Electronic Design

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Software-Defined Vehicles: The Future of the Automotive Industry

Sponsored by Texas Instruments: The poster child for new automotive technology is a dynamic, adaptable system that allows for continuous improvements to the driving experience through software.

Software has become increasingly complex in automobiles. Today, it's estimated that well over 100 million lines of code exist within a modern car—for comparison, there are about 15 million lines of code in a Boeing 737 aircraft.

Modern vehicles primarily employ a domain architecture, organizing electronic control units (ECUs) cabled together into specific domains such as the powertrain domain, driver-assistance domain, body control, or chassis.

Getting into the Zone Architecture

Software-defined vehicles (SDVs) change vehicle architecture by shifting from domain to zone architectures *(Fig. 1)*. Zone architectures offer a good remedy for the shortcomings of domain architectures. The latter group domain functions based on their geographical location, or zones, inside the car, which doesn't optimize wiring because the ECUs for each functional domain can be scattered throughout the vehicle.

The zone architecture gives OEMs much more control thanks to high-level software maintenance firmware-over-the-air (FOTA) updates and always-on cloud connection to enable new functions and improve features. By centralizing software and decoupling hardware from software, these design schemes lead to reduced costs and new features. Adding new features and applications requires updating only the central computer or zone control module software, because the downstream sensors and remaining ECUs controlling the mechanical actuation (headlights, door modules, audio amplifiers, etc.) are extracted from the application software.

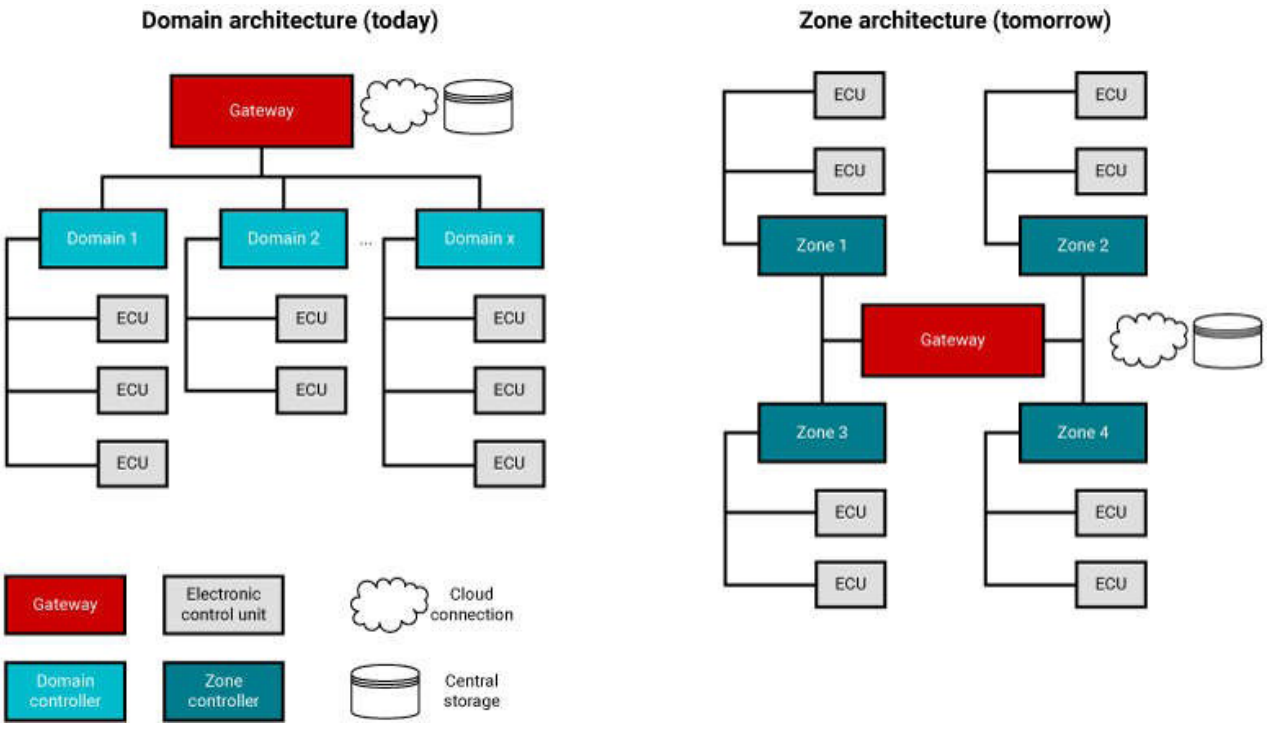
Zone architecture requirements necessitate new solutions to overcome power-distribution, sensor and actuator, and data-communication challenges. For example, the transition to decentralized smart fuses, more use of smart actuators and sensors, and higher-bandwidth interfaces with the right support on very diffuse data-type combinations can address the most apparent design problems in zone architecture implementations.

What is a Software-Defined Vehicle?

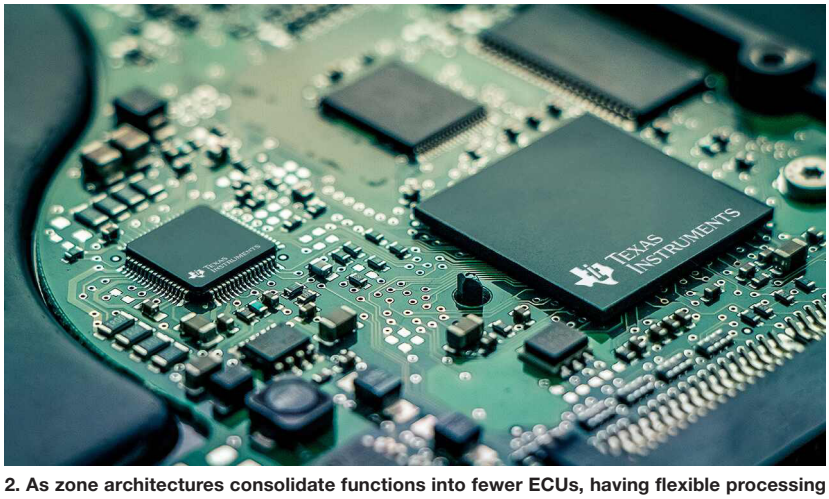
A software-defined vehicle enables smoother interactions between a vehicle's internal systems and the outside world. SDVs decouple network functions from proprietary hardware, allowing for parallel physical and digital development. These vehicles can significantly enhance safety, reduce costs, and provide a more personalized driving experience.

Specific benefits derived from software-defined vehicles include:

- **Scaling across all vehicle platforms:** An economy vehicle can implement the same software as a luxury brand for functions such as remote keyless entry, window control, and rearview cameras. Luxury models could offer premium features through software over and above baseline features. Although hardware changes may still be required, the overall approach is modular and scalable.
- **Easier maintenance:** SDVs leverage real-time performance insights to enable predictive maintenance, reducing unexpected breakdowns and extending vehicle lifespan.
- **Lower costs:** In SDVs, vehicle functions are integrated into fewer chips. This makes it possible to reduce wiring complexity and weight, among other factors.



1. Comparing domain and zone architectures. (Credit: TI)



2. As zone architectures consolidate functions into fewer ECUs, having flexible processing solutions is critical for SDV designs. TI's microcontrollers and processors offers a wide range of performance capabilities and features such as integrated hardware security modules for cybersecurity. (Credit: TI)

- **Over-the-air (OTA) updates:** This is the A-lister when it comes to an SDV's advantages. Traditionally, the vehicle has been viewed as an embedded platform, where the software has been hardware-dependent. This means that the software for one system may not be easily transferred to another without large up-front engineering costs. With OTA updates delivered remotely to a connected car, vehicle manufacturers can deliver new features, fix bugs, and enhance security.
- **Real-time connectivity:** SDVs leverage vehicle-to-everything (V2X) communication, enabling real-time data exchange, navigation assistance, and remote diagnostics, as well as providing platforms for telematics, automated driving, and more.
- **HEV/EV battery-management system (BMS):** Supporting the trend toward software-defined vehicles is challenging designers to develop smarter, more advanced battery-management systems (BMS). New driver chips support safe and efficient control of power flow in battery management or other powertrain systems with functional-safety compliance and built-in diagnostics to reduce development time. This helps to advance the adoption of electric vehicles worldwide.

Creating Software-Defined Vehicles

The Scalable Open Architecture for Embedded Edge (SOAFEE) is an industry-led collaboration between companies across the automotive and technology sectors. This

collaborative effort aims to create a standardized software architecture for SDVs, streamlining development processes and enhancing interoperability across the industry.

SOAFEE intends to adopt standards in both cloud native and edge computing, allowing automotive OEMs to focus on their core competencies and increase the reusability of software. By making SOAFEE hardware agnostic, this special interest group (SIG) plans to simplify vehicle software solutions.

SOAFEE Architecture v1.0, the first architecture release from the initiative, opens the door to applying cloud-native technologies in the automotive, real-time, and safety domains in future SDVs. Cloud-native technologies are a set of tools and practices that enable organizations to build and run applications in the cloud.

SDV technology continues to evolve. From more advanced driver-assistance systems (ADAS) to smarter EV powertrain systems, TI is working alongside automakers to reimagine how reliable and intelligent technology can lead to safer, better vehicles.

TI offers an array of design resources for SDV applications, from interactive reference diagrams with subsystem product recommendations to technical white papers and trend-revealing blogs *(Fig. 2)*.

The choice of a new system technology often comes down to knowledge and availability. This is where TI comes in. The company offers years of system expertise and scalable software solutions along with the latest technology so that you can bring the right solutions to your customers.