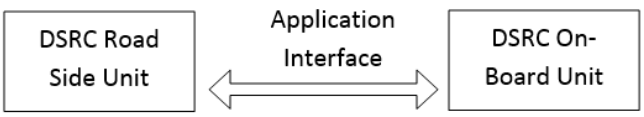

Fig. 2.-DSRC interaction.

The IEEE 802.11b/g/n standard is used for all wireless local area networks (WLAN) in the frequency bands of 2.4, 3.5, 5 and 60 GHz bands. [20]. IEEE 802.11p is an addition over the established standard to provide wireless access in vehicle environments (WAVE). Within this standard, the ITS band of 5.9 GHz (5.85-5.925 GHz) is used for V2V and V2I communication[21]. Another standard knows as IEEE 1609 Family is a higher layer standard based on 802.11p for WAVE. It defines both an architecture for the networks as well as standardized set of services. Generally, the DSRC units confine to these standards.
DSRC units exhibit some common characteristics. As an example, the features of Motorola VML750 LTE vehicle modem have been described below-

1. 3G/4G LTE connectivity support.
2. Wi-Fi connectivity for up to 32 devices, based on 802.11b/g/n at 2.4 GHz.
3. Wired connectivity by 1 Ethernet port at 10/100 Mbps using RJ-45 connector. One USB 2.0 port.
4. WLAN security and VLANsupport.
5. Built-in GPS.
6. Roof-mounted and Multiple-In-Multiple-Out (MIMO) antenna design for increased range and performance.
7. Rugged construction, shock-proof design and operating temperature range of-30^{o}C to 60^{o}C.

Fig. 3.-Motorola VML750 LTE vehicle modem

Vehicle telematics has been used for many purposes. In this paper, we shall focus on three key implementation examples. They are as follows-

III. APPLICATIONS OF TELEMATICS

A Infotainment Systems:

In the connected world of today, it has become common to see the majority of people possessing devices such as laptops and smartphones which can connect to the internet to provide common services such as internet browsing, e-mail and other forms of aural/visual/written communication. The infrastructure of offices and homes commonly facilitates this by the means of wireless (E.g. Wi-Fi) or wired platforms (E.g. LAN). However, the same cannot be said about mass transit and personal vehicles.
As an implementation of telematics, many vehicles today feature an on-board PAN (Personal Area Network) in the form of a GSM/GPRS-based hotspot for providing internet access to the occupants ofthevehicle[17].
The system uses a DSRC inside the vehicle[11] which used the existing cellular network to facilitate the internet connection. Anantenna is installed outside the vehicle. This antenna can send and receive data to and from the cellular network. The antenna usually communicates with the base station which is nearest to it. The antenna is connected to the rest of the embedded circuit of the system. A microprocessor performs the required digital signal processing (DSP) locally and then uses these signals to generate a short-range Wi-Fi network within the vehicle using an antenna inside the vehicle. The system is modular in architecture meaning that parts of it can be replaced or upgraded without affecting the rest of the components.

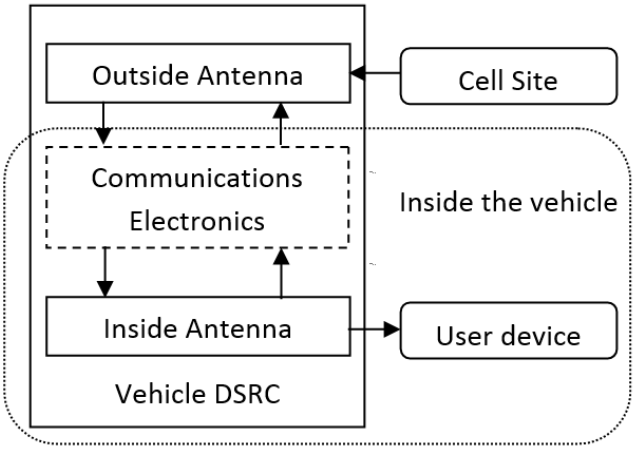

Fig. 4. Infotainment Systems

For the devices connecting to this hotspot within the vehicle, it is no different than connecting to any other wireless internet network elsewhere. This means that if signal format is compatible amongst the system and the devices, the connection is seamless. As an example of compatibility[16], both ends of the communication chain must follow the same networking protocols such IPv4 or IPv6[17].
Vehicle hotspots are becoming more common. Especially since the need of broadband internet on-the-go has been steadily increasing[18].
In India, this technology is yet to be mass-adopted. The main reason for this is that hotspot technology is reserved for more expensive vehicles. With time, the cost of the technology is bound to reduce. This will lead to the mainstream acceptance.

B Telematics-based Insurance
Telematics-based services[3] are also making way into the insurance landscape. An embedded electronic device known as a 'black box' (a rugged-type DSRC unit which can sustain shocks and damage) can be installed in a vehicle during the manufacturing process or from aftermarket shops. It is capable of recording data about the vehicle at periodic intervals. It can monitor factors such as speed, gear, position of the pedals, steering angle and so on, at any given instance of time. The device can also transmitthis data to a remote server (cloud integration). Vehicle insurers are using it to provide telematics-based insurance services.There are two main scenarios related to this-

1. Since the data obtained from the black box is transparent, detailed and periodic, insurers can generate a collection of data about various road users and perform data analysis on it to create better insurance schemes and products. Thus they can attract more profitable customers. It also means that the analysis is more reliable as it is based on real data, rather than approximations or assumptions[13].
2. In the event of an accident and the subsequent insurance-claim, the black box data is consulted. The data can give deep insights about the driver's driving habits. It can verify the legitimacy of the insurance claim with more accuracy. This in turn can reduce the chances of an insurance fraud.

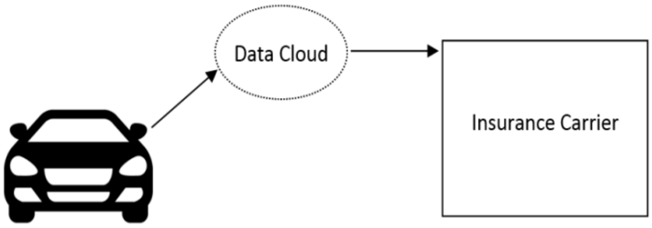

Fig. 5. Telematics-based insurance service

Black-box devices are more expensive than conventional DSRC units given their robust construction and usage scenario.
Since most vehicles do not have telematics capabilities in India, the insurers are confined to use older methods such as manual inspection of an accidental vehicle. If telematics is used, the time and resources spent on an insurance claim can be significantly reduced. It would also provide more accurate results.

C. Wireless Traffic Management System for Emergency Vehicles:
This technology relates to a very specific issue in the Indian scenario. In India, the response time of ambulances is very slow. The WHO-prescribed response time is within 8 to 10 minutes. In India, the time is around 18 minutes. GVK EMRI (Emergency Management and Research Institute) is a pioneer in Emergency Management Services in India. It works in 16 states within the country through a PPP (public-private-partnership) with the state governments. The foundation has emphasized on the development of a system which can reduce the response times. [10]
The system uses the following hardware-Microcontroller-One in the vehicle module. Another in the traffic light module. Communication-ZigBee X-Bee Series 2
The arrangement is akin to the usual arrangement of DSRC units in V2I communication.

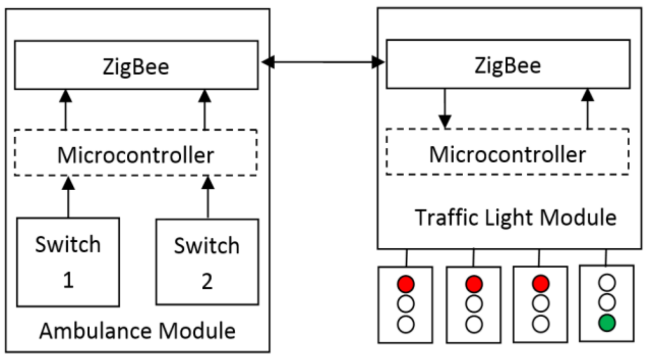

Fig. 6. Wireless Traffic Management System

The ambulance driver uses a set of buttons to engage the system. Consider the scenario of the ambulance approaching

an intersection with a red light. The driver will press the first button to engage a subroutine wherein all lanes get a red signal. Then the yellow light is blinked on and off for every lane in a round robin order. The driver will keep a look out for the moment when the yellow light for his lane in blinked. As soon as that happens, he will press the second button to confirm his lane choice. As a result, the lane for the ambulance is given the green while all others stay red. Thus the wait time at intersections is considerably reduced. This will create a significant difference when the route of the ambulance has many intersections[15]: a typical scenario is many Indian cities.
The range of the system is up to 100 meters.
The impact of such a system is two-fold-

1. By reducing the response time, lives can be saved in emergency cases. It is estimated that a reduction in response time by a little as 1 minute, can increase the chances of survival of a patient by 24%.
2. If the time required to service an emergency case decreases, the ambulances can service more patients every day. It is worth noting that in India, there is one ambulance per 144,736 people which is above the prescribed limit of having one ambulance per 100,000 people. [12]

D. Telematics-powered Co-operative Vehicle Guidance-
Traditionally, designers have tried to create guided vehicles autonomous. That is, vehicles would only rely on themselves for guidance. Given the concept of V2V and V2I communication, a new breed of guided vehicles is eminent. These vehicles would use co-operative method instead of just autonomous method.
In this method, every vehicle would continually communicate with other vehicles around it on the road. The vehicles would exchange information about current route, speed, upcoming turns to take and so on. This information will be updated at a high frequency amongst the vehicles. By analyzing this information, the vehicles can by guided.
Co-operative guidance can yield improvements in the following areas-

1. The efficiency with which we use the roadways, by reducing congestion.
2. Reducing chances of accidents and improving safety[9].
3. Reducing fuel (energy) consumption and associated environmental impact.

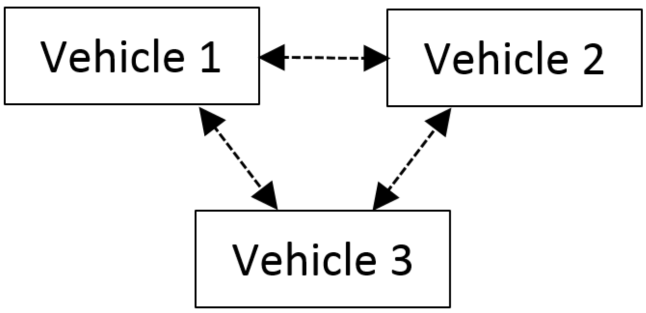

Fig. 7. vehicle to vehicle communication

IV.CHALLENGES IN VEHICLE TELEMATICS

In light of the Indian scenario[4], the following points are worth noting-

1. Lack of standardization-Telematics is still not a fully realized concept[12]. New applications are being invented every day. Though the sphere has seen rapid technology growth, there still remains a lack in standardization of the platforms.
2. Interoperability issues-This is a direct consequence of the above listed point. Since every manufacturer follows their own designs, the compatibility between two designs is not very seen often. Such discretization results in many under developed design implementations[6].

Latest advancementsSmartphone makers have stepped in this market recently.Software like Android Autoand Apple CarPlayis becoming common and early adopters of the technology are showing promising results.Smart phones are very common. That is a good starting point for technology unification as some basic standards are followed. Secondly there is not much need for any extra hardware since the smart phones can handle many heavy processing tasks themselves, thereby offloading the need of dedicated telematics hardware.

3. Infrastructure issues-India at the moment, does not feature a robust infrastructure to facilitate such technologies but the scenario is rapidly growing. The ‘Digital India’ program is underway and soon there will be ‘Smart Cities’ in India. These cities will be capable of supporting telematics.

V. CONCLUSION AND FURTHER RESEARCH

We have discussed about Vehicle Telematics and its applications. We have also shed light on the Indian scenario of telematics and the future of the technology. Finally, we have discussed about the challenges of telematics in brief.
In conclusion, we can say that telematics is an important new technology and one that can significantly alter the way we think about transport as a concept. Its implementation would be beneficial.
There is a wide scope of applications that telematics can be used for. A research to identify these applications would be a valuable addition to the current work.

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