L&T Technology Services

ECU Virtualization: Key to the SDV Revolution

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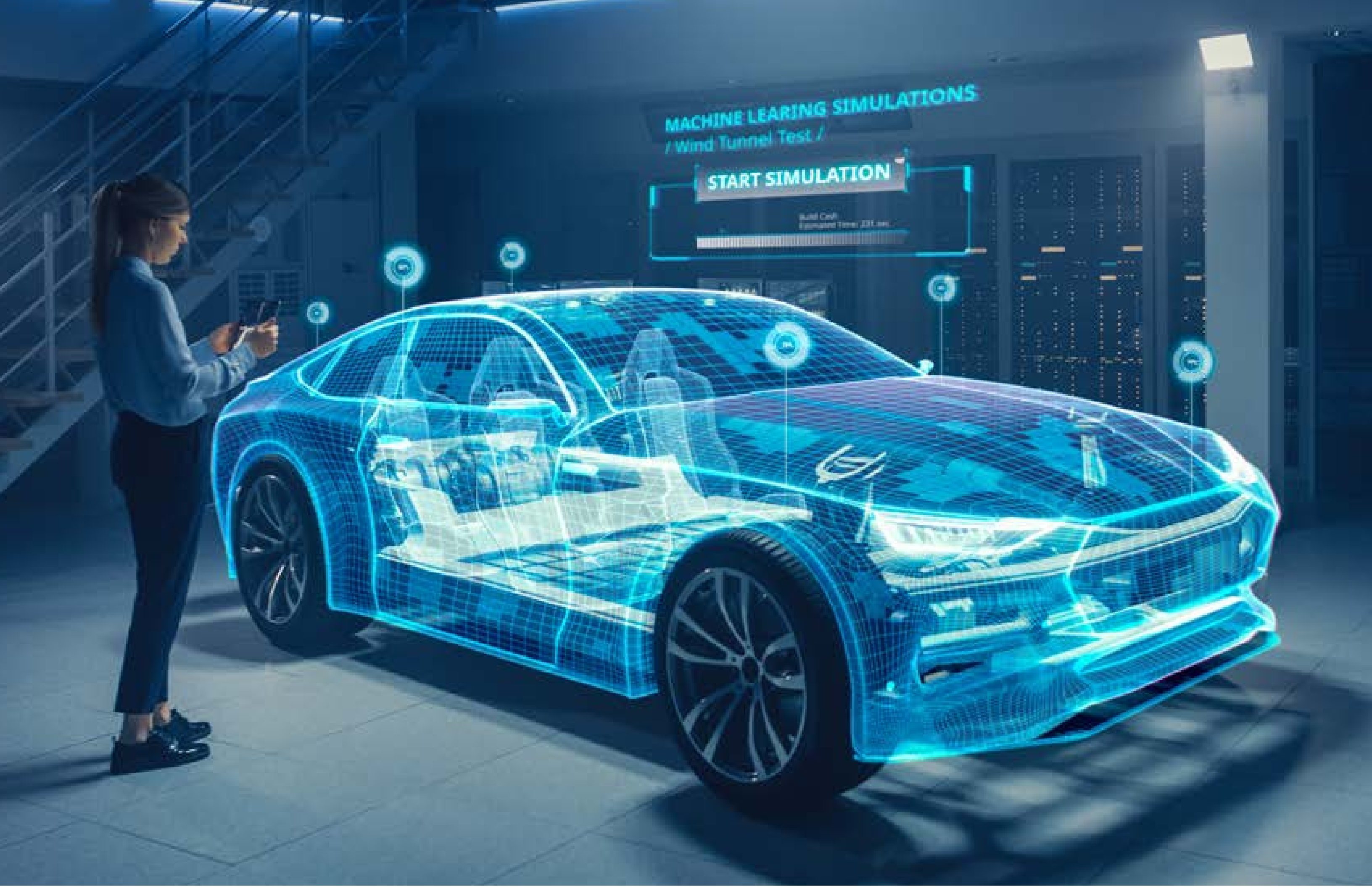


INTRODUCTION

As the global automotive industry continues its rapid evolution toward connected, autonomous, and electrified vehicles, the complexity of Electronic Control Units (ECUs) has grown exponentially. The rise of **software defined vehicles (SDVs)**, is further redefining the automotive landscape, helping accelerate the evolution of the development landscape across every stage of the V-Cycle.

In this scenario, ECU virtualization has emerged as a key pillar of the SDV journey. The current paper explores the concept of ECU virtualization as a revolutionary approach to streamline the verification and validation processes in automotive industry. By leveraging virtualization technologies, automakers can enhance testing efficiency, reduce costs, and accelerate time-to-market while ensuring the safety and reliability of ECUs.

ECUs IN OPERATION: THE NEED FOR VIRTUALIZATION

Modern vehicles are equipped with intricate ECUs responsible for various critical functions. Ensuring the reliability, safety, and performance of these ECUs demands rigorous verification and validation processes.

Virtualization offers a breakthrough solution to streamline these processes, enabling comprehensive testing in a controlled and efficient virtual environment.

As vehicles become more advanced, managing the number of ECUs is becoming a major challenge. This complexity drips down to every stage of product development. The solution to these challenges, again, lies in ECU virtualization.

ECU virtualization allows engineers to test and validate new software and hardware configurations without the need for physical prototypes. By virtualizing ECUs, engineers can reduce the time and cost required for testing and development, as well as improve overall system reliability.

A major focus of ECU virtualization is the enhanced ability to test and validate software and hardware configurations in a safe and controlled environment. With virtual ECUs, engineers can create complex boundary value scenarios and test them for corner cases . This allows engineers to identify potential issues and bugs in the system before deploying it in the field, which can save considerable time and money in the long run.

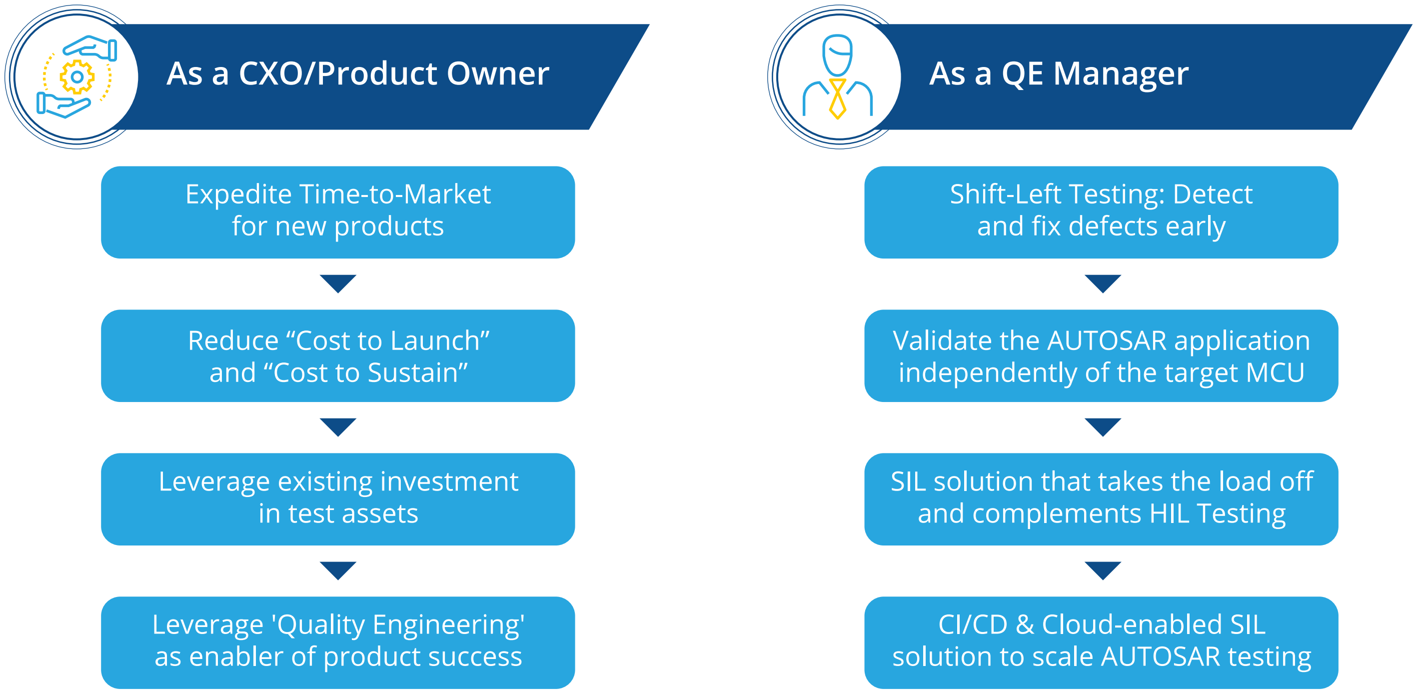


Figure 1: The Motivation for Building a Virtualization Platform

ECU virtualization also allows for a more efficient and effective testing environment. With virtual ECUs, engineers can test multiple scenarios simultaneously, which can significantly reduce testing time and cost. This is especially important for autonomous vehicles, where testing can be time-consuming and expensive. By virtualizing ECUs and deploying a smart test strategy, engineers can test and validate autonomous driving scenarios in a safe and controlled environment, which can help accelerate the development of autonomous vehicles.

ECU virtualization delivers the ability to optimize system performance and reliability. By creating virtual ECUs, engineers can identify potential bottlenecks and performance issues in the system and adjust as needed. This can improve overall performance of the vehicle giving a delightful customer experience.

Virtualizing ECUs can also help improve collaboration and communication among different teams involved in the development process. With a virtual ECU platform, engineering teams can share data and collaborate on designs in real-time, which, in turn, can improve overall system performance and reliability. This can also lead to better communication between different departments, such as software and hardware, which can help streamline the development process.

KEY BENEFITS OF ECU VIRTUALIZATION

Virtualization helps in addressing the issue of limited or non-availability of Hardware. Since the entire hardware is virtualized the need of an ECU for testing is no more a bottleneck. The virtualized unit can be deployed without any limitation, allowing each developer to have their own virtual instance of hardware available for testing and prototyping.

A virtualized ECU also allows for testing a wide range of scenarios, including rare or extreme conditions that are difficult to replicate physically. This results in improved test coverage and more robust ECU performance. Moreover, the ability to create automated test scenarios is also enhanced as the test case creation is more software oriented compared to the conventional approaches.

Physical ECU testing also involves substantial expenses related to hardware, equipment, and facilities. Virtualization reduces these costs by eliminating the need for physical setups, enabling concurrent testing on shared resources.

Moving from a real ECU to a virtual ECU, opens up the door to leverage cloud and cloud-based technologies. It becomes easier for the testers and even developers to access hardware like environment for testing and verification. Moreover, with such a setup, we can frontload a lot of testcase thereby reducing the dependency of HIL (Hardware in Loop) benches.

ECU virtualization helps accelerate the testing cycle by enabling quick deployment of virtual instances and facilitating rapid iteration. The testing team can also use the virtual instance for verification of Test Script and other pre works before the actual run. This agility is especially crucial for meeting tight development schedules.

Regression test scenarios can run seamlessly on a virtual platform compared to performing the same on a real device. Data scenario injection can be done on a much larger scale using virtual environment.

Virtual environments further enable testing without endangering physical assets, ensuring the safety of testers and equipment. This also allows for repeatable and consistent testing conditions, contributing to the reliability of results. The Systems Sciences Institute at IBM has reported that the cost of bug escaping at each levels increases exponentially. With virtualized ECUs, engineering team can induce a variety of test scenarios early in the development process, enabling for an early detection and resolution of defects before they propagate to the physical hardware. This helps in eliminating bug penetration to a higher level, and minimizes associated cost overruns.

IMPLEMENTATION STRATEGIES FOR ECU VIRTUALIZATION:

ECU virtualization could involve following either of the several pathways listed below:

Hardware-in-the-Loop (HiL) Simulation:

Virtualized ECUs can be integrated into HiL simulation setups, allowing accurate testing of the ECU's interaction with other vehicle components in a controlled environment. This will reduce the dependency on the actual HIL system. Enabling faster testing and better defect capturing effectiveness.

Software-in-the-Loop (SiL) Testing:

ECU software can be executed in a virtual environment, facilitating comprehensive software testing, including fault injection and scenario-based validation.

Cloud-Based Testing:

Leveraging cloud resources, virtual ECUs can be distributed across various testing environments, enabling scalable and parallel testing of multiple scenarios. With cloud enablement, we can take advantage of large data from various sources for validation and tuning of algorithms. This in turn enhances the robustness of the vehicle and ensures a safer product.

KEY CONSIDERATIONS:

Automakers and OEMs looking to adopt the ECU virtualization journey would benefit from the emerging landscape if they can work the following considerations in their roadmap:

Real-Time Performance:

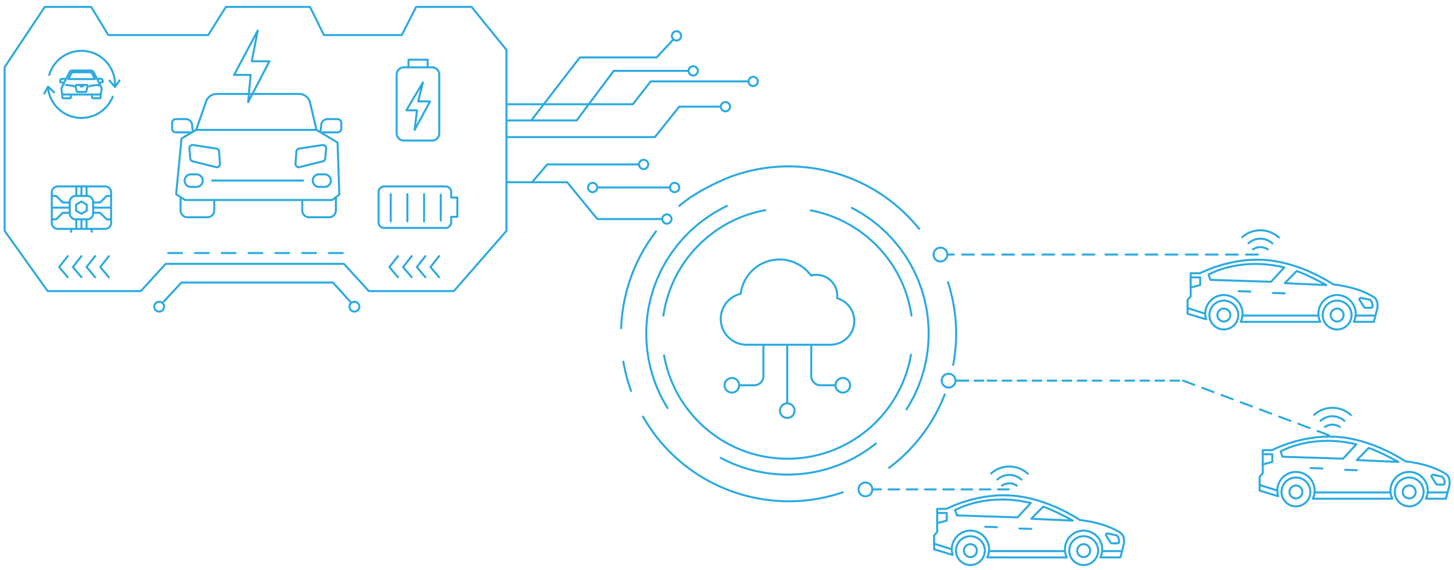
Ensuring that virtualized ECUs perform in real-time, especially for safety-critical applications, demands careful consideration of the virtualization overhead.

Security and Intellectual Property:

Protecting sensitive ECU software and preventing unauthorized access becomes more critical in virtualized environments.

Hardware Abstraction:

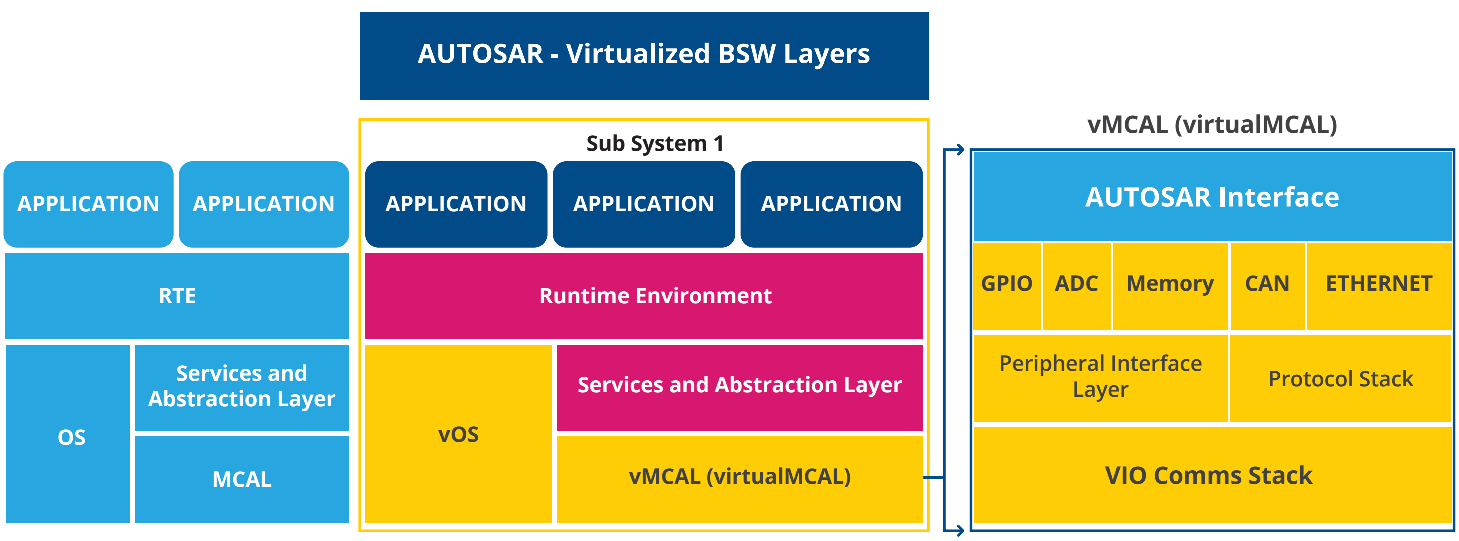
Accurate virtualization requires mapping physical hardware behaviors to virtual equivalents. This abstraction introduces challenges in accurately replicating hardware interactions. As the design get more and more complex with the software modeling of the system also increases.



A reliable Engineering Research and Development (ER&D) partner, combining deep domain expertise with multi-geography delivery capabilities, can prove to be a major differentiator here.

At LTTS, EmbedVIO-VT serves as a home-grown framework for Embedded System Hardware virtualization (Level 3 Virtualization), specialized for AUTOSAR Applications. EmbedVIO-VT consists of library packages and interfaces to virtualize ECUs developed on classical AUTOSAR platform, with no/minimal code modification needed in the application layer. These interfaces also allow for tying embedded variables to plant models for more in depth test coverage and debugging.

EmbedVIO-VT: vMCAL Under the Hood

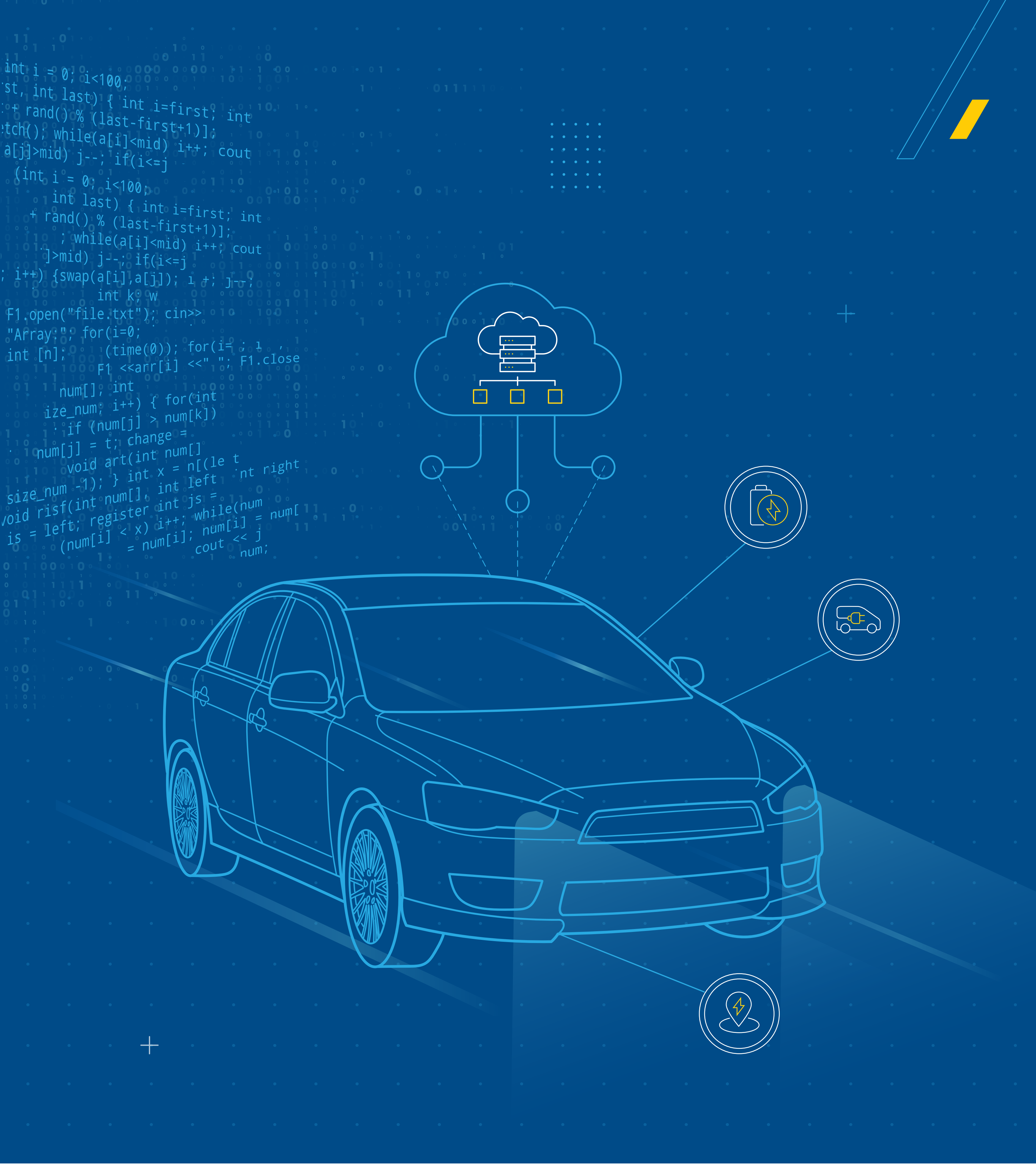


LOOKING AHEAD:

ECU virtualization is poised to play a pivotal role in the evolution of automotive testing, revolutionizing the verification and validation landscape. As virtualization technologies mature, they will continue to bridge the gap between physical and virtual testing scenarios, facilitating seamless integration and ensuring the safe and reliable performance of increasingly complex ECUs.

Virtualization can also provide a push towards cloud enablement, helping the industry to tap into the benefits and ease inherent to the platform. A careful consideration on the level of virtualization the team should target and making informed architecture considerations can also help in the seamless creation of virtualized targets.

By harnessing the power of virtualization, auto manufacturers and OEMs can therefore enhance test coverage, reduce costs, accelerate development cycles, and deliver safer and more reliable vehicles to market. As the technology advances and existing challenges are addressed, ECU virtualization will continue to shape the future of automotive testing.



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