Technical Article

What You Need to Know about Bluetooth Smart in Automotive

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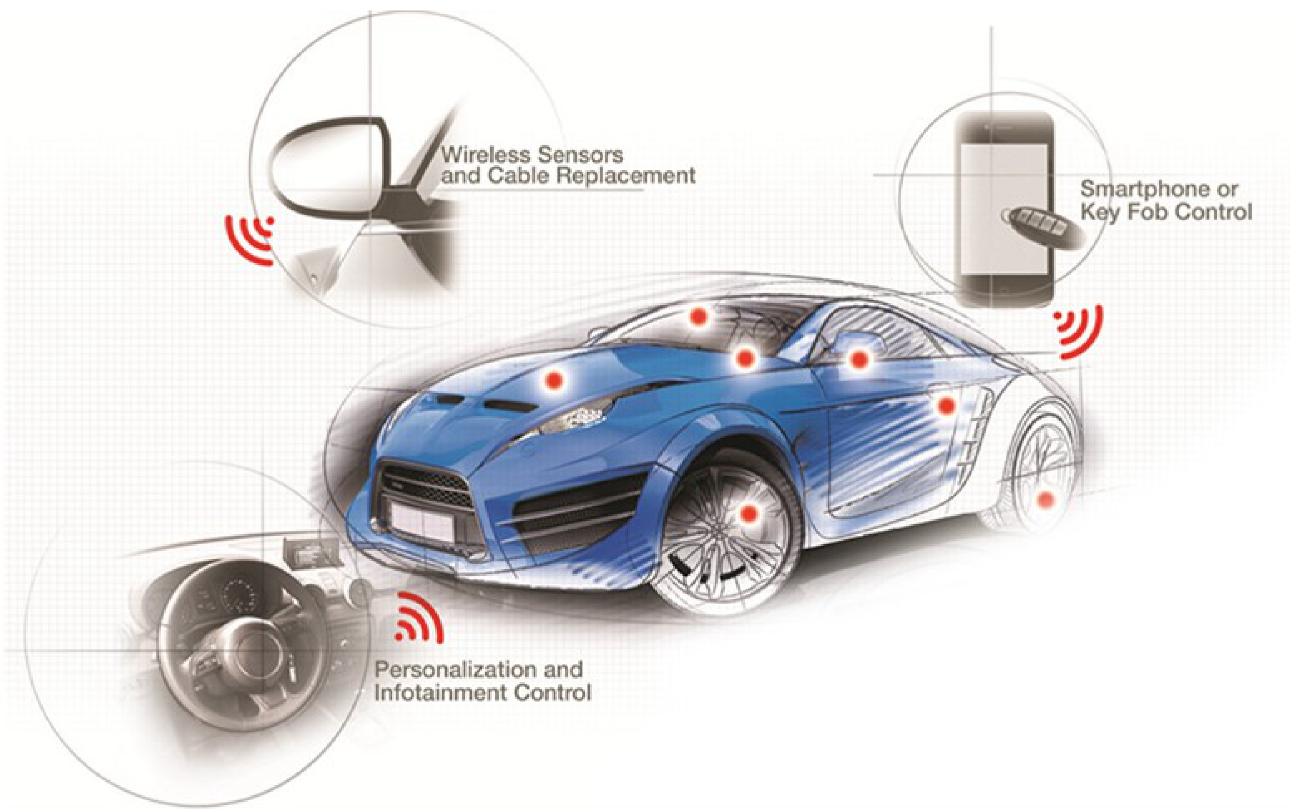
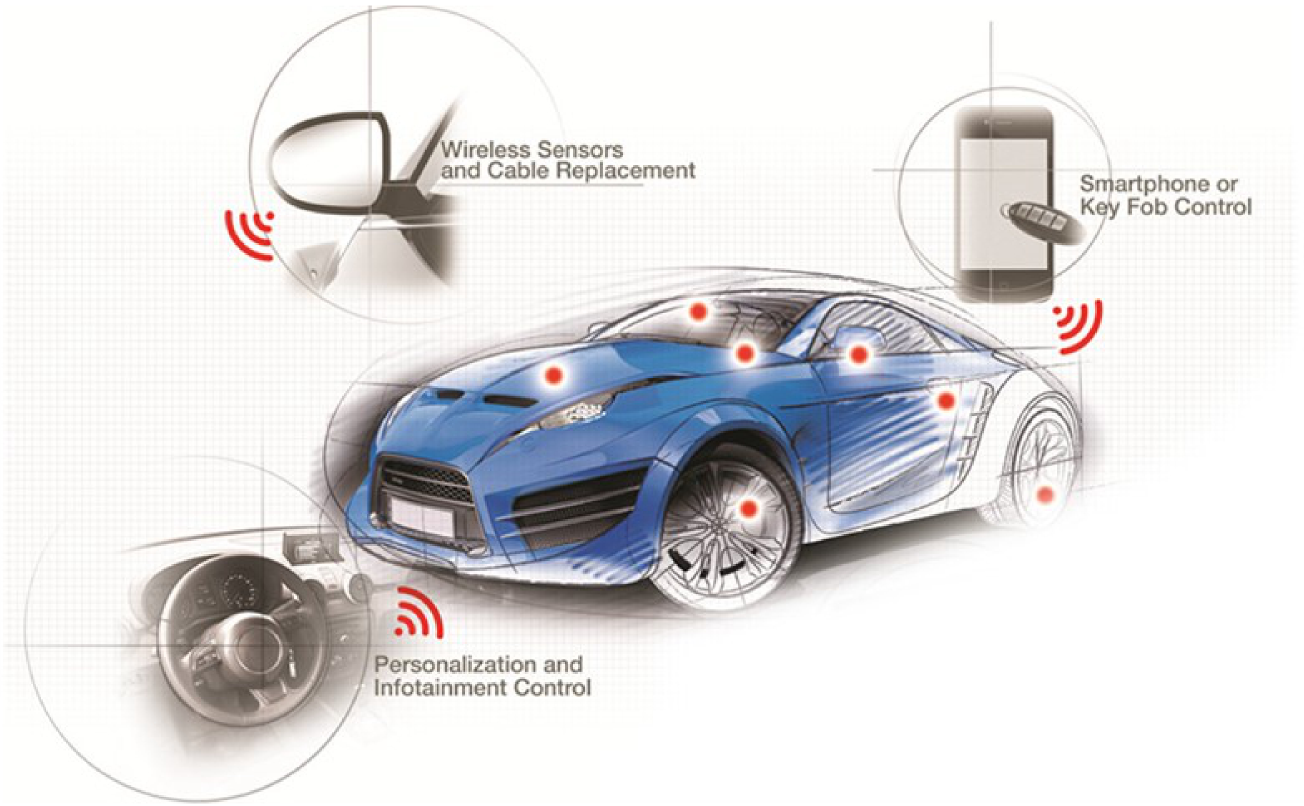
Over the last couple of decades, the automotive vehicle has transformed internally from a mechanical beast to an electronic supercomputer. A little more than a decade ago, when a car broke down, a driver with intermediate technical experience could easily guesstimate the problem and maybe even fix it. Today, it's a bit different. In our modern and more technically-mature society, most cars have extremely advanced electronic systems that are controlled from multi-core application processors usually hidden in electronic control units (ECU) located at multiple locations within the car. One does not simply have to guesstimate potential problems as an intelligent system has already given you the diagnosis, proposed next steps and maybe even solved it. That's a high class user experience.

User experience goes hand in hand with the technology that hides behind the interior. While maintaining an esthetically satisfying design with pro-active safety features the ECUs operates on full speed. The ECUs runs advanced sensor fusion so that every instant of driving time provides live feedback to the control system with information on surrounding objects, speed, calculated driving path, etc. There already are self-parking cars and the only thing preventing autonomous vehicles is the moral aspect of the trust that the driver must give the system. The technology is already there.





There are several types of ECUs, each responsible for a subsystem, for example doors, speed, telematics, transmission etc. The ECUs collects data from various sets of sensors in the car, which can easily reach more than 100 and then merge that data and make a decision based on the combined data. These collections are traditionally made by wires in the car. These wires need to be manually mounted in narrow and tight spaces, which is one of the more time-consuming tasks of the automotive production line and also adds weight and cost. These wires can be replaced by wireless communication and this blog covers the benefits of using *Bluetooth®* Smart.

Bluetooth Smart

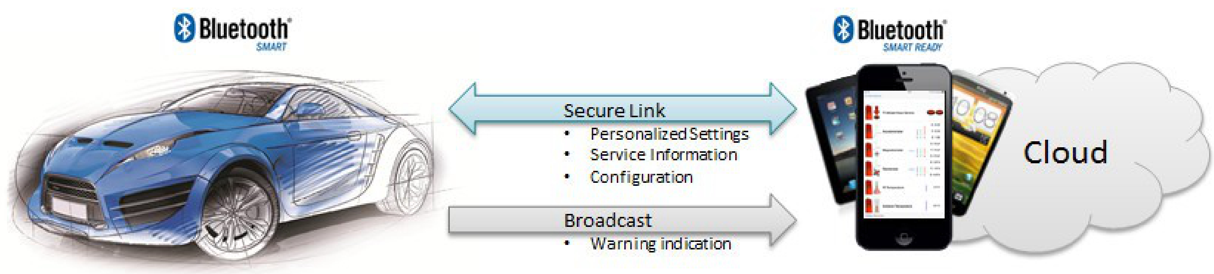
Bluetooth Smart is the branding for devices that use Bluetooth low energy technology, which became part of the Bluetooth 4.0 specification in 2010. Since then Bluetooth 4.1 and Bluetooth 4.2 have been adopted, enhancing the capabilities for the protocol by adding new features to increase throughput and secure the data even further. The technology is designed to be low power, secure and easily deployed. The most common use cases involve sharing small amounts of data with an operational lifetime for years on a single coin cell battery. The low power consumption is achieved by allowing the device to stay in sleep mode during most of the operating time, briefly waking up to transmit few bytes of data. In most cases, the technology is covered by a single-chip solution, which makes it cost- and board space-friendly as well. Additionally, Bluetooth Smart is not bound to use specific profiles like classical Bluetooth. Bluetooth Smart can use custom profiles as long as they comply the Generic Attribute Profile (GATT) architecture.

For automotive applications, simplified design process and easy deployments come as the prime benefits. The challenges introduced by adding a wireless protocol are related to the security aspects. The security in Bluetooth Smart ensures that the communication is protected by using 128bit Advanced Encryption Standard (AES) to encrypt over-the-air (OTA) packets which ensures confidentiality. When a connection is created, an authentication and authorization process is executed in order to protect against MITM attacks by using passcodes or OOB pairing (through another medium, example NFC). When connection has been established, communication occurs over 37 frequency hopped channels to withhold privacy. Integrity check is performed on every packet to ensure non-corrupted and reliable data transfers. So there are plenty of mechanisms built into the core and they are being improved over time. Bluetooth 4.2 introduces elliptic curve cryptography (ECC) with Diffie-Hellman key exchange, to further increase security.

Applications

Think about that box filled with cables you have at home (everybody has one). It's quite heavy, right? Wires are heavy, which is why wire replacement is a very interesting topic for automotive applications. By introducing wireless connectivity solutions, the cost can be significantly reduced. Cost refers to not only the material but deployment costs for the manufacturing as well as fuel reduction cost for the consumer. Sensors can be found in many places in the car and mounting cables to all of them is not always practical. Consider the impractical locations of tire pressure sensors, which cannot be solved with a classical wire. There are other moving units in the car, which benefit from wireless communication such as infotainment controls in the steering wheel. In-car lighting controls could also be implemented wirelessly to deliver ambient, clustered and programmable LED lighting.

Smartphones are important components in the Bluetooth Smart ecosystem, because the majority of smartphones available today are Bluetooth Smart Ready. This means that the ECUs in the car can communicate with the sensors and the driver's smartphone to provide diagnostic data or receive personalized configuration settings. The compatibility also extends to tablets, which allows service technicians to interact with the central unit, or maybe the individual sensors, if allowed. The smartphone can also operate as a key with the introduction of additional safety checkpoints. One example would be the fingerprint reader (iPhone 5S/6) or pin/pattern code access.



The user manual for the car could be available interactively on the smartphone. This could allow the car to send an alert, such as low tire pressure, that would be encapsulated with information on the smartphone regarding what to do next, for example providing information on the closest fuel station. Service reminders could also be pushed to the smartphone, which could provide an option to schedule a time with a pre-selected or closest auto-repair shop. This is where cloud services can be introduced, allowing the car to interface with the Internet through the smartphone, which is one way how Bluetooth Smart enables the Internet of Things (IoT).

Conclusion

As automotive vehicles, not limited to cars, become more advanced and surprisingly intelligent, more information is required to be able to make decisions that are rational and safe. Therefore, sensor fusion becomes more important as does the need for wireless connectivity like Bluetooth Smart to interface seamlessly with the core functionality of the vehicle via in-car controls or smartphone.

The prime single-chip solution for the discussed topics in this article is TI's Bluetooth Smart CC2541-Q1 wireless MCU. It's a complete hardware and software solution for automotive applications that includes a Q100 qualification, sample applications and evaluation tools to go from idea to first prototype in an easy, efficient and safe manner. There are plenty of examples of custom GATT profiles and all security features are available out-of-the-box.

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