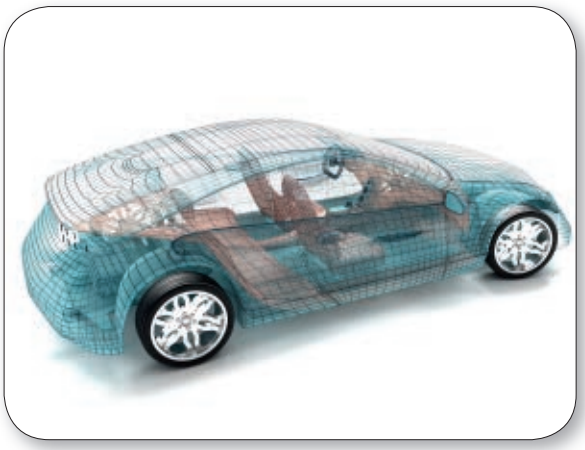
Data Distribution Service in autonomous car design

By Stan Schneider, CEO Real-Time Innovations

Builders of autonomous vehicles face a daunting challenge. To get a competitive edge, intelligent vehicle manufacturers must deliver superior driving experience while meeting demanding requirements in distributed systems design for safety, resilience, security, scalability, fault tolerance, and fast data processing.



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An autonomous car is a highly distributed dynamic system of extreme complexity, where component objects continuously make real-time local decisions based on system-wide constraints and approximate global state. With respect to autonomous car design, RTI explains the relevance of the most widely adopted, open, industry-leading standard for real-time and embedded systems: Data Distribution Service (DDS). DDS provides a proven foundation for highly resilient and responsive distributed control systems. Its real-time performance, high reliability, open architecture, and publish/subscribe decoupling greatly accelerate and simplify distributed system development, making it highly applicable for autonomous cars. DDS is the only technology that can deliver microsecond latency, IEC 26262 safety certification, top security, and operational proof in billion-dollar product lines.

Smart machines (such as autonomous cars) are changing the world and driving the current phase in the evolution of the Industrial Internet of Things (IIoT). Indeed, the Industrial Internet is where some of the most exciting innovations are developing – innovations that are reshaping infrastructure for industries from medicine to power generation. The IIoT relies on new networking standards such as DDS for real-time applications in medicine, energy, transportation, and remote monitoring and control (SCADA). DDS middleware provides reliable, physics-speed connections between smart devices and subsystems that make up hospital networks, power grids, fleets of unmanned military vehicles, and now autonomous cars.

One of the important benefits of DDS is that it allows developers to design high-level publish-and-subscribe application programming interfaces instead of writing low-level networking code. By eliminating potentially tens of thousands of lines of custom application code and its certification evidence, Connext DDS Cert helps developers save millions of dollars in cost while reducing risk and accelerating time-to-market. With DDS, modules communicate by simply publishing the data and commands they produce and subscribing to the data they need. Connext DDS handles all of the communication details. These include discovery and presence detection, routing, reliability, failover, serialization, and state synchronization for late joiners. For time-critical applications, it provides real-time quality of service control and visibility.

While implementation details for autonomous cars are still tightly guarded design secrets, deployment examples in adjacent markets provide a wealth of information about DDS and its ability to solve the most challenging connectivity problems. The following use cases have one or more connectivity requirements in common with autonomous cars. In the case of autonomous cars, requirements span three main areas: performance, safety, and integration. Systems must ensure performance to successfully connect components, optimize safety at every level of a fully autonomous system, and make it easier to integrate complex, reliable software from diverse components.

Familiar names such as Audi and Volkswagen are among the carmakers that have already introduced RTI Connext DDS to enable high-performance connectivity for testing and enhancing smart cars today. Audi was able to replace a proprietary fiber network and test rig with a DDS data-bus, giving the company a flexible way to connect multiple simulation vendor systems. RTI middleware enables a modular test environment with the speed to handle data coming from all of the electronic systems in a vehicle during simulated operation. The autonomous vehicle algorithms are part of the Volkswagen effort in driver assistance and integrated safety. The system combines radars, laser range finders, and video to assist safe operation. VW uses RTI Connext DDS to help drivers avoid obstacles, detect lane departures, track eye activity, and safely negotiate turns. The DDS protocol connects

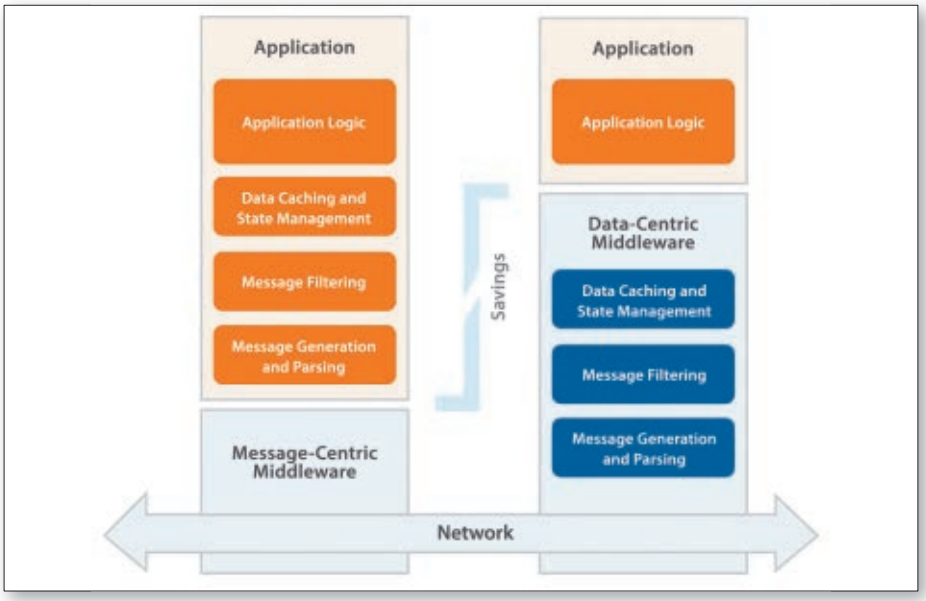

Figure 1. Unlike message-centric connectivity models, data-centricity offers superior modularity, simplicity, and scalability.

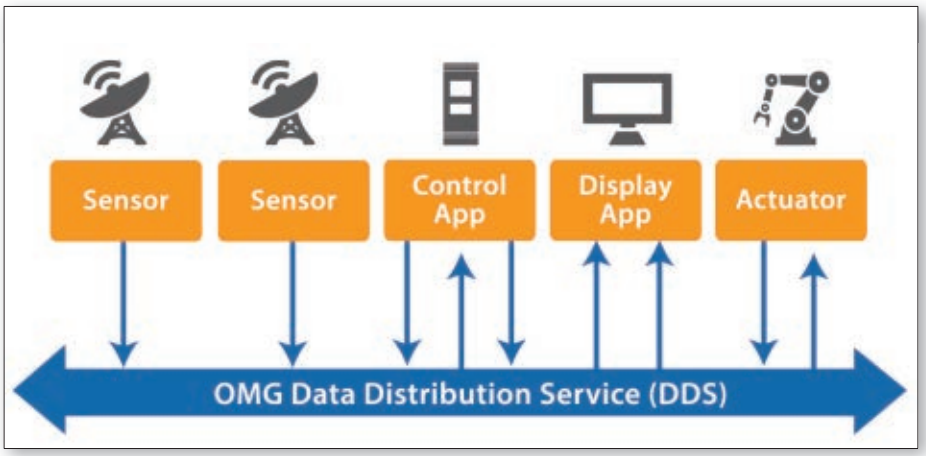

Figure 2. DDS enables seamless connectivity between sensors, actuators and applications.

all of the required components to create a single, intelligent machine with driver-assistance features and integrated safety. In its journey towards fully autonomous cars, Volkswagen has already taken advantage of DDS technology to reach some major milestones. In 2013, the DDS middleware of the company was deployed in an electric vehicle capable of autonomously driving to and from a recharging station after dropping off passengers.

Engineers of aeronautic and defense systems have long relied on RTI infrastructure technology to develop unmanned aircraft as well as unmanned vehicles for deployments on land and under water. DDS compliance aligns with many open architecture initiatives, including the Future Airborne Capability Environment, UAS Control Segment Architecture, and Open Mission Systems. Connext DDS Cert also helps developers of unmanned air systems prepare for integration into the National Air Space (NAS). To operate in the NAS, UAS will have to be certified to the same safety standards as civil aircraft. This can be particularly challenging since most UAS software was not designed to be certifiable. UAS also have complex communication requirements, with flight-critical components distributed across the air and ground segments. Connext DDS Cert accommodates UAS communication requirements while minimizing the amount of custom code that must be certified. Stringent safety requirements within this industry segment closely resemble automotive compliance specifications. The certification process depends on close collaboration between technology vendors and solution designers – and in the case of autonomous cars, RTI has already established working relationships with vehicle manufacturers. These joint efforts and investments will ensure the required certifications and safety levels the automotive industry requires.

Advanced device connectivity is changing medical practices, lowering costs, and improving patient outcomes. Some medical applications of DDS demonstrate how it can be used to integrate complex, distributed subsystems and devices in a manner that ensures the required performance. For example, RTI Connext DDS provides precise, distributed control for the subsystems within leading-edge computed tomography (CT) imagers. In hospital infrastructures, RTI DDS implementations are also in use to connect a myriad of technologies for patient monitoring and diagnostics that power modern hospital equipment.

DDS continues to evolve in tandem with smart devices and distributed systems. Unlike other middleware, DDS emerged more than a decade ago to address real-time, physics-speed connectivity. It is the only middleware capable of satisfying the three fundamental requirements. 1) Reliability: if five minutes – or five milliseconds – of downtime is a disaster, DDS implements natural redundancy to ensure continued operation. 2) Performance: if the system needs millisecond or microsecond response, it provides fast peer-to-peer connections. 3) Integration at scale: if the system integrates ten or more applications, or deals with thousands of addressable data items, data-centric DDS eases complex data flow.

To minimize overhead, the DDS publish-subscribe model delivers fine control of quality of service (QoS) parameters including reliability, bandwidth control, delivery deadlines, liveliness status, resource limits, and security. It includes an explicitly managed communications data model, with a choice of connection types. Furthermore, it is data centric, with inherent understanding about the contents of the information being managed and shared. It features inherent automation (no hard-coded interactions between applications and devices) and device discovery (easy add-on of new devices without any configuration changes required). Compared to traditional point-to-point communications, DDS offers a superior data-bus with plug-and-play simplicity, scalability, and an architecture that can evolve while maintaining exceptional performance levels. Scalability and integration capacity of DDS are also instrumental in enabling connections of the car with other vehicles and their own environments, including external systems such as traffic monitoring.

With a long history of successes in similar IIoT applications, RTI has become a trusted expert assisting the innovators of future autonomous cars. The ease of integration and flexible, reliable, and fast publish-subscribe data model of the RTI Connext DDS middleware are suited to addressing many of the toughest challenges posed by autonomous cars. This includes vehicle subsystem integration and control, spanning driving control, safety, infotainment, and diagnostic functions as well as intervehicle

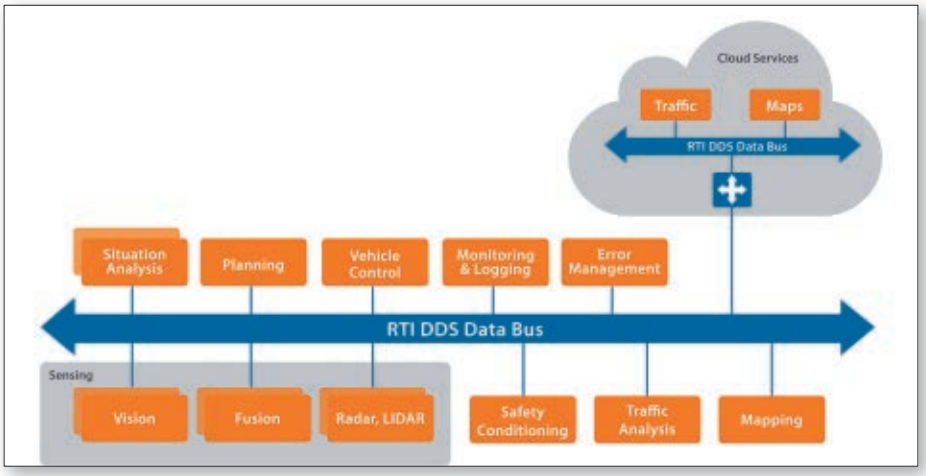

Figure 3. DDS in connected vehicle architecture

interactions, for collision avoidance and optimized travel experiences. Tracking and control functions are used for fleet management, traffic monitoring and management, crisis management, and government agency coordination. Sensor and camera data aggregation is performed at millisecond speeds, local and remote feedback loops are available, as well as reliable communications over unreliable channels (for example, wireless, cellular) and ability to operate within redundant environments (intelligently delivering only one copy of data). This results in rapid time to market for safety-certifiable infrastructure, using RTI Connext DDS Cert. From its inception, DDS has addressed the broadest range of real-world industrial systems and it remains the only common real-time connectivity platform in such widespread use. More than a dozen implementations are available today, with the growing ecosystem strengthening the standard.

The IIoT and DDS continue to foster bold new intelligent machines – and now even cars that can drive themselves. At the forefront of real-time connectivity, RTI continues to partner with industry-leading developers and technology innovators to extend the DDS standard and ensure it aligns with the needs of the most demanding applications, such as autonomous cars. The current portfolio of RTI Connext solutions meet the connectivity needs of the most complex subsystems and simplify the integration of the in-vehicle and remote systems that contribute to safe, reliable, autonomous car experiences. ■

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