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SOFTWARE-DEFINED VEHICLES: THE PATH TO AUTONOMY?

The future of automotive technology will be strongly influenced by a need for higher safety, security, and intelligence moving towards autonomy. In addition, this intelligence will be largely delivered through software. However, these trends will not occur in isolation from the traditional concerns of economics, market competition, and variant management. Finally, these collective requirements have to be treated in the context of an increasingly connected world. The transition to the new world will result in fundamental changes to architecture and supply-chain models.

Globally, the automotive world is likely to move from the current model of CAN-networked (Controller Area Network) closed ECUs (Engine Control Units) to an open network, programmed as a car.

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Challenges for current vehicle architectures in a world demanding safety, security, and autonomy

Requirements

The vehicle of the future will be required to offer the following:

- Increased levels of active and passive safety, likely related to increased levels of legal requirements for certification
- A high-level of security against intrusion from connectivity or physical operations
- High-level intelligence for Advanced Driver Assistance Systems (ADAS), providing increasing support for all aspects of driving and vehicle behavior, eventually moving into full autonomous driving
- The ability to accept updates for both functional and safety-related features
- Requirement to keep time to market and costs as low as possible
- Optimization of emissions or charge consumption
- A platform for connected services and an ecosystem of content
- The possibility to personalize systems for end customers.

Approach

The current approach to vehicle architecture and supply chain is largely based on black/grey box integration via CAN of function-dedicated ECUs. While this approach has served the industry well to date, it faces a number of challenges in delivering the requirements described above. These include the following.

Global system behavior management

The impact of safety and security of the level which is anticipated will require the demonstration of detailed, and high confidence in, safety and security cases. These cases will be based on the full chain of interactions for the vehicle systems implicated in the relevant features. Of particular note is that demonstrating these cases will involve a number of additional issues such as timing and latency, data semantics, and safety or security status. The current approach deals with these issues in an ad-hoc manner, often at the ECU interfaces and through case-by-case negotiation. In the scaling up required for the future, this approach will prove to be too expensive, and challenged by the interactions needed to be considered for the higher-level features.

Data distribution and access

The increased intelligence in the targeted features coupled with their impact on vehicle dynamics and physics will be based on high data consumption from sensors, UI, and connected infrastructure. The data will be used by a variety of features and in a number of ways, including frame-based computation, heartbeat management, and client/server or publish-subscribe interactions. In addition, the evolution of features or the addition of new features will open up further data-distribution needs through the life of the vehicle.

In the current architecture, data is accessed or distributed in a point-to-point fashion, usually in a hard-wired manner. It is quite clear that future architectures will need to support a coordinated data plan and with a wide range of distribution and access possibilities.

Feature optimization, evolution, and management

As stated above, a number of changes to the management of the vehicle feature inventory will arise:

- The development of features which leverage existing capabilities
- The delivery of updates and new features over the air
- The need to update safety features, calibration data, and policies with integrity and occasionally with urgency
- An increased requirement to support a wide ecosystem of feature developers, beyond the current n-tier suppliers.

The current architecture has no fully defined and economic approach to this, largely due to the ad-hoc interfacing and software visibility of the ECU-based feature support.

Integration economics

The final major challenge faced by the current architecture in the face of an expanding and changing requirements base is that of economically managing integration. Already today, an infotainment system can cost close to 200 million euros in delivery, based on industry benchmarks. In the future, ADAS functionality will require the same level of integrated and coordinated behaviour but with the addition of safety issues. A drastic rethink of the architecture support for integration is required.

TAKEN TOGETHER, THESE CHALLENGES CAN BE RETHOUGHT AS ONE OVERARCHING ISSUE:

HOW TO DEAL WITH THE VEHICLE AS A UNIQUE SYSTEM?

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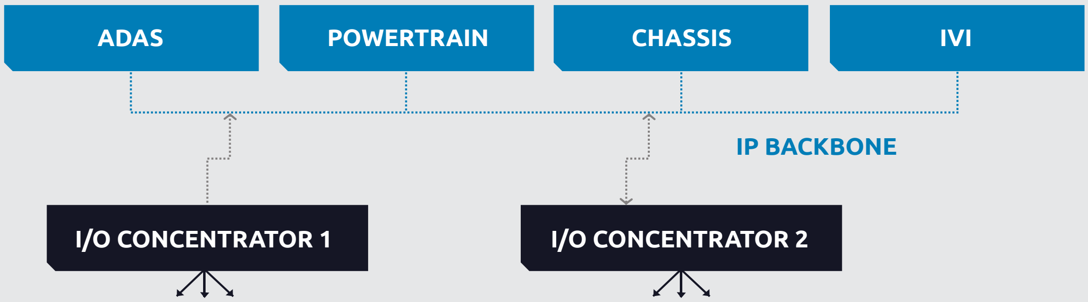
Rethinking the vehicle as a network programmed to be a vehicle

A rework of the vehicle E/E architecture

In light of these challenges and also with the permanent pressure to optimize the bill of materials (BOM), weight, and emissions, OEMS are investigating a rework of the vehicle E/E architecture.

One common theme is emerging: that of increased software running on optimized and more general-purpose hardware platforms.

The vehicle processing is largely centralized in a number of central controllers. In one version of this idea, each central controller is targeting a dedicated domain, for example ADAS. These controllers sit on a high-bandwidth and more generic IP backbone. I/O is managed by a small number of low-intelligence concentrators distributed close to the sensors and actuators. The concentrators fan out to CAN, Flexray, GPIO, etc.



An alternative to this approach is to use the same topology, but to allow features to be distributed across the processors arbitrarily and not necessarily by domain.

Regardless of the partitioning approach, this architecture is largely about providing a platform to run software. This view reflects the increasingly dominant role of software in the automotive sector. The key point is that the environments running on the domain control will offer the possibility to mix and match software components from different suppliers in a secure and controllable manner.

Specifically, these environments will offer:

- Inter-component communication
- Security mechanisms and architecture
- Interference protection
- A level of diversity of operating system and platform services (Linux, RTOS, Autosar, etc.)
- Fault detection and management.

A unique definition for a number of transversal issues is required.

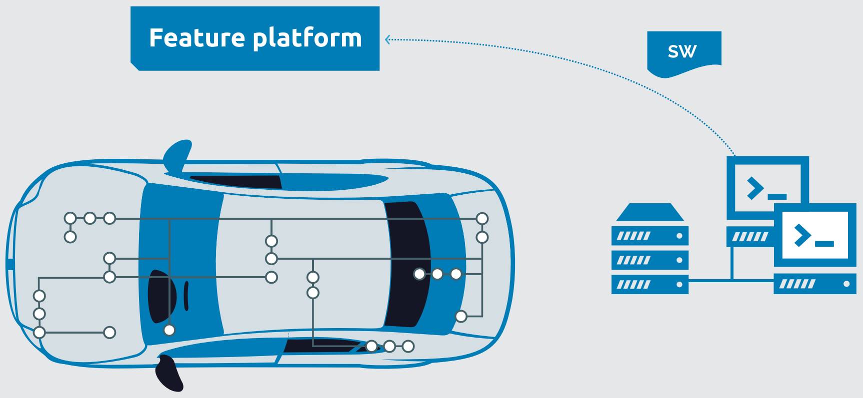
However, these features in themselves are necessary but not sufficient. In order to complete the picture of the vehicle as a unique system, a unique definition for a number of transversal issues is required.

This includes such things as:

- Resource prioritization and run-time control
- Data dictionary management
- Global configuration control
- System-wide diagnostics
- Integration process
- User management.

In practice, such concerns are best served by a middleware with appropriate tooling and process.

CONFIGURATION	**STANDARD ERROR**	**MODULAR SAFETY CASES**
RESOURCE MAP	**DATE PLANE**	**DECLARATIVE POLICY**
STANDARD LIFECYCLE	**FEATURE INTERACTION**	**COST-STYLE INTEGRATION**
END-TO-END SECURITY	**ARBITRATION**	**TOOLING**



The overall approach is to make the vehicle a software platform as a means to recognize the weight of feature to be delivered by software, and to allow the flexibility of such a software approach to be realized in a controlled, safe, and secure manner.

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The software-dominated vehicle: benefits and challenges

The vision described above is becoming generally accepted as being the key to allow the automotive industry to address the future usage requirements economically, safely, and securely. In such an architecture, it will be possible to treat system development, evolution, and update as a more formalized and secured version of the processes already used in other markets and sectors.

The main challenges to the adoption of such an approach are largely non-technical. In particular, the following cultural and business issues need addressing:

- Reworking relationships and business models in the supply chain
- Reskilling the automotive engineering community to deal with more advanced software tools and processes
- Reworking the development flow to actively manage security, safety, and the integration economics in an end-to-end manner
- Managing the roadmap for the deployment of the new approach in a manner which adds value to early adoption.

These challenges will need to be addressed efficiently and in the face of competition from new players and non-traditional new entrants in the automotive sector.

In facing these challenges, the automotive sector will need to become a software industry and drive its system engineering to respond to this change in an efficient manner. The car of the future will be defined largely by its software-delivered features and by its ability to meet expectations derived from mainstream experience of software platforms, software timescales, and software business models. The technical support for this change will have to pass by an improved platform and supply-chain structure for software coupled with the integration of new players and mainstream technology providers.

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