Evolving automotive gateways for next-generation vehicles

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Introduction

Automotive architectures are rapidly evolving with a trend towards semi-autonomous and eventually fully-autonomous vehicles. Automotive manufacturers are also including a variety of features such as smart access, car sharing, predictive maintenance, vehicle tracking, fleet management and over-the-air (OTA) updates to enhance connectivity and in-vehicle communication. These advanced features generate an ever increasing amount of data which need to be processed, by a high-performance processor, and communicated securely and safely across interfaces such as CAN, LIN and higher-speed networks, such as Ethernet. As a result, car manufacturers are reevaluating the architecture of automotive gateway and telematics control unit systems.

The automotive gateway

An automotive gateway is a system whose core function is to safely and securely transfer data within the vehicle. There is the potential for several gateways in the vehicle: the centralized gateway and multiple domain gateways.

A centralized gateway in a car safely and securely transfers data between numerous domains, such as the telematics control unit (TCU), powertrain, auto body, infotainment system, digital cockpit and ADAS applications.

A domain gateway (or domain controller) has a similar function but routes data between ECUs within its respective domain.

Centralized gateways typically require more processing performance, interfaces and higher-bandwidth networking protocols than domain gateways. **Figure 1** illustrates how to implement the two types of gateways in a vehicle.

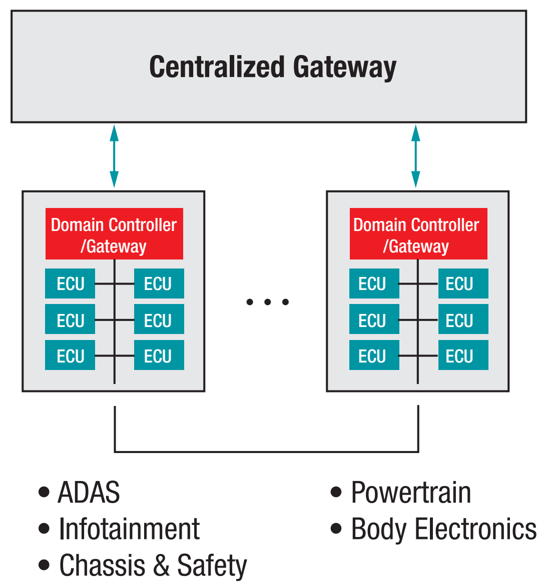

Figure 1*. Example SoC architecture, featuring a centralized gateway and two domain gateways.*

TCU

The TCU is the ECU in vehicles that provides connectivity to the internet and cloud.

Cars connecting to the internet and the cloud are becoming more and more ubiquitous, with car manufacturers outfitting vehicles with Wi-Fi®, *Bluetooth*® and cellular data options.

Such connectivity enables emergency calling (eCall) and access to entertainment and other content online while traveling, along with providing OTA software updates to the digital content in the car.

Newer trends—such as car sharing, replacing key fobs with mobile phone access, fleet management and tracking, insurance providers monitoring driving habits remotely, and car dealers monitoring vehicle health remotely to schedule preventive maintenance such as oil changes—all require a connection to the internet and cloud.

Another emerging trend toward full autonomy is a vehicle's ability to communicate with entities such as cars, infrastructure (such as traffic lights), or even people. This is aptly known as vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) and vehicle-to-pedestrians (V2P). Dedicated Short Range Communication (DSRC) or c-V2X connectivity usually facilitates such communication.

In short, Telematics connects the car to the outside world. **Figure 2** illustrates telematics pictorially.

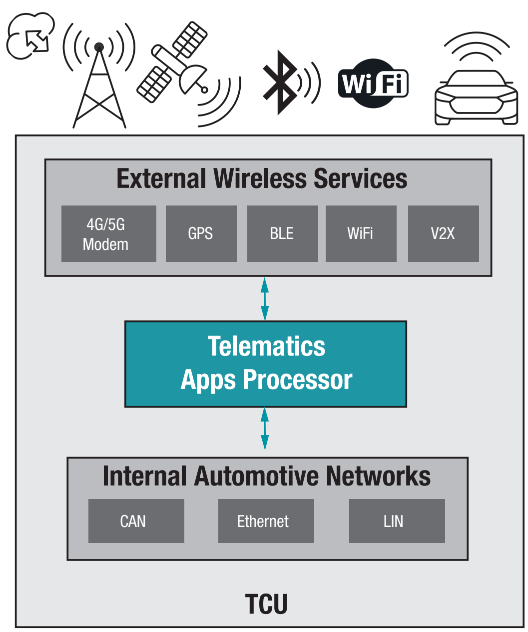

Figure 2*. Example of telematics.*

Evolving gateway and TCUs require application processors

Automotive gateway processors have traditionally been 32-bit microcontrollers (MCUs) with embedded Flash and supported gateway interfaces that were lower-speed interfaces such as Controller Area Network (CAN), Local Interconnect Network (LIN) and FlexRay™. However, as cars are increasing in ADAS and connectivity functionality, vehicles have to process and communicate an ever-increasing amount of data securely and safely, at very low latencies, between various domains.

Since interfaces such as CAN-Flexible Data Rate and LIN are not designed to handle vast amounts of data at low latencies, car manufacturers are migrating to an Ethernet TCP/IP-based protocol for handling higher-bandwidth data movement. TCP/IP is attractive because it's a well-established communication protocol in the consumer space, and thus considered less risky than a less-proven protocol.

Since MCUs by themselves may not able to keep up with the processing requirements of future gateways, higher-performing application processors are replacing or augmenting certain MCU functions to process and route the data of future gateways. Furthermore, as in-vehicle networks migrate to an Ethernet-based network, automotive gateways supported by an application processor can help process and route data between various domains quickly and efficiently.

Connectivity is necessary for OTA updates to refresh entertainment content and other services, such as vehicle/ride sharing apps and remote vehicle access. TCUs have a cellular or Wi-Fi® modem to provide connectivity and an application processor to process data received from the modem. Processing involves decrypting the data, validating the data and routing it to the gateway or to a different domain ECU. In current architectures, the modem and processor are integrated on a single semiconductor device. However, because modem standards are constantly evolving, car manufacturers are moving to an architecture that separates the modem from the processor. Moreover, both automotive gateways and TCUs are migrating to an Ethernet-based network powered by an application processor with high-speed connectivity peripheral support, like

PCIe, and high compute power to process and route data between the various domains.

The advantage of separating the processor from the modem is that the ECU can be quickly migrated to a new modem standard by replacing only the modem, preserving the processor and all associated software running on it.

Safety and security are also gaining importance in automotive gateways and TCUs as cars become more connected and autonomous. A dedicated embedded security processor or subsystem can help protect access to vehicle security keys, enhance communication channels security and ensure that trusted software updates cannot be used as part of a cyberattack. Safety functions are typically implemented in discrete MCUs certified to be safe. But an SoC that integrates both application processors and a safety MCU offers automotive OEMs a lower bill-of-materials (BOM) cost.

Development cost

As discussed in the previous section, gateway and TCU systems are becoming increasingly complex in terms of functionality. This results in a high development cost for car manufacturers. Ideally, this cost would not have to be incurred for every tier/model of a vehicle.

OEMs and Tier-1 suppliers can streamline development costs by working with a device in the Jacinto™ DRAx processor family, that provides a scalable and software-compatible platform that can help address the needs of next-generation gateway and TCU systems. Jacinto DRA8x processors help enhance connectivity throughout the vehicle by supporting a variety of high-speed I/O such as PCIe, USB3.x, and Gigabit Ethernet and traditional automotive peripherals, such as CAN-FD and LIN. These processors are also tailored for use in automotive gateways and include on-chip MCU subsystems to help meet the real-time processing demands and performance required for TCUs, application processors and automotive gateways.

The DRA829V is the latest device in the DRA8x processor family. The DRA829V device is an enhanced system-on-a-chip (SOC), which integrates several computational and processing elements to make it easier for automotive gateways to effectively manage and support higher throughputs of data in real time. Features such as a cluster of Arm® Cortex®-A72 MPUs and clusters of Arm Cortex-R5F cores for real-time processing and high speed peripherals such as USB-3, integrated PCIe switch and a Gigabit Ethernet switch eliminate the need for external components for higher bandwidth data transfers. Another key feature of the DRA829V processor is its integrated MCU subsystem for functional safety, which supports ASIL-B to ASIL-D functional safety operations on-chip. The DRA829V processor also includes a suite of traditional automotive peripherals, such as CAN-FD, LIN and MOST. For security critical applications, the DRA829 device supports secure boot and run time environment via an integrated High Security Module (HSM).

Further, DRA829V processors offer a range of computational power and mix of peripherals providing cost optimized devices for a range of automotive gateways.

The Jacinto DRA8x processor family includes support for several high-level and real-time operating systems in the Processor SDK along with fully compatible and scalable software development kits (SDKs) that enable OEMs to leverage and reuse design efforts among their product lineup, which ultimately results in lower development costs. With unified software, car manufacturers are able to scale costly software R&D investments and deploy software through their entire centralized gateway platform for entry- to premium-level vehicles.

Innovating next-generation gateway systems

The architecture of automotive gateways and TCUs are changing rapidly to efficiently process and move vast amounts of data between the various domains in the car. A scalable SoC with an integrated MCU subsystem, application processors and high-speed I/O functionality would help meet the demands of this new architecture with a reduced system BOM.

TI's scalable hardware and software-compatible family of DRA8x SOCs helps meet the demands of the new gateway and TCU architectures, helping to reduce system BOM cost and development cost for automotive gateways.

Additional resources

- Learn more about Jacinto DRA8x processors for automotive gateway applications.
- Get more information on TI solutions and design resources for automotive gateways.
- Download our reference designs for Automotive Gateways and TCUs.

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