STMicroelectronics Introduces Stellar

Case Study

The first automotive MCU with real-time virtualization for powertrain, smart gateway and domain controllers

Goal

Car manufacturers are defining new architectures that integrate multiple vehicle functions into centralized systems called domain or zone controllers. STMicroelectronics Stellar family enables users to create safe, secure and deterministic solutions for these new architectures to address vehicle electrification and vehicle systems where powertrain, braking and vehicle dynamics functions are integrated.

Challenge

The powertrain is traditionally a very complex automotive application that sets demanding latency constraints to meet strict real-time responses and requires advanced timer functionalities, accurate analog capabilities and high-level safety guarantees. These challenges have been recently further emphasized by the integration of electrification features such as charging, battery management, inverter traction control, and the evolution of vehicle architectures into domain and zone-oriented architectures.

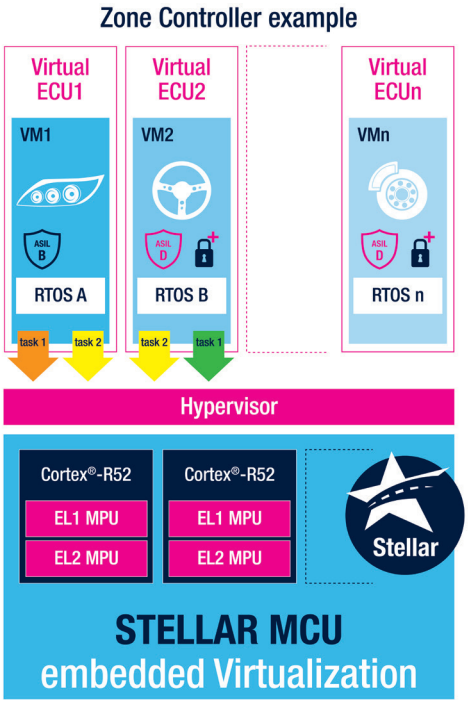
For next-generation architectures, automotive microcontrollers must be able to provide more capabilities than ever before. Alongside offering all the features for traditional powertrain applications they must also have a high level of connectivity, increased routing capabilities, and features to guarantee software separation. This compartmentalization of software must enable the safe integration of multiple virtual ECUs in the same physical box. In fact, this increasing software complexity and integration can only be managed with a better utilization of hardware resources, simplified maintenance of the different modules and separate containers for the multiple virtual ECUs. These virtual ECUs can coexist in the same physical MCU only if freedom from interference (FFI) and secure compartmentalization of software functions is guaranteed while supporting concurrent multiple ASIL safety levels.

With the increasing pervasion of electronic controls in vehicles, software updates have become far more relevant for car makers, and they need to ensure safe, secure updates, without risk to other functions.

Solution

Stellar is a new category of high-integration automotive microcontrollers which enables safe, real-time virtualization for automotive domain architectures. With a rich feature set and high real-time computing capability for traditional powertrain and chassis and safety applications, Stellar MCUs feature innovative virtualization features. These features provide freedom from interference between applications, as well as accelerators for high throughput secured data routing and built-in Over-the-Air update functions.

Designed as a real-time automotive MCU with innovative features to maximize function integration and ensure safe and secure software updates, Stellar Integration MCUs feature hardware-enforced hypervisor capabilities. These capabilities are enabled by the Arm Cortex-R52 processor and the firewall support integrated in the Network On Chip package. These support complete separation and compartmentalization among applications and allows the isolation of mission-critical functions. In addition, Stellar supports several real-time operating systems running independently without interference with different functional safety levels, and superior processing capabilities for encrypted communication over ethernet or CAN with dedicated AES-light accelerator to offload centralized Hardware Security Module (HSM) for MCASec, IPSec and CAN authentication functions; all while ensuring fast task execution.



A great fit for powertrain applications, Stellar features embedded non-volatile memory for fast start-up and real-time responsiveness, advanced analog functions, state-of-the-art timers for complex timing, rich connectivity, innovative safety and security features to meet the most challenging OEM requirements.

Each MCU in the family implements Arm Cortex-R52 multicore clusters for easy integration of complex real-time environments, securing a strict physical separation and compartmentalization and protection of safety-critical partitions, while delivering low-latency deterministic responsiveness. To support freedom from interference for all application resources, the virtualization is deployed throughout the whole device from the CPU down to the peripherals. Furthermore, Stellar Integration MCUs integrate additional ad-hoc hardware features to further enhance the isolation robustness of all parallel-executed virtual ECU applications.

Efficient interrupt management allows multi-tasking execution of safety-critical applications, with real-time scheduling policies to switch between tasks while still granting the preconfigured rules of Quality of Services. Stellar achieves this while preserving the determinism and performance required in real-time systems.

Manufactured in ST power-efficient 28nm FD-SOI technology, Stellar is the first MCU family featuring Phase Change Memory (PCM), a high-density non-volatile memory with high performance and reliability that delivers unrivalled capabilities for Software Over-The-Air –(OTA) updates and management of multiple firmware images.

Automotive Applications

- Drivetrain
- Electrification
- ADAS
- Vehicle Dynamics
- Braking
- Smart Gateway
- Domain Controller

Benefits

1. Stellar MCUs allow the integration and simultaneous execution of real-time functions with different safety requirements on a single device, addressing the evolution of new vehicle architectures and enabling freedom from interference by enforcing physical and deterministic separation between functions necessary for the embedded hardware virtualization.

2. Manufactured in an ST proprietary robust 28nm process, Stellar integrates analog capabilities, features fast embedded NVM and reaches Grade 0 automotive mission profiles.

3. Strict function separation and the advanced NVM architecture allow independent software updates without creating vulnerabilities in other partitions, which remain isolated. This also implies no need for system re-certification when one function is added or updated.

Why Arm

Arm Cortex-R52 delivers an unpreceded level of performance to meet the increasing computational needs of advanced real-time automotive applications. The 8-stage pipeline microarchitecture, support for fast bus ports with ECC protection, double-precision FPUs, hardware acceleration for advanced SIMD arithmetic instructions (NEON) are only a few of the multiple techniques and technologies adopted to outperform competitive cores.

Built upon the Armv8-R architecture, this innovative core is designed with a focus on safety. Its comprehensive safety package, built-in self-test features, software test libraries, and support for fault-tolerant Lockstep computer systems make Stellar Integration MCUs the right choice for System-on-Chip integration targeting ASIL-D class applications.

Featuring a 2-level Memory Protection Unit and a low-latency Generic Interrupt Controller, the Arm Cortex-R52 processor enables hardware support for hypervisor, providing unique capabilities for resource isolation and real-time execution, essential for the upcoming virtual ECUs in the drivetrain domain and automotive applications in general.

Lastly, the Arm Cortex-R52 processor benefits from Arm's industry leading ecosystem of software, tools and services providers to accelerate scalable innovation across the automotive value chain. These include Arm's own accurate processors models for benchmarking and hardware-less software development, and its highly-optimizing C/C++ compiler toolchain qualified for applications targeting ISO 26262 ASIL D.

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