# Top Level Newsletter: Connected Vehicle

## (Published by IEEE Orange County Section)

**September 2022**
**Volume 33.0**

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This issue includes three articles concerning….

(1) Trends in automotive silicon electronics

(2) 5G edge relocation use cases and challenges

(3) Edge-based collision avoidance for vehicles and vulnerable users: (Re-print from newsletter v14.0)

**General Notes**

This series of newsletters is intended to provide the IEEE member with a top level briefing of the many different subjects relevant to the research, development and innovation of the connected vehicle.

The objective is to provide a platform for fast learning and quick overview so that the reader may be guided to the next levels of detail and gain insight into correlations between the entries to enable growth of the technology. Intended audiences are those that desire a quick introduction to the subject and who may wish to take it further and deepen their knowledge. This includes those in industry, academia or government and the public at large. Descriptions will include a range of flavors from technical detail to broad industry and administrative issues. A (soft) limit of 300 to 600 words is usually set for each entry, but not rigorously exercised.

As descriptions are not exhaustive, hyperlinks are occasionally provided to give the reader a first means of delving into the next level of detail. The reader is encouraged to develop a first level understanding of the topic in view. The emphasis is on brief, clear and contained text. There will be no diagrams in order to keep the publication concise and podcast-friendly. Related topics in the case of Connected Vehicle technology, such as 5G cellular and the Internet of Things will be included. The terms Connected Vehicle and Automated Driving will be used inter-changeably. Articles from other published sources than IEEE that add to the information value will occasionally be included.

This newsletter forms part of the regional Advanced Technology Initiative (ATI) of which connected vehicles form a constituent part. Technical articles solely from IEEE journals/magazines are referred to by their Digital Object Identifier (DOI) or corresponding https link. The link for each article is provided. Those readers who wish to delve further to the complete paper and have access to IEEE Explore (www.ieeexplore.ieee.org) may download complete articles of interest. Those who subscribe to the relevant IEEE society and receive the journal may already have physical or electronic copies. In case of difficulty please contact the editor at kaydas@mac.com. The objective is to provide *top level guidance* on the subject of interest. As this is a collection of summaries of already published articles and serves to further widen audiences for the benefit of each publication, no copyright issues are foreseen.

Readers are encouraged to develop their own onward sources of information, discover and draw inferences, join the dots, and further develop the technology. Entries in the newsletter are normally either editorials or summaries or abstracts of articles. Where a deepening of knowledge is desired, reading the full article is recommended.

1. **What is Next for Automotive Electronics (Joao Trovao)**

**Published in:** IEEE Vehicular Technology Magazine (Volume: 17, Number 3, September 2022) pp 113-120.

**Abstract:**

The automotive industry is experiencing a remarkable move from the internal combustion engine (ICE) to an all-electric power platform. This natural shift is essentially supported by electric drive development where wide-bandgap (WBG) materials are at the center of this transformation. The shift to gallium nitride (GaN)- or silicon carbide (SiC)-based power electronics is taking place due to the theoretical limits of Si MOSFETs that has been reached by the industry for many power systems. Battery charging is maybe the first high-volume market to demonstrate GaN adoption, and SiC devices are now increasingly used in high-voltage power converters with stringent size, weight, and power requirements. Definitively, EVs are considered the heart of the global push toward a more sustainable future.

Many updates on power electronics solutions, topologies, and devices are anticipated in the coming years. The advances made with GaN and SiC are constantly reported as a key point to accelerate global electrification; reduce carbon footprint, weight, volume; and increase performances. The increased use of new materials will allow losses reduction with significant energy savings.

As electromobility becomes increasingly crucial, eco-friendly battery technology is no longer an option but a prerequisite. Battery manufacturing is a nightmare because numerous complex processes are required to achieve a consistent product. The evolution of this segment has been continuous.

A new research edge is the elimination of the amount of cobalt used in batteries for traction. The stability provided by cobalt is replaced by the increase of nickel, which has been treated to make it comparable in physical properties to cobalt to reduce costs.

The battery is the backbone of an electric vehicle (EV): more cells provide more charging capacity, which means greater distances to travel before needing a recharge. But energy needs are not the only requirement for car performance. The density of power combined with density of energy should be blended to have a good car for pleasurable driving. Using estimation solutions in battery management gives designers the ability to enhance battery pack performance, lighten the load on an EV, and balance

electric load distribution while meeting the highest standards of functional safety to improve its reliability with fewer add-on physical monitoring systems.

Optimally, each battery cell must be monitored to maximize battery performance. As a typical EV has hundreds of pouch cells or thousands of cylindrical cells, for example, or even more, the ability to remove sensor cables and auxiliary devices improves system reliability.

Intelligent battery management systems play a vital role in the process of future developments in EVs. Eliminating unnecessary wires, connectors, and insulating parts can increase overall reliability of the system. The estimation solutions that use digital twins in battery management offer designers several possibilities to reach battery market requirements and needs..

The momentum by electric and hybrid vehicle engineers to improve energy conversion efficiency is moving toward exceptionally reliable devices. At this point, design parameters are changing and are now related to power level, conversion efficiency, operating temperature in real operation, ease of heat dissipation, and the overall system. The external opinions define the keys to performance in EV design as basically the battery and the propulsion system. These key aspects are related to the perception of the range of an EV, or the distance it can travel fully charged. The popularity of electric and hybrid vehicles has led to new integrated solutions; for example, battery electronics, must now be more integrated and able to communicate information from each cell and/or module in a battery pack to a pivotal point for processing. In addition, battery management electronics must maximize range, life, safety, and reliability while minimizing cost, size, and weight.

All electric or hybrid vehicles use regenerative braking to charge the battery during deceleration. In addition, solar cells can be used to restore the battery to a full charge or to compensate for a quiescent current in the car. For instance, Sono Motors' revolutionary goal is to speed up the transformation of mobility by making every vehicle solar

The capture of energy used in the automotive sector consists of taking energy from external sources and converting it into electrical current to power any device. The capture of kinetic energy is a universal means of collecting energy in actuator compartments due to vibrational energy always being present with different amplitudes. Using various conversion principles and a suitable microelectronic system, this energy can be efficiently converted into electrical current. However, energy-harvesting performance is highly dependent on its ability to adapt to the environmental source. Recent advances in the development of ultralow-power microcontrollers have resulted in devices that offer unprecedented levels of integration in terms of the power required to operate. Harvesting energy from sources such as heat, light, sound, and vibration can have a significant impact on economic and environmental factors, reducing costs and generating new sensor technologies for the automotive industry in the near future.

There is no doubt that electric cars are gaining in popularity, with their eco-friendly features in terms of quality, functional simplicity, and above all, energy efficiency. Functional drive is provided by the electric motor, whose construction is simply compared to the ICE. In terms of energy efficiency, the comparison between thermal and electric cars is emblematic: a thermal car has an energy efficiency of approximately

16%, while an electric one has an energy efficiency of roughly 85%. The electrical nature of propulsion has an advantage over a combustion-based one: energy regeneration. Electricity offers great flexibility, including the use of various forms of energy harvesting that help recharge the battery and thus prolong operation of the vehicle itself. Energy-harvesting technologies are therefore at the forefront of the R&D landscape for a new generation of electric cars.

However, EVs not only require battery packs, they also need dc–dc converters, typically from high- to low-voltage electronics; a dc–ac traction inverter to drive electric motors (usually three-phase, but increasingly, polyphase is used for reliability purposes) and provide power to the wheels; and ac–dc converters to charge vehicle batteries while recovering energy from braking operation (reverse function of inverters) and from a residential or high-power charging station (for fast charging). EV chargers are categorized by how quickly they charge an EV battery.

For decades, Si has led the transistor sector, but that has been progressively changing. A new generation of semiconductors made of two or three materials has been developed and offers unique advantages and superior characteristics. For instance, compound semiconductors gave us the light-emitting diode: one type is made up of a mix of gallium arsenide (GaAs) and GaAs and phosphorus; others use indium and phosphorus. Although these new semiconductors are harsher to make and more costly, they offer significant benefits over Si based. The designers of new, more demanding applications, such as automotive electrical systems and EVs, are interested in improved semiconductors that meet their rigorous specifications. The two semiconductor devices that have become solutions are GaN and SiC.

Finally, lidar refers to the technology that incorporates both light and radar techniques to detect surrounding objects. It scans an area of 360° with a pulsating infrared laser and identifies the reflected light. This information is translated into a detailed 3D image of the nearby scenes to approximately 300 m, with a resolution of several centimeters. Its high resolution makes it an ideal sensor for autonomous vehicles—especially self-driving ones—to improve identification of adjacent objects. Lidar units operate from a dc voltage in the 12–24-V range that is derived from a dc–dc converter. (1241 words)

DOI: https://doi.org/10.1109/MVT.2022.3179790

## 2. Relocation in an Edge-Enabled 5G System: Use Cases, Architecture, and Challenges (Grzegorz Panek et al)

**Published in**: IEEE Communications Magazine (Volume: 60, Issue: 8, August 2022) pp 28-34.

**Abstract:**

With the growing development of 5G and its new services, edge computing is becoming the cornerstone of the ongoing network transformation. Its integration into 5G network infrastructure brings new research opportunities related to the design and implementation of high-performance systems, enabling the accomplishment of the three main promises of 5G: very high speed, low latency, and massive

connectivity. This trend has generated strong interest in realizing effective life cycle management of latency-sensitive edge applications in order to achieve a high level of QoS while ensuring the service continuity in the case of user mobility. This article deals with the relocation of edge services, commonly called edge relocation, which aims to relocate edge application instances between edge clusters in order to ensure uninterrupted service. To achieve our objective, we propose a cloud-native edge-enabled 5G solution that complies with ETSI and 3GPP standards. The latter performs pre-relocation and relocation of edge applications in order to support the service continuity. Various scenarios of edge relocation are discussed, and illustrative use cases are provided. Next, a proof of concept is described to demonstrate how edge relocation can be implemented and leveraged to ensure service continuity in the case of infrastructure performance degradation. Finally, unique research opportunities are identified.

**Excerpts:**

The authors deal with the relocation of edge services, commonly called edge relocation, which aims to relocate edge application instances between edge clusters in order to ensure uninterrupted service, To achieve their objective, they propose a cloud-native edge-enabled 5G solution that complies with ETSI and 3GPP standards.

- Network infrastructure needs to gain more agility to deal with sudden and unprecedented changes in customer behavior.
- These infrastructures should leverage reliable artificial intelligence (AI) tools to optimize network automation while making use of effective observability.
- Massive digital inclusion should be achieved, which requires ubiquitous, increased, and always available connectivity, with appropriate levels of service quality……

According to the 3rd Generation Partnership Project (3GPP), edge relocation is one of the main issues also addressed by the European Tele-communications Standards Institute (ETSI) in the context of integrated MEC (multi-access edge computing) and the 5G network. By edge relocation, we refer to the ability to relocate the edge application running on a source MEC host to a target MEC host. Edge relocation is a key enabler of the edge-enabled 5G system. Several edge applications, leveraging 5G (e.g., autonomous vehicles, gaming), may require stringent QoS; specifically, very low latency and high availability. Hence, the edge infrastructure will be highly stressed, observing high load or highly mobile users. From this perspective, it is very important to support the migration of applications in order to ensure service continuity during the mobility of the end user across the system or in the case of source MEC host performance degradation (lack of resources, failure, etc.)…..

The advent of 5G has driven the emergence of new use cases sensitive to latency. Some of them such as e-health, video streaming, unmanned aerial vehicles, autonomous vehicles, cloud gaming, and extended reality have, in addition, mobility needs. To deal with the aforementioned challenging requirements, it is important to use the MEC solution to perform data processing or content delivery as near to the end user as possible. Indeed, provided by the operator through its infrastructure, MEC can offer an ecosystem for efficient and seamless application mobility. Envisioning an intelligent edge-enabled 5G system is crucial to achieve the targeted performance…..

*Autonomous vehicles* are seen as the most relevant service that 5G will deliver. Self-driving cars embed a set of sensors and cameras that are constantly processing the nearest surroundings. The autonomous central car management system is characterized by low-latency communication (~ 15 ms) in high-mobility scenarios (C-vehicle-to-everything, V2X). Therefore, it needs to be located as close as possible in order to guarantee uninterrupted service continuity with quick response time. In this area, the support of application relocation and user data synchronization between MEC hosts in order to manage and coordinate autonomous cars is crucial…... (654 words)

DOI: https://doi.org/10.1109/MCOM.001.2100623

### 3. ( Re-print from newsletter v14.0) Edge-Based Collision Avoidance for Vehicles and Vulnerable Users: An Architecture Based on Mobile Edge Computing, Marco Malinverno et al

IEEE Vehicular Technology Magazine Volume: 15, Issue: 1 March 2020 (pp27-35)

Collision avoidance, one of the most promising applications for vehicular networks, dramatically improves the safety of vehicles that support it. In this article, we investigate how it can be extended to benefit vulnerable users, such as pedestrians and bicyclists, equipped with a smartphone. Owing to the reduced capabilities of smartphones compared to vehicular onboard units (OBUs), traditional distributed approaches are not viable, and multi-access edge computing (MEC) support is needed. Thus, we propose an MEC based collision-avoidance system, discuss its architecture, and evaluate its performance. We find that, thanks to MEC, we are able to extend to vulnerable users the collision avoidance protection traditionally applied to vehicles, without impacting its effectiveness or latency.

The U.S. National Highway Traffic Safety Administration reported more than 37,000 traffic fatalities in 2017, and, today, the World Health Organization (WHO) estimates 3,400 daily traffic-related deaths, 50% of which could be avoided with appropriate action.Because of these statistics, safety has emerged as a prominent application of vehicular networks. Among safety applications, the most popular—and, arguably, the most effective—is collision avoidance. The idea of collision avoidance is fairly simple: vehicles are equipped with an OBU that periodically (and anonymously) broadcasts a basic safety message (BSM) containing the vehicle's position, direction, acceleration, and speed. [Equivalently, the cooperative-awareness messages standardized by the European Telecommunications Standards Institute (ETSI) could be considered.] The OBU uses the BSMs sent by other vehicles to assess whether they are set on a collision course; if this is the case, the vehicle can alert its driver and/or take immediate action, such as emergency braking.

Collision-avoidance systems are especially important in the presence of obstacles, such as buildings, that prevent drivers/vehicles from realizing the danger in a timely manner. Their importance and relevance have been acknowledged by transportation regulators: in December 2016, the U.S. Department of Transportation published a notice of proposed rulemaking for vehicular communications. The document proposes establishing a new Federal Motor Vehicle Safety Standard, number 150, to make vehicular networking technology compulsory: 50% of newly manufactured vehicles would have to be equipped with such capabilities in 2021, 75% in 2022, and 100% in 2023. However, an important part of the picture is missing. According to the WHO, half of traffic fatalities concern vulnerable users, such as pedestrians and bicyclists. Obviously, users like these cannot carry an OBU, which puts them beyond the scope of traditional collision-avoidance systems. On the positive side, vulnerable users do often carry smartphones, equipped with all of the sensors—most notably, a global navigation satellite system and an accelerometer—needed for collision avoidance. Our suggestion, therefore, is to leverage smartphones to integrate vulnerable users into collision-avoidance systems, thereby extending to them the associated safety benefits. Smartphones differ from OBUs in two key aspects. The first is their lack of support for network technologies, such as IEEE 802.11p wireless access in vehicular environments, that are popular in vehicular networks. The second is represented by their computational power and energy limitations: constantly processing an endless flow of incoming BSMs would impose too great a strain on the CPU and battery of a smartphone. Both of these concerns can be addressed with the help of the MEC paradigm, where computation happens within the mobile network. (535 words)

**DOI: https://doi.org/10.1109/MVT.2019.2953770**