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Enabling Flexible Vehicle Architectures with AUTOSAR and DDS

AUTHORS

Kai Richter
Senior Expert Classic AUTOSAR (ITK Engineering GmbH)

Emilio Guijarro Cameros
Automotive Applications Engineer (RTI)

OVERVIEW

The Automotive Industry is rapidly transforming, fueled by consumer demand for automation and continuous connectivity, and enabled by technical leaps in communications bandwidth and raw computing power. These changes require an architectural shift in automotive design, as the traditional electrical/electronic architecture cannot provide the necessary scalability for the new data centric approach required to run the interconnected "system of software systems" of tomorrow's cars.

AUTOSAR™ and DDS™ are two software standards that can accommodate these new requirements. AUTOSAR is the standardized automotive open system architecture designed for automotive ECUs. The two AUTOSAR platforms, AUTOSAR Classic and AUTOSAR Adaptive, provide the layered software architecture approach for different vehicle use cases. In particular, the AUTOSAR Adaptive platform addresses the design challenges of in-vehicle high-performance computing and addresses the connectivity and continuous software updates necessary for next-generation vehicles. It also acts as an integration platform for software from multiple suppliers.

The Data Distribution Service™ (DDS) standard is a middleware protocol and data-centric connectivity framework that integrates the components of a distributed system together. It enables data to be at the center of future mobile digital platforms by enabling low-latency data connectivity, extreme reliability, and a scalable, flexible architecture. DDS fosters the development of a loosely coupled, modular and open architecture system which reduces complexity, time to market and system costs.

Rising to meet the demands of connected digital vehicles, these powerful two standards – AUTOSAR and DDS – now work together. In the AUTOSAR Adaptive platform, DDS components are optimized for end-to-end data sharing without the need for custom integration. AUTOSAR Adaptive defines a DDS network binding to support autonomous systems with a production-ready communication framework that delivers the reliability, scalability and performance required for complex systems. Together, AUTOSAR and DDS provide automotive manufacturers with a high-performance approach to designing and operating next-generation vehicles.

THE DIGITAL CONNECTED CAR

The Automotive Industry is in a state of disruptive change, propelled by consumer demand for continuous connectivity and data-driven technologies that are fueling advancements in connected cars, autonomous driving, shared and digital services as well as electric cars[1]. Manufacturers and suppliers must address various challenges in building a connected digital car. The cars of tomorrow must be designed to operate in diverse real-time environments, interoperate with other systems within the vehicle, connect to off-vehicle systems and offer built-in automotive-grade cyber security and functional safety.

Manufacturers now use new hardware components such as camera, *LIDAR*, *RADAR* and high-performance computer hardware for observing and processing the car environment data required for highly-automated driving. High-bandwidth links such as Ethernet and an increasing amount of software are necessary to connect such systems to the control units of the car and process its data. The high amount of connectivity increases even more as the car interacts with the outside world so that customers can use digital services provided by connected sensors, devices and machines collectively known as the *Internet of Things* (IoT). For example, the customer can receive a recommendation for nearby service and replacement parts of the car via a mobile phone. Or, the car can receive data from a nearby parking garage to locate, reserve and pay for a space. Another example is where the car can learn how to drive in a parking space and it will reverse out of this space by a press of a button on the driver's phone. The car is turning into a system within a system of systems, because nearly all cars will be connected to, and part of, the collective IoT landscape, requiring secure connections for updates and upgrades over the life of the car. [2]

This requires a change in architecture from traditional car design. The domain-oriented electrical/electronic (E/E) architecture [3] is not scalable for updates and upgrades over the life of the connected digital car, because the communication network uses predefined messages which are defined when the car was designed. As such, it does not allow subscriptions to digital services in a dynamic manner. In addition, the automotive software architecture of this E/E architecture has no flexible update mechanism for new applications and no access to the external world since they are designed for replacing the entire software of an electronic control unit (ECU) in a garage, instead of dynamically over the air.

For example, smart sensors are intelligent embedded devices that data is distributed to via one or more ECUs. They can be controlled over a communication network within their defined network domain. Smart sensors are part of the essential vehicle functionality, but they could take an even more important role in the connected digital car, if there was a communication protocol which would allow for the integration of a smart sensor in a digital service. The right communication protocol could elevate the functionality of a simple control unit which is directly connected to a simple sensor, enabling it to become a digital service through new dynamic data exchange.

This allows new application use cases for new digital services such as driver usage for predictive maintenance and adjusting insurance premiums, using AI to detect driver fatigue or changing road conditions ahead, or over-the-air software updates.

Manufacturers are moving to a more centralized and flexible E/E architecture where the connectivity is controlled by flexible and reliable communication protocols as well as new automotive-grade software architecture frameworks. One approach is to create a group-wide software platform with its own operating system features that can be upgraded and expanded by the user from outside of the car. The large amount of software code is handled by software suppliers and digital software teams of the manufacturers.[4, 5]

E/E Architecture of a Connected Digital Car

Since the connected digital car is connected to external digital services, it requires a flexible E/E architecture which in turn requires a communication protocol that works with connected systems and new digital services both within and outside the car. The components and communication networks of such an architecture are illustrated in Figure 1.

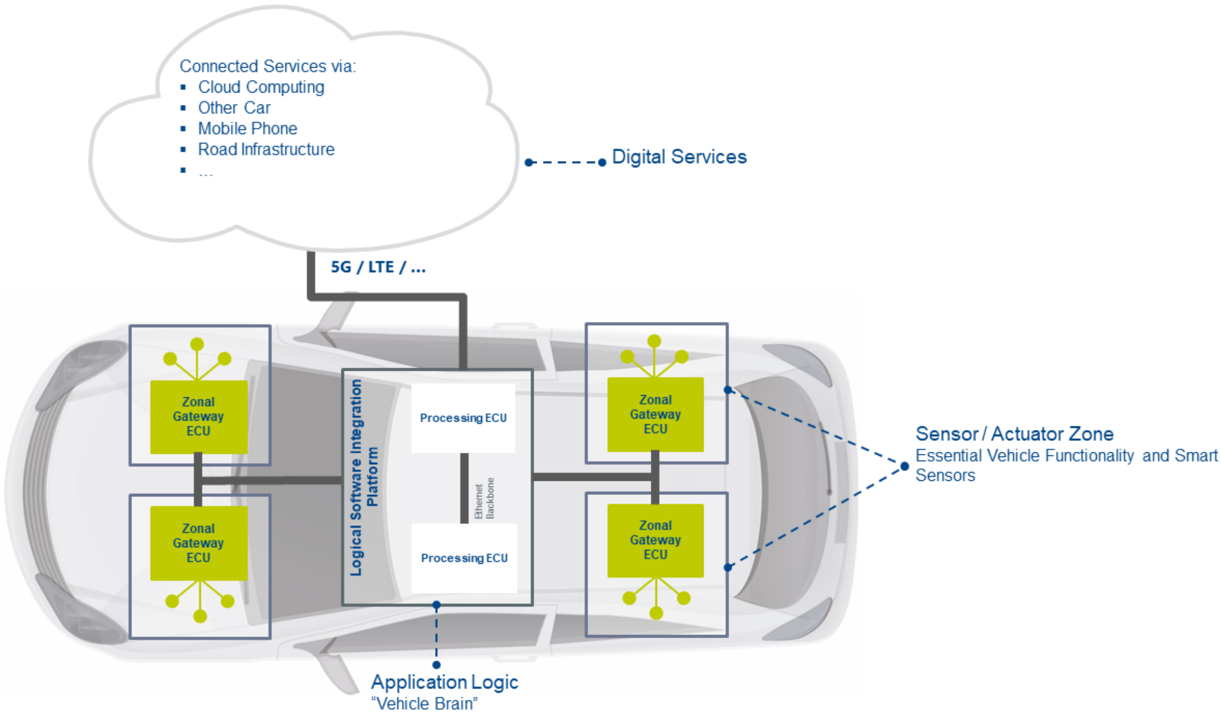

Figure 1: The components and communication networks of a digital connected car (source: ITK Engineering GmbH, depositphotos/tele52)

The essential vehicle functionality found in legacy car architectures is well known and is reliable and applicable to the connected digital car. Its vehicle components such as powertrain sensors and actuators are moved into a sensor and actuator zone. Sensor and actuator values are processed in a safe, secure and real-time manner by zonal gateway ECUs or in so-called smart sensors units. The sensors and actuators are either connected directly by analog wire or by a bus interface (LIN, CAN, FlexRay) to the zonal gateways.

The processing ECUs act as the vehicle "brain" since they can combine complex application logic for automated driving and digital services from communication nodes inside and outside the car.

External digital services will be connected via a mobile communication network such as 5G to the following infrastructure nodes:

a. A cloud computing infrastructure which could offer a live parking map for finding a free parking space
b. Vehicle-to-x infrastructure which could communicate what other cars see on the road ahead
c. Mobile phone infrastructure which could be used for upgrading the car functionality via an application store, etc.

Because of the wide range of internal and external connected services, the E/E architecture of the connected digital car needs to support different communication methods. These include:

Signal-based communication, where several other nodes exchange signal values. Example network technologies are LIN, CAN and FlexRay.

i. Service-based communication, where nodes subscribe to services and data can be exchanged via events, fields and methods. One example of network technology is Ethernet.
ii. Data-centric-based communication, where nodes subscribe to and exchange topics which contain the topic name, data payload and Quality of Service (QoS) type. One example of this network technology is Ethernet.

AUTOSAR

AUTOSAR (AUTomotive Open System ARchitecture) is the standardized automotive open system architecture designed for automotive ECUs. The *AUTOSAR* Consortium members specify the basic system functions, functional interfaces and the development methodology between vehicle manufacturers and suppliers. There are two *AUTOSAR* platforms: *AUTOSAR Classic* and *AUTOSAR Adaptive*. Both platforms are required to fulfill the requirements of modern cars.

AUTOSAR Classic Platform

AUTOSAR Classic Platform is a well-known layered software architecture. The software requirements are realized by a static configuration of its layers at design time. As such, it is less flexible regarding changes at runtime. However, that's still acceptable since this platform usually remains stable over the lifetime of the vehicle since the application logic of the controlled sensors and actuators doesn't change. The sensors and actuators still fulfill their function; for example, the actuator of a window opening will still open and close the window. Its real-time operating system is dedicated to an embedded microcontroller as the target hardware.

AUTOSAR Classic interacts directly with sensors and actuators by abstracting the peripherals of the microcontroller into signals. This signal-oriented approach is used by the applications for processing input/output values of sensors/actuators and for sending and receiving bus data. The *AUTOSAR Classic Platform* connects to a wide range of vehicle networks such as *LIN*, *CAN*, *FlexRay* and *Ethernet*. The architecture also supports sending and receiving service-oriented resources such as events, fields and methods. A protocol transformer inside *Runtime Environment* translates the service-oriented protocol into the standardized interface

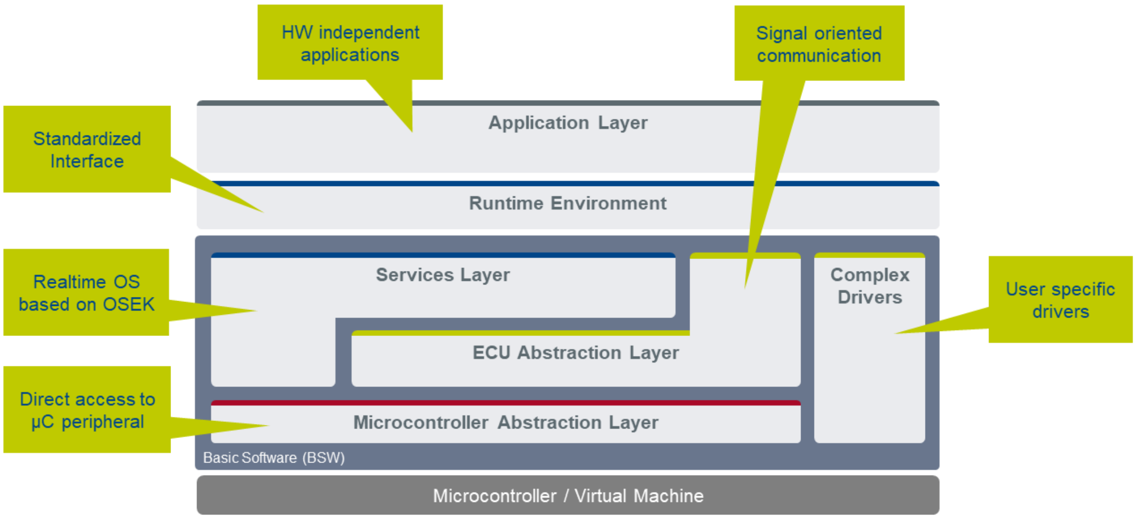

Figure 2: The AUTOSAR Classic Platform (source: ITK Engineering GmbH)

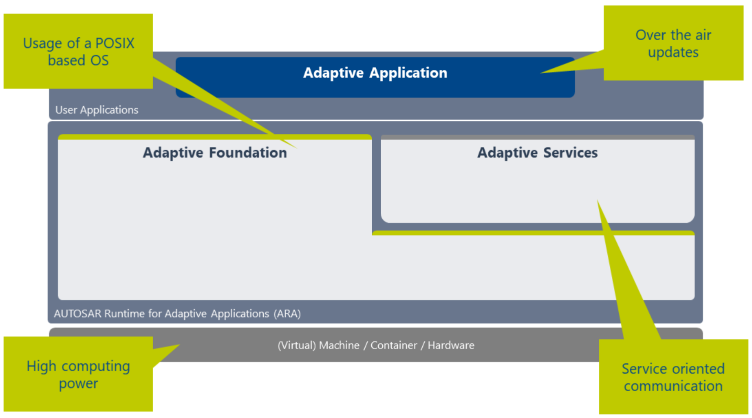

Figure 3: The AUTOSAR Adaptive architecture (source: ITK Engineering GmbH)

AUTOSAR Adaptive Platform

The *AUTOSAR Adaptive Platform* addresses new market requirements resulting from the high-performance needs, connectivity and continuous software Over-the-air (OTA) updates for next-generation vehicles. It serves as an integration platform for software from multiple suppliers, addressing the limitations of the *AUTOSAR Classic architecture*. *AUTOSAR Adaptive* is designed for flexibility in order to enable software changes at runtime. *AUTOSAR Adaptive Platform* builds upon a POSIX operating system and consists of functional clusters which are grouped in services and the *AUTOSAR Adaptive* basis. Those functional clusters assemble functionalities like *Communication Management* in a service-oriented manner. As an example, network bindings such as DDS and SOME/IP are used to communicate with other ECUs over Ethernet.

AUTOSAR in the Connected Digital Car Architecture

The system functionalities of *AUTOSAR Classic* and *Adaptive* do not replace each other. Instead they complement one another in the E/E architecture of the connected digital car as shown in Figure 4.

The *AUTOSAR Classic Platform* is still needed for the core vehicle functionality, such as controlling the electric motor of

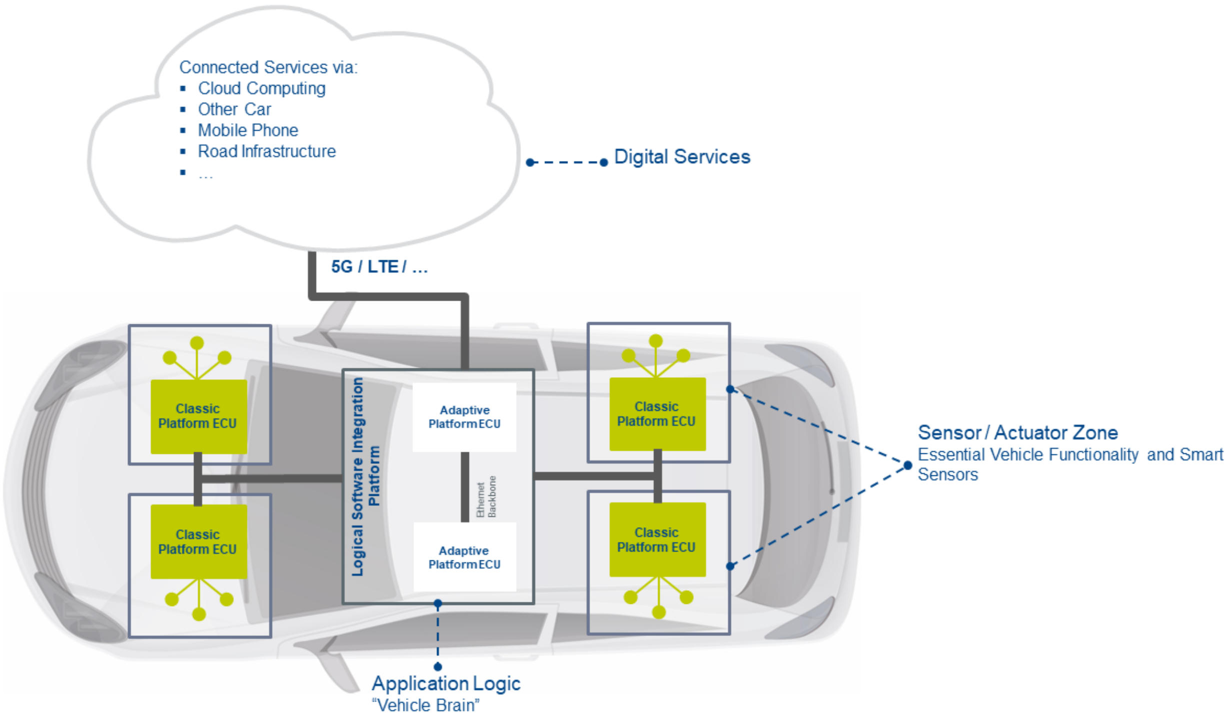

Figure 4: AUTOSAR Classic and Adaptive architecture in the digital car (source: ITK Engineering GmbH, depositphotos/tele52)

the car. Vehicle manufacturers require low hardware costs for their series production of cars. In addition, they want a reliable software solution that provides the core vehicle functionality. *AUTOSAR Classic* works well as a reliable architecture when the software change rate and the number of suppliers are limited. For these vehicles, manufacturers and suppliers choose low-cost microcontrollers with minimal *RAM*, *ROM* and *CPU* resources and the *AUTOSAR Classic Platform* as software which can be preconfigured and optimized for such minimal resources.

The inter-communication between *AUTOSAR Classic* control units and smart sensors and actuators in the vehicle network is handled by bus interfaces of low-to-medium bandwidth such as *LIN*, *CAN* and *Ethernet*. Redundant data such as brake by wire data is secured by the *FlexRay* interface.

The digital relevant data (e.g., statistic and diagnostic information, core vehicle control data) flows between the *Adaptive* and *Classic* Platform control units. They are currently compatible with each other using the *SOME/IP* protocol over *Ethernet*, but they don't rely on it.

AUTOSAR Adaptive takes on the role of a vehicle brain, as it has the application logic for controlling the car environment using high bandwidth data from RADAR and LIDAR sensors. It can perform driving strategies and provides the entry point to other connectivity services outside the car. For example, it has access to a cloud computing environment over mobile communication networks such as 5G. As an integration platform, *AUTOSAR Adaptive* makes it easier to update software over the cloud.

The E/E architecture of the connected digital car allows it to interact with both *AUTOSAR* platforms from the car network to an external network and vice versa. The user from the external network is obviously more restricted to the pre-defined digital services of the *AUTOSAR Classic Platform* because of its static configuration at design time. There are fewer restrictions to use pre-defined and new digital services on the *AUTOSAR Adaptive Platform* because the platform is enabled for software updates.

DDS

Data Distribution Service (DDS) is a middleware protocol, connectivity framework and API standard for data-centric connectivity from the Object Management Group® (OMG®). It integrates the components of a distributed system, providing low-latency data connectivity, extreme reliability and a scalable architecture required by business- and mission-critical applications.

In a distributed system, middleware is the software layer that lies between the operating system and applications. It enables the various components of a system to more easily communicate and share data. This layer simplifies the development of distributed systems by solving the mechanics of passing information between applications and systems, thereby letting software developers focus on the specific purpose of their applications.

DDS is data centric by design and built to accommodate data in motion from different sources. With DDS, applications directly interact with data existing in a shared global data space. This enables scalability through routing, provides Quality of Service (QoS) policies affecting how data is transmitted and managed by all participants, supports dynamic discovery and offers several approaches to data security (both data- and transport-oriented).

Designing autonomous vehicles requires using a combination of revolutionary architectures and evolutionary technologies. The architecture must seamlessly integrate software and hardware from multiple vendors, support compliance with evolving standards and enable continuous feature and performance improvements. For these reasons and many more, OEMs are choosing the standards-based DDS databus as the connectivity middleware for their architectures and platforms. DDS offers the comprehensive capabilities that system designers need in order to build with maximum flexibility and scalability (including future-proofing). At the same time, it provides a simplified environment that keeps designs streamlined, low-maintenance and cost-effective.

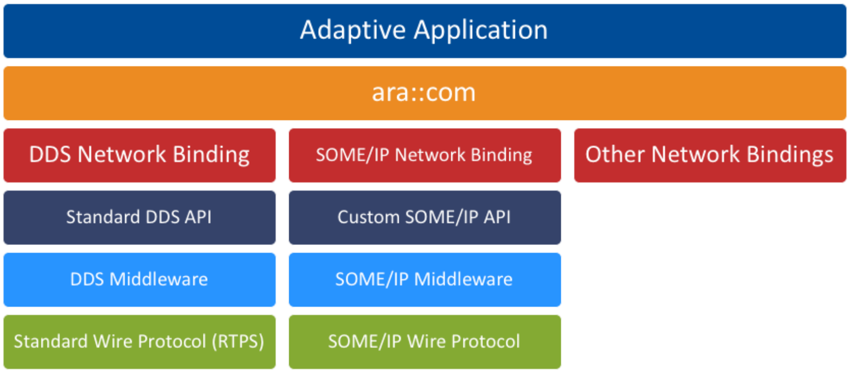

Figure 5: DDS in the AUTOSAR Adaptive Platform (source: AUTOSAR)

DDS integration into the AUTOSAR Adaptive Platform

Since its inception, the *AUTOSAR Adaptive Platform* has strived for a communications management architecture that is independent of specific network communication technologies and is specifically based on Service-Oriented Architecture (SOA). Scalable service-Oriented MiddlewarE over IP (SOME/IP) was the first technology to be incorporated in the Communications Management functional cluster, and DDS promptly followed in March 2018 with the release of 18-03 of the AUTOSAR Adaptive Platform standard materials.

DDS represents a sizable evolutionary step from SOME/IP, bringing in a large catalog of standard built-in features, such as content- and time-based filtering, transport-independent reliability, partitioning, durability, liveliness, latency/deadline monitoring, extensible types, and more. There are important benefits when AUTOSAR Adaptive works with DDS to build upon a communications framework that is not only compatible with existing ara::com APIs and applications, but also provides important benefits for reliability, performance, flexibility and scalability.

From an architectural standpoint, the DDS Network Binding shares a common conceptual space below the ara::com Functional Clusters, where each network binding translates common ara::com API and meta-model SOA semantics to its own set of middleware-specific API calls that eventually produces either ECU-local or remote inter-process communication.

Of note is that while SOME/IP only standardizes the low-level interoperability wire protocol (shown in the green boxes in Figure 6), DDS standardizes the platform-facing APIs as well (dark blue boxes), leading to interoperability across industry vendors not only at the wire level, but at the source code level as well.

DDS integration into the AUTOSAR Classic Platform

Due to the history, current status and overall design goals of the *AUTOSAR Classic Platform*, DDS is not part of its standard materials at time of publication of this document. However, DDS can be quite useful in *AUTOSAR Classic* designs to replace or complement communication features of the platform. Integration of leaf nodes in the vehicle's electronic architecture, such as smart sensors, can greatly benefit from being seamlessly integrated into the DDS databus.

OSEK is the operating system interface for *AUTOSAR Classic*. Implementations of DDS involving microcontrollers and resource-constrained microprocessor systems have existed for a long time, and their OSEK ports are a reality as well. This allows *AUTOSAR Classic* application-level software components to bring DDS support as a statically-linked library supported by the *Classic* Platform's Communication Services, and thus leverage DDS via its standard APIs for intra- and inter-ECU communications where other technologies abstracted by the RTE (RunTime Environment) would have been insufficient.

As with the *AUTOSAR Adaptive Platform*, DDS can integrate more deeply at the services layer where other technologies such as SOME/IP or J1939 already exist, providing RTE-level DDS-specific transformers and pushing the DDS core middleware implementation away from the application layer down under the PDU router. This solution, although more demanding for AUTOSAR stack and tooling vendors, would allow applications to work against a single communications set of APIs (the RTE).

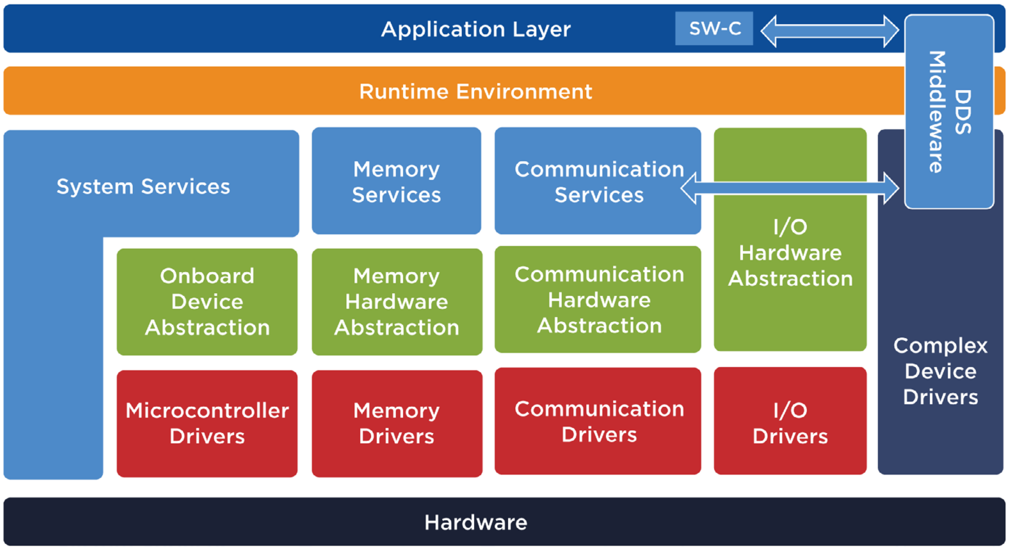

Figure 6: The AUTOSAR Classic Platform with DDS (source: RTI)

ENABLING FLEXIBLE VEHICLE ARCHITECTURES

AUTOSAR and DDS were both designed for flexible, scalable architectures. Now, the demands of connected digital vehicles are creating a greater need for high-performing interconnected systems. As such, AUTOSAR Adaptive and DDS work together to enable interoperability and advanced functionality for the industry.

Automotive technology and customer expectations continue to push the industry towards new functionality based on an ever-growing amount of data. Distributed architectures evolved into domain architectures, which are already further evolving into centralized or zonal architectures, bringing even more challenges for OEMs and supply chain companies who need the following non-functional requirements in their systems:

- **Scalability**, as the modern vehicle has become less of a product and more of a platform, where the customer purchases and auto-installs OEM-authorized updates and new features
- **Interoperability**, where vendors inside and outside the OEMs' supply chains compete to provide built-in and off-the-shelf components (both in hardware and software) that must integrate seamlessly
- **Functional safety** and **cybersecurity**, in an ever-growing attack surface where not only privacy but also immediate physical harm is at stake
- **Performance**, with an ever-growing number of richer data streams circulating both within and beyond the vehicle

Let's review these requirements in more detail.

Scalability

Since the inception of automotive electronics, the number of vehicle parts has grown substantially. To accommodate this, a process of integration subsequently followed which did not necessarily decrease the conceptual number of elements, but rather amalgamated them into general-purpose or multifunction integrated parts.

AUTOSAR Classic dealt with scale from a static point of view, where systems of unbounded complexity became easily manageable at design and deployment time. AUTOSAR Adaptive evolved signal and request-response communication into service-oriented communication, where services interfaces are designed for dynamic discovery and interoperability.

DDS supports the scalability capabilities of the AUTOSAR communications architecture, with features well beyond any other standardized ara::com network binding that includes dynamic discovery, data-centric routing and content filtering, redundancy, persistency and multicasting.

Interoperability

One of the main benefits of AUTOSAR is immediate access to a healthy ecosystem of products, components and services that interoperate between them. Examples of this include OEMs designing and effortlessly integrating back into implementations by industry Tier-1 companies, which may not even use tools from the same vendor. AUTOSAR fosters such interactions by standardizing not only wire protocols, but also software APIs and meta-models.

DDS contributes to those three categories by standardizing protocols, APIs and file formats built for the long haul. These are continually revised, improved and sanctioned through the OMG standardization process. Many meta-models, including those from AUTOSAR, include DDS-specific provisions.

Applications leveraging DDS for their communications share a common set of wire protocols, APIs, QoS policies and file formats upon which their business logic is defined. In practice, this translates into faster, more robust developments that evolve and expand efficiently and under controlled costs.

Using DDS with AUTOSAR not only guarantees and expands features for internal interoperability within AUTOSAR systems, but also opens them up to external systems from different ecosystems (i.e., ROS 2) and even industries such as energy (for charging stations), media (for In-Vehicle Infotainment) or cloud services (for traffic and navigation).

Functional Safety and Cybersecurity

From the earliest stages of AUTOSAR development, it has been clear that both vehicles and humans have great potential to not only serve, but also harm each other. Providing autonomous or semi-autonomous functionality can greatly increase safety from operator error, yet vehicle malfunctions can cause economic and health damages, whereas malicious agents can tamper with car systems to steal information and even control the car beyond the driver's intent. AUTOSAR relies on, and references, ISO-26262 and ISO-21434 international standards for safety and security requirements, respectively.

DDS, due to its extensive deployment in mission-critical industries such as aerospace & defense, energy and healthcare, brings historically proven built-in features and accepted standards to this area. The DDS standard APIs and wire protocols already align with ISO-26262 in terms of protective measures, avoiding information repetition, corruption, out-of-order delivery, etc. The DDS Security standard expands on this, providing an additional layer of security covering secrecy, authentication, access control, non-repudiation and logging.

Performance

As car functionality expands, so does the computational demands on most, if not all, of its subsystems. The media revolution of the last decade, where in-car communications jumped from minimal signal distribution to rich media (audio and video) streaming, pales now in comparison to the advent of assisted and autonomous driving systems. Now, rich two- and three-dimensional perception data is constantly transmitted and processed, along with high-detail mapping streamed over the internet on demand.

Mechanisms for efficiently distributing large amounts of data have always existed, but integrating them in flexible, scalable systems has been a larger challenge. AUTOSAR's service-oriented communications architecture is designed to make no compromises between all the previous traits (Scalability, Interoperability and Security) and performance. Zero-copy APIs for event/notifier publication and flexibility of network binding choice are two examples of how DDS can enable the performance necessary to give cars (and their owners) the desired multimedia experience.

Highly specialized network bindings may be chosen in design, deployment and even at runtime to leverage high-speed inter-process communication channels or hardware interconnects. DDS, which is itself a layered architecture, offers unique capabilities to communicate using a single network binding over many different transports (UDP, TCP, DTLS, TLS, Shared Memory, etc). DDS uses a single set of data-centric protocols that seamlessly cross platform boundaries and provides unique features such as monitoring, debugging, persistence, routing, and more.

CASE STUDY

After understanding the fundamentals and benefits of DDS and AUTOSAR, it is time to look at an actual example of how they would participate and interact in a modern vehicle architecture. As a first step, we will partition our vehicle in the classic automotive E/E domains:

- Powertrain
- Chassis
- Body
- In-Vehicle Infotainment (IVI)
- Advanced Driver Assistance Systems (ADAS)
- Vehicle-to-X (V2X)

For a long time, these domains have dictated network topology within the car, with distinct hardware acting both as controller for domain-specific devices (sensors, actuators) and gateways towards other domains ("domain architecture"). It is also important to understand that although the components of these domains are tightly coupled conceptually (i.e., a throttle pedal and an engine), this is not the case in the physical world, where components related to a single function are widely spaced throughout the vehicle, thus requiring extensive wiring.

The recent trend is to reduce in-vehicle wiring to a minimum through homogenization of networking technologies at all levels of the Open Systems Interconnection (OSI) model, from physical to application layers. The benefits of this wiring reduction include:

- Lower production costs
- Simpler maintenance
- Reduced vehicle weight
- Adaptability across markets
- After-market extensibility

Commercial benefits aside, the biggest advantage of combining AUTOSAR and DDS from an engineering standpoint is that functional domains and network topology are no longer adversaries, but instead are allies in the vehicle. The network topology adapts better to the vehicle's physical constraints, and the functional domains provide a flexible overlay on top of the physical car in what's called a zonal architecture.

As shown earlier in this paper in Figure 4, the white boxes or "Processing ECUs" represent powerful multi-core systems running AUTOSAR Adaptive (OS + runtime stack) and even AUTOSAR Classic on isolated hardware or VM cores, along with specialized hardware such as GPGPUs or VPUs. AUTOSAR Adaptive represents an ideal fit for these units since it brings a degree of functionality, access to high-performance computing, and flexibility not available in AUTOSAR Classic, including (but not limited to):

- Heterogeneous computing beyond general-purpose microprocessor architectures
- Secure, large-scale storage
- Service-oriented communications
- Advanced cryptographic services
- V2x and cloud services
- Execution and Platform Health management

Although they use homogeneous general-purpose networking, these powerful ECU systems have fast (usually 1Gbps or more) access to other ECUs and the Zonal Gateways.

The Zonal Gateways excel in peripheral I/O and programmability, which allows them to run highly-specific and time-sensitive tasks autonomously without making the trip to the central Processing ECUs. They also serve as "ingestion points" for sensors and actuators of any nature, offloading Processing ECUs from routine tasks such as protocol conversions or data pre-processing. They might even be re-purposed on the fly according to the vehicle state (i.e., low-frequency motion sensing for security purposes while parked, or high-frequency ADAS sensor ingestion while in motion).

Zonal Gateways may run AUTOSAR Classic, AUTOSAR Adaptive, or even a combination of both depending on the specific set of functionalities they provide, although the proportion will usually lean towards the AUTOSAR Classic side, considering the safety-critical nature of many tasks accomplished by these units.

A safe assumption is an 80-20% split in Processing ECUs (80% of the functionality running on AUTOSAR Adaptive, 20% on AUTOSAR Classic) and 20- 80% for Zonal Gateway ECUs, with the 20% AUTOSAR Adaptive functionality on the later ECUs devoted to AUTOSAR Adaptive interoperability at vehicle network level.

In all these scenarios (Processing ECUs and Zonal Gateway ECUs), DDS shines both within and alongside AUTOSAR as an application layer (according to the OSI model) or framework layer (according to the IIC model) communications backbone thanks to its unique distributed, data-centric nature. It provides superior performance through features such as transport-independent reliability, dynamic and static discovery, type extensibility, redundancy, type descriptions, security, timing, content-aware filtering and persistence. DDS also rises to the great challenge of future vehicle architectures through its ability to securely and safely communicate high-performance ECUs, constrained ECUs and cloud services on multiple ecosystems (even beyond AUTOSAR) with a single standardized set of wire protocols, APIs and file formats.

CONCLUSION

Connected cars require a high-performance, scalable and data-centric architecture. In the paper, ITK Engineering and RTI have described the two standards that form the architecture to accommodate these requirements, AUTOSAR and DDS. Together, they provide automotive OEMs with the flexibility to design and run the car of the future. The commercial benefits of the AUTOSAR Adaptive / DDS approach include lower production costs, adaptability across markets, streamlined maintenance and after-market extensibility. For engineering teams, this provides a network topology that accommodates the physical constraints of the vehicle and common functional domains that provide a flexible overlay (zonal architecture) on top of the physical car.

As challenging as the architecture may be, the connected car is just one part of the evolving future transportation system. As engineering teams prepare for this world of unknowns, flexibility and a future-proof architecture will be increasingly important. For this reason, the open data-centric nature of the AUTOSAR / DDS architecture can provide the stability and flexibility for the connected car to seamlessly adapt to an increasingly intelligent and interconnected transportation system.

REAL-WORLD IMPLEMENTATION OF AUTOSAR AND DDS

For OEMs and suppliers looking to integrate DDS with AUTOSAR in order to achieve a data-centric exchange in autonomous vehicle development, ITK Engineering GmbH and Real-Time Innovations (RTI) are working together to provide AUTOSAR-compliant implementation services with market-leading, ready-to-use RTI Connext® DDS software. The two experienced leaders in DDS and AUTOSAR services reduce project risk and provide a faster implementation with a 'best of breed' approach for using the two standards through an integrated architecture and customized engineering services. This combined expertise helps to ensure that the vehicles are engineered and designed correctly in a fully AUTOSAR- and DDS-compliant architecture, regardless of the unique project specifications.

For more information on how AUTOSAR and DDS could work in your specific vehicle architecture, please contact the authors.

[1] *Eisert/Meckel/Schaal (2016, 22. Jule), S. 19; McKinsey (2016a), S. 4; McKinsey (2017).*

[2] *Bernhart/Alexander (2020, Jan), Focus Roland Berger / Computer on wheels S. 2.*

[3] *Bernhart/Alexander (2020, Jan), Focus Roland Berger / Computer on wheels S. 12.*

[4] *VW Digital Car & Services / https://www.volkswagenag.com/presence/investorrelation/publications/presentations/2019/09_september/2019-09- 09_Presentation_IAA_Senger_en.pdf*

[5] *Car.Software organization / https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-strengthens-new-software-organization-5607*

ABOUT ITK ENGINEERING

With over 1,300 associates, ITK Engineering is an internationally recognized technology company and is a wholly owned subsidiary of Robert Bosch GmbH. ITK is characterized by high-level expertise in the digitalization, electrification, automation, and connectivity of systems and has gained over 25 years of experience in the automotive industry. Through tailor-made development of systems and software, particularly in the field of embedded systems, ITK is helping shape the mobility of tomorrow.

Incorporating new ideas from research into development processes as well as jointly working on new technologies are core aspects of innovativeness. Therefore, ITK not only represents customers in collaborative committees, but is also an active member itself – for instance as a premium member in the AUTOSAR consortium. Based on its expert knowledge, the company is a reliable partner for classic and adaptive AUTOSAR solutions. www.itk-engineering.com

ABOUT RTI

Real-Time Innovations (RTI) is the largest connectivity framework provider for smart machines and real-world systems. The company's RTI Connext® software enables intelligent architecture by sharing information in real time, making large distributed applications work together as one. RTI Connext DriveTM , is the automotive-specific software framework that accelerates the development and deployment of autonomous vehicles. Proven through millions of hours of operation in critical autonomous systems, RTI Connext Drive works interoperably with AUTOSAR Classic, AUTOSAR Adaptive, ROS and other standard-based systems. With over 1,500 deployments, RTI software runs the world's most rigorous systems including autonomous vehicles; space launch and exploration; traffic control; industrial automation; connected healthcare; robotics and UAVs. The company is the leading vendor of products compliant with the DDS standard. RTI is privately held and headquartered in Sunnyvale, California with regional headquarters in Spain and Singapore. www.rti.com

Im Speyerer Tal 6
76761 Ruelzheim, Germany

www.itk-engineering.com
company/itk-engineering
itkengineering

232 E. Java Drive,
Sunnyvale, CA 94089

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