A comprehensive study of vehicle communication framework in Malaysia

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Abstract. In the sector of transportation, vehicle to vehicle communication and vehicle to infrastructure communication are becoming a trending topic of studies, as effective information transfer is required for most critical systems. Many protocols were then suggested with better coverage and small end to end delay in restricted bandwidth for data communication purposes. Research on some of the wireless communication technologies are carried out in this paper. The aim of this paper is to define various wireless communication technologies that emerged in the literature and to disclose the possibilities attained once this approach has been applied.

Keywords. Connected Vehicle; Wireless Fidelity; Light Fidelity

1. Introduction
The creation of more viable travel technologies has become one of the key environmental problem for the next century through the new phase of urbanisation with increasingly stringent emission standards and high pressure to improve effectiveness of transportation. Connected vehicles are envisioned to provide effective technology, reduce accidents, improve safety and reduce traffic congestion [1]. A series of technical, financial and regulative difficulties will be faced with the seamless inclusion and convergence of vehicular communication, transportation technologies and mobile devices. The development of vehicle communication system is important so that road users and others can share data with elevated accuracy in actual moment [2]. This also will enable pervasive sensing to monitor the status of a vehicle and the surroundings [3]. Apart from that, development of information analytical tools to process big quantities of linked vehicle data is crucial. This could also enable to use a middleware platform for data sharing and management control. In this paper, we introduce a series of research on recent developments, current research difficulties and potential approaches to regulate and evolving techniques to achieve safer and effective vehicle communication in Malaysia.
2. Literature Review

In recent years, there has been a number of concerns in vehicle to vehicle (V2V) communication, particularly in the area of safety [4]. The fact that the communication between cars can assist to reduce traffic deaths, over 37,000 of which happened on US highways in 2016, is now rather well recognized [5]. Based on this basis of vehicle to vehicle communication, many instances are assessed, including pedestrians and cyclists, concerning interaction between the vehicle and its environment [6]. In the latest years, it is more helpful that different types of communication techniques be presented in a precise overview of the rapid advancement of vehicle communication. Communication in connected vehicle can be classified in terms of transmitter and receiver.

2.1. Connected Vehicle Technology

2.1.1. Vehicle-to-Environment (V2E)
Vehicle to Environment (V2E) means an intelligent transportation system in which all vehicles and infrastructure devices are interconnected. Besides that, pedestrians and cyclists are also linked to the systems. This communication will provide precise understanding of the traffic scenario across the full highway network, which will assist to optimize traffic flows, decrease congestion, decrease road accidents and minimize emissions [7].

2.1.2. Vehicle-to-User (V2U)
Vehicle to User (V2U) allows road users to be comfortable and safe. Two distinct classes offer information systems that assist the road users to identify whether to take an action or not and support systems involve of car monitoring more or less separately in an emergency or in a clear context [8].

2.1.3. Vehicle-to-Network (V2N)
Vehicle to Network (V2N) provides a network connection to the vehicle, which can reach the vehicle on several frequencies. This interaction could provide not important but helpful information, such as closures of road for maintenance and cloud-based services which enhance experiences and also act as a hotspot for connecting to the Internet [9].

![Figure 1. Connected Vehicle Technology](image-url)
The significant distinction between V2E and V2U is the legislative and has network limitations. V2E communication such as V2V and V2I concentrating on alerts or safety-related correspondence is regulated by a tighter legislative structure compared to V2U as any delay can cause serious effects on public safety. Safety-related messages cannot be cut-out, thus putting additional constraints on the communication protocol and the network itself is essential [11]. The network requires to have a low latency and a minimum interval for the same purpose [12]. Unlike V2E, V2U is not aimed at timely systems because many systems are designed for infotainment and comfort, with the exception of possible emergency urgent calls. The legislative and network demands for V2U are therefore not as critical as for V2E.

2.2. Communication Classification
A significant communication classification is required here which are Line of Sight (LOS) and Non-Line of Sight (NLOS) communications. Today, self-driving vehicles are more focused on LOS activities. A mix of the cameras, radars, LIDARs and ultrasound detectors that all rely on LOS communication to comprehend and generate options to provide a safety riding environment, are equipped in each self-driving vehicle prototype. However, an object unexpectedly appearing in perspective of a vehicle or vehicle that approaches an invisible unusual junction by a self-driving vehicle, may possibly contribute to a collision. NLOS Communication offers a needed and helpful additional safety element for the vehicle in such circumstances. V2E belongs to the NLOS class which can possibly improve the safety of self-driving cars. In order to increase the LOS safety capacity of a self-sufficient vehicle, it is therefore also essential for V2E communication [13] [14].

2.3. Communication Readiness
Let us take a look at the technologies that will shape the core of the V2E related linked environment. V2E covers safety systems vital to fast, sturdy, and prompt result which any delay in delivery of messages could cause a potential crash. The SAE Dedicated Short Range Communication (DSRC) Technical Committee have created an information manual, SAE J27355, which describes 16 and more particular V2X addresses over the years and with important transportation stakeholder feedback. Systems for safety includes of curve speeds, emergency electronic brake lights, red light violations, forward collision warning and speed limit zones. All these alerts are picked and then send to the vehicles around their location by the vehicle nearest to their location of incidence [15]. Some of the communication readiness protocols used for the diffusion of such messages, which are Dedicated Short Range Communication (DSRC) and Long-Term Evolution (LTE).

2.3.1. Dedicated Short Range Communication (DSRC)
As portion of the requirements for applying Wireless Local Area Networks (WLAN), DSRC depends on IEEE 802.11p, an extension to the IEEE 802.11 rule, for apps linked to cellular communication in vehicle settings (WAVE). In order to support the DSRC communication protocol, 75MHz of spectrum was assigned for ITS use in the 5.9GHz range. The capacity to interact for comparative vehicle speeds of 250 km/h is a main characteristic of 802.11p. Several field trials of this technology were completed with a remarkable large-scale pilot financed by the U.S. Department of Transportation (DOT) in Wyoming, Tampa and New York City that includes over 10,000 vehicles. NXP effectively pursued the DSRC 802.11p technology route for V2X systems. The DSRC is focused on the Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA) 802.11 family. The device listens to the stream in this protocol before transmitting a packet and only sends the packet if the stream is clear. This leads to a pause because of the moment it took to wait for the stream available. Moreover, when the communication overlaps, messages may crash between two or more systems. Therefore, the need for a safe communication, where there are no signal drops, is not always fulfilled by DSRC. In addition, the scope of 150-300m is usually supported, which means that the vehicle will not take up the signal except in this range. DSRC needs a set infrastructure known as Road-Side Units (RSUs) for safety communication with vehicles. Thus, it is essential to install these RSUs in highway networks to ensure that DSRC is adopted successfully overall [16] [17].
2.3.2. Long Term Evolution (LTE)

Communication subcomponents from V2V, V2I, V2P and V2N for Vehicle to X (LTE-V2X), which means that the kinds of messages and services activated will probably exceed the accessible SAE J2735 options. LTE-V2X is able, with its network, to use years of cellular technology to provide an impressive solution for DSRC communications. No additional infrastructure is required, as the current cell infrastructure may be used by LTE-V2X. The advantages of LTE-V2X is that it depends on the same frequency of V2V communication for safety messages in the lack of a network connection. In Cellular V2X (C-V2X) technology, Qualcomm has been developing this work for several years. LTE-V2X operates on the need for good or more costly hardware in synchronous communication with elevated clock synchronisation demands. Synchronisation of the clock ensures that there are no messages dropped and digital messages are collected on a clock's edge or level. Thus, it is necessary to synchronise the message and the clock frequency and match of phase to capture messages always. This tuning is usually, however for instance, indoors corridors, underground parking spaces made with Global Navigation Satellite System (GNSS) transmissions which may not have been accessible everywhere. As DSRC 802.11p needs RSUs, and computer synchronisation software needs LTE-V2X, it is likely that either implementation has related expenses, which either the end user or the government will bear. Relative speed of 300 km/h or more are supported by LTE-V2x. In addition, the LTE-V2X range is more than 450m, which means that the road users have a longer response time than DSRC communications. The planned development of LTE-V2X into 5G will lead to significant anticipated latency and bandwidth gains [18] [19] [20].

3. Related Works

Research is an ongoing process of exploring things that could determine to solve issues. In [21], the author describes that IEEE 802.11n relatively works well in urban environment for delay sensitive and bandwidth hungry applications. The author describes that in recent times, the demand of multimedia applications is high, and therefore, users are interested in applications that could be incorporated with VANET. As such, the frame aggregation system in IEEE 802.11n considerably improves the goodput by transferring an aggregated frame, which reduces the moment of header formation as the present transmission makes a single header instead of various headers and reduces the inter frame moment, which reduces error. However, the mechanism for frame aggregation is still ineffective in the case of transmitter failure due to collision. Secondly, the size of the aggregated frame cannot be enhanced arbitrarily owing to several factors including constraints enforced by the IEEE 802.11 standard, variability in signal quality and short-term fairness.

In a separate view, a new CAN gateway technique for fast vehicle to vehicle communication is proposed in [22]. The proposed method can reduce the number of CAN frames to be transmitted by using the partial network table to request the information to ECUs, it can reduce the time required for the transmission of the CAN frame. For this purpose, the suggested technique can be regarded as appropriate for vehicle to vehicle transmissions implemented for delay sensitive services. However, the concern is that the modern vehicle uses a network of Electronic Control Units (ECUs) to implement systems such as door locks, anti-lock brakes, and engine control. Several bus protocols have been used in the implementation of these systems, with the most popular being the CAN bus. The CAN bus has been designed with security, but its accessible design has many vulnerabilities. The transition from isolated mechanical systems to networked electrical systems has enhanced the performance of vehicles but has made them more vulnerable to network attackers.

In [23], the author has conducted a VANET-based vehicle to vehicle communications among three vehicles in ad-hoc environment. In spite of movement parameters such as velocity and range with wireless sensors, the device design allows vehicle to vehicle interaction for actual time data transmission. VANET is used to prevent accidents by passing location coordinates in the closest region within their ad-hoc variety for all vehicles with GPS and RF technology. Nevertheless, VANET is nonetheless compared to standard MANET in distinct ways. The distinctive properties of VANET are driver behaviour, mobility restrictions and high speed of vehicles. These features offer significant
suggestions for VANET. Thus, multiple challenges must be dealt for vehicular communications to be widely deployed depending on the type of hardware components and sensors used.

In addition, [24] the author proposed a vehicle system using ZigBee protocol. The suggested system solves many of the issues that current devices face by using a GPS module instead of the standard speedometer and also utilizes sensors in fields where human interference is either unintended or life-threatening. The system aims to use the latitude and longitude to show their closeness to communicate with the vehicle in its surroundings with the assistance of its location. With the assistance of a signal, road users are warned when these vehicles are very near in the vicinity. In this way the road users can communicate with each other and act according to the situation. Despite of the advantages/usage, ZigBee protocol is low-cost for installation and ease maintenance. ZigBee protocol also presents a number of difficulties to their design, particularly in keeping an equilibrium between signal strength, power (transferred and obtained) and range. Increasing the range from a sensor node to a base station improves the transmission energy needed and reduces the strength of the message.

4. Methodology

In Malaysia, a hybrid strategy may eventually be a perfect model to communicate between vehicles, given the advantages and disadvantages of each wireless communication technologies. The benefits of each technology can be combined to create a stronger alternative through a hybrid strategy. The ideal solution for the future is probably to combine the advantages of the wireless fidelity communication (Wi-Fi) providing medium-range connectivity and light fidelity communication (Li-Fi) for short-range connectivity.

4.1. Wireless Fidelity Communication (Wi-Fi)

Wireless Fidelity Communication (Wi-Fi) is a wireless technology that enables devices to interact with full speed via a wireless message, a radio wave. Wireless antennas transmit radio waves from receptors from devices that are equipped with Wi-Fi network. Whenever a device gets a signal that is normally not more than 200 meters from antennas within the range of a Wi-Fi network, the Wi-Fi element uses the data to create a link without the use of cables between the user and the network. In this project context, Wi-Fi is still possible to be used for vehicular communication because Dedicated Short Range Communication (DSRC) were designed from Wi-Fi standard (IEEE 802.11). Hence, Wi-Fi is selected over DSRC because of the spectrum standard varies among countries [25].

4.2. Light Fidelity Communication (Li-Fi)

Instead of over-use of radio waves, with white LED bulbs, Li-Fi uses visible light communication (VLC) to transmit data and achieve the purpose of illumination. The optical transmission can be varied at a very high speed by fast and slight changing the current on the LED. The variation of the current passing to the LED transmits high speed data and cannot be seen by the human eye. In this project context, Li-Fi has the potential to provide high-speed data communication with improved energy efficiency without introducing any flickering to the end user. Li-Fi is unlicensed and hardware readily available, which can be used for data transmission [26].
The proposed framework is designed that every vehicle has a vehicular communication device with Wi-Fi and Li-Fi.

5. Discussion

A vehicle to everything (V2E) system includes many elements, such as intelligent transportation and intelligent connected vehicle. Different systems have varying demands for V2E environments such as latency, efficiency, throughput, user density and safety. In Figure 3 and Figure 4 respectively, research is performed to determine the benefits of Wi-Fi and Li-Fi.
6. Conclusion
In this paper, the highlight is the study of wireless communication technologies for vehicle communication in Malaysia. While there are many research studies on the possible communication technologies for vehicular systems, there are also many exciting opportunities for alternative approaches for vehicular context. Comparing the different communication technologies helps us to gain a deeper understanding on their possibilities. By examining the Wi-Fi and Li-Fi through the lens of the possible alternative, the two complementary transmission methods may have their ability to serve in various ways for future intelligent transportation systems.

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