Software-defined vehicles: How open source fuels innovation

"With Red Hat's Linux expertise, services, and market position and Exida's leading position in assessment, safety analyses and certification, Red Hat and Exida are committed to giving automation and automotive companies with functional safety applications, access to innovative and high-quality open source software."

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What is a software-defined vehicle?

To meet consumer and driver expectations, automakers are finding the need to transform from hardware-centric vehicle architecture into a software-centric design to manage the growing complexity of domain-specific systems. At the core of this transformation lies the concept of the software-defined vehicle (SDV)—a vehicle whose features and functions are primarily supported and upgradable through software. The advancement of SDVs brings along benefits, including increased comfort and safety with automated driving, personalized driver experiences, and support for new revenue streams. But the realization of SDVs comes with many challenges related to software architecture, safety certification, cybersecurity, software reusability, and an available talent pool. A strong open source strategy not only complements existing models in the industry but also has the very potential to help automakers address oncoming challenges and emerge as industry leaders.

The forthcoming automotive revolution

Rising automotive consumer expectations fueled by advancements in the mobile user experience has greatly affected automakers. Software-based features in cars are impacting the customer experience more than ever. Drivers now expect personalization, advanced communication services, and improved driver assistance systems. Automakers are planning the next generation of vehicles to deliver-enhanced digital experiences.

Historically, automakers have used distributed electrical/electronic (E/E) platforms with function-oriented electronic control units (ECU). These ECUs using tightly coupled proprietary software can bring about vendor lock-in and have limited the ability to scale across vehicle lines and model years. To support the advancement in technology, these platforms are upgraded approximately every four-to-six years. During upgrades, automakers often spend more time focusing on non-differentiating components of the vehicle software, such as the OS, over brand-differentiating premium features or services. As a result, they experience high development costs, limited reusability, a long time to market, and cannot support rapid feature function development consistently.

To remain competitive and provide drivers with safer and more engaging experiences, a new way of developing features is required. The concept of the software-defined vehicle allows automakers to deliver novel features and new functionalities rapidly. This is supported by the consolidation of single-purpose embedded systems into general purpose, high-performance platforms whose resources and functionality can be remotely defined and repurposed with modern software architecture.

The transition towards software-defined architecture allows rapid adaptation to the customer needs. One reliable and quick way to modernize architecture is by leveraging open source. Open source is a term used for software and a way of working. Open source software (OSS) is developed in a decentralized and collaborative way, relying on peer review and community production. OSS, along with the open source way of working, helps find new ways to solve the problems in communities and industries. The outcome is publicly accessible, and anyone can view, change, and distribute it as needed.

Although open source operating systems (OSs) are widely used in today's vehicles and have the biggest market share of infotainment systems,[1] the true potential of open source is not being used, especially to address the challenges related to the transition toward SDVs. Adapting a strong open source strategy provides a strong and state-of-the-art approach, software, tools, and access to a wide range of talent that is a real value multiplier in the realization of the SDV.

What will it take to realize the software-defined vehicle?

The evolution of in-vehicle hardware and software architecture

The distributed E/E platforms inside the vehicle have deeply embedded functionalities. Such functionalities are based on monolithic software architectures and require a long time to develop and deliver to market. Following traditional embedded workflows and one-off releases, these platforms only partially support incremental deployment and continuous delivery of new features, bug fixes, and upgrades.

The next-generation vehicle architecture allows the consolidation of purpose-built control units into flexible edge systems with higher performance. These systems can support extremely large volumes of data processing and help to shift from monolithic software architectures to a more modern microservices architecture. Microservices are processes, each organized around individual capabilities, and can scale independently. The transition to microservices architecture allows the complex vehicle software components to be scalable, reusable, and updatable in a more robust fashion.

Designing and building software as microservices for next-generation vehicles leads to certain crucial requirements, including but not limited to authentication, authorization, service discovery, observability, resilience, scalability, and more. In the past, such fulfillments have mostly required proprietary solutions, either because of the licensing of the components, or specialized requirements. The open

1 *"Market share for infotainment for operating system providers from 2014 to 2022," Statista, 15 June 2015.*

70% of developers prefer open-source-based cloud providers.[2]

source technologies already have advanced support for such requirements and allow using drop-in components without the need to reinvent the wheel and vendor lock-in. Automakers can avoid missing out on transformational features or trends and have enough portability to switch to other interesting solutions without being stymied.

While the software-defined architecture can be implemented with different methods, the state-of-the-art approach for running microservices application architecture is containerization. The industry-leading technologies and containerization platforms used for building, delivering, and scaling containerized applications are open source, including Kubernetes, Docker, and podman. Over the years, these open source solutions have advanced significantly and are a strong reference point for implementing similar concepts within the automotive industry. These container solutions themselves have originally been developed on top of the open source OS Linux® and to date have the most extended and mature support.

From an in-vehicle architecture to a cloud-native approach

It's not only about in-vehicle architecture anymore, it's about the digital life cycle. With increased connectivity, vehicles can communicate with their environment, collect, and exchange a huge amount of data in real-time, and support cloud-native development approaches. The cloud-native approach allows the industry to continuously develop and test vehicle software in a cloud environment and remotely deploy updates throughout the vehicle life cycle using over-the-air (OTA) updates.

Microservices' architecture inherently supports cloud-native development. In addition to container and microservices technologies, the actualization of cloud-native includes application definition, orchestration, management, runtime, provisioning, and mainly DevOps—a set of tools and practices that support, automate, and speed up continuous integration and continuous delivery (CI/CD) and deployment of cloud-based applications.

89 % of IT leaders believe enterprise open-source is as secure or more secure than proprietary software.[3]

The industries that have experienced a digital transition mostly adapted an open source strategy. According to an IoT & Edge commercial adoption survey, 74% of organizations factor open source into their deployment plans,[4] which clearly reveals that the dominant edge platforms will either be open source or based on open source. This is because a good open source strategy naturally incorporates engagement with the huge ecosystem of existing communities and a proven ecosystem of developer toolings to support digital transitions. For example, the Cloud Native Computing Foundation (CNCF) is an open source community to support cloud-native development.[5] It has 778 members with a total market cap of US$19 trillion and a funding of US$30.3 billion. CNCF hosts more than 120 projects with more than 142,000 contributors, representing 189 countries. These projects span from containers and microservices to programmable infrastructure, CI/CD networking, storage, logging, nodes, services, monitoring, visualization, and more, all of which support and accelerate digital transition such as that currently happening within the automotive industry.

The open source approach supports cloud portability without vendor lock-in and assists with adaptation velocity. The automotive industry does not need to start at the beginning—rather, they can take advantage of the existing tools to significantly reduce their cost and time to market.

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2 *Oram, Andy. "The value of open source in the cloud era." O'Reilly, February 2021.*

3 *Red Hat Report. "The state of enterprise open source," 2021.*

4 *Eclipse Foundation. "2021 IoT & edge computing commercial adoption survey report," 2022.*

5 *Cloud Native Computing Foundation. "CNCF 2021 annual report," 2022.*

94% of technology managers and software developers rate OSS better than proprietary software and prefer to develop related skills.[6]

More automation and connectivity mean higher security and safety standards

Software-defined vehicles will be strongly influenced by a need for tough IT security and functional safety standards. The evolution of in-vehicle architecture and its digital life cycle increases the attack surface and leads to increased cyber risk.

In security, neither open source solutions nor proprietary solutions have the potential to be more secure than the other in terms of integrated features. However, keeping vulnerabilities secret does not make them go away.

89% of IT leaders believe enterprise open source is as safe or even safer than proprietary software. Proprietary software keeps the software expertise with the vendor or developer, which relies on that vendor ecosystem, costly and time-consuming change requests, and longer development cycles.

Open source relies on transparency to resolve security issues with the greatest efficiency. Open source developments nurtured by devoted contributors can find, review, and address security vulnerabilities faster through the open source community.

The security and safety of the SDV go hand in hand. The safety standards currently used in the automotive industry have had the same monolithic approach as that of software architecture itself. There are, however, already operational working groups (ISO-PAS 8926) actively working to evolve the standard and cope with changing industry dynamics. Besides certification efforts by the world's leading provider of enterprise open source solutions, ISO/AWI PAS 8926 is laying out a framework to assist the development of safety-related systems incorporating existing software products, including open source Linux OSs, into new vehicle architectures.

ISO PAS compliments the earlier efforts initiated by the open source community in terms of ELISA;[7] a project that helps Linux-based systems meet the requirements of safety-critical automotive functions. The methodology being outlined by ELISA paves the path toward creating an in-vehicle software architecture that can safely run on a continuously certified open source OS. The combined effort of the community allows the safety concepts to be reused and certification achieved in less time with fewer resources.

Cultural shifts and open talent pool

Ongoing digital transformation and SDV conceptualization in the automotive industry requires a deep cultural shift, immense software capabilities, and the use of agile development approaches. Delay in doing so can leave the industry with reduced productivity and competitiveness.

The pace required for transformation is not possible from the tried and tested V-shape model life cycles and familiar processes. Legacy development methods do not adhere to the DevOps concepts and its required agile mindset.

The cultural shift, along with a solid open source strategy, promotes rapid decision-making and helps escalate advancement with the support of the community. The potential of an open source strategy is led by the fact that automotive manufacturers can tap the vast pool of experienced developers, knowing that orders of magnitude are more comprehensive than each company's resources. In addition, the open source community encounters a variety of use cases routinely; thus, the diversity of ideas that emerge often offers better solutions than if development and deployment were limited to its own organization only.

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6 *Oram, Andy. "The value of open source in the cloud era." O'Reilly, February 2021.*

7 *The Linux Foundation Projects. "Advancing open source safety-critical systems," 2022.*

Leaning on the OSS expertise of the community can further help automakers become more competitive with the industry disruptors through advanced open source tooling and agile development practices. It facilitates significant cost reduction on non-differentiating but foundational building blocks that would otherwise become a duplicated effort among competitors.

Open-source strategy can enable software-defined vehicles

Customer driving forces and emerging requirements are exponentially increasing the complexity of software in vehicles. Using a safe, modular, and scalable software platform that continues to evolve with the support of cloud-native and agile software development is imminent. To address complex requirements from ideation to realization of similar platforms in diverse industry segments, several open source tools and technologies have emerged through community development and are now considered the standard in fulfillment of these requirements.

Automakers can smoothly drive the evolution of software-defined vehicles by adapting an open source strategy and leveraging the technological advancements that have already been made and the pool of world class open source developers behind it. Automakers' participation in open source empowers the value-multiplier; it's one thing to use mature open source technologies off the shelf like any other proprietary solution, but quite another to contribute back with code and emerge as an industry leader.

Red Hat contributions in SDV solutions

Red Hat In-Vehicle Operating System is a Linux-based automotive solution developed, maintained, and designed with the intent of continuous functional safety. Its mission is to deliver an open, safety- and security-focused Linux-based in-vehicle OS as the foundation for SDV to drive advanced innovation. Vehicle manufacturers and partners across the automotive ecosystem gain greater flexibility to focus on delivering innovative driving experiences throughout a vehicle's life cycle.

About Red Hat

Red Hat is the world's leading provider of enterprise open source software solutions, using a community-powered approach to deliver reliable and high-performing Linux, hybrid cloud, container, and Kubernetes technologies. Red Hat helps customers develop cloud-native applications, integrate existing and new IT applications, and automate and manage complex environments. A trusted adviser to the Fortune 500, Red Hat provides award-winning support, training, and consulting services that bring the benefits of open innovation to any industry. Red Hat is a connective hub in a global network of enterprises, partners, and communities, helping organizations grow, transform, and prepare for the digital future.

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