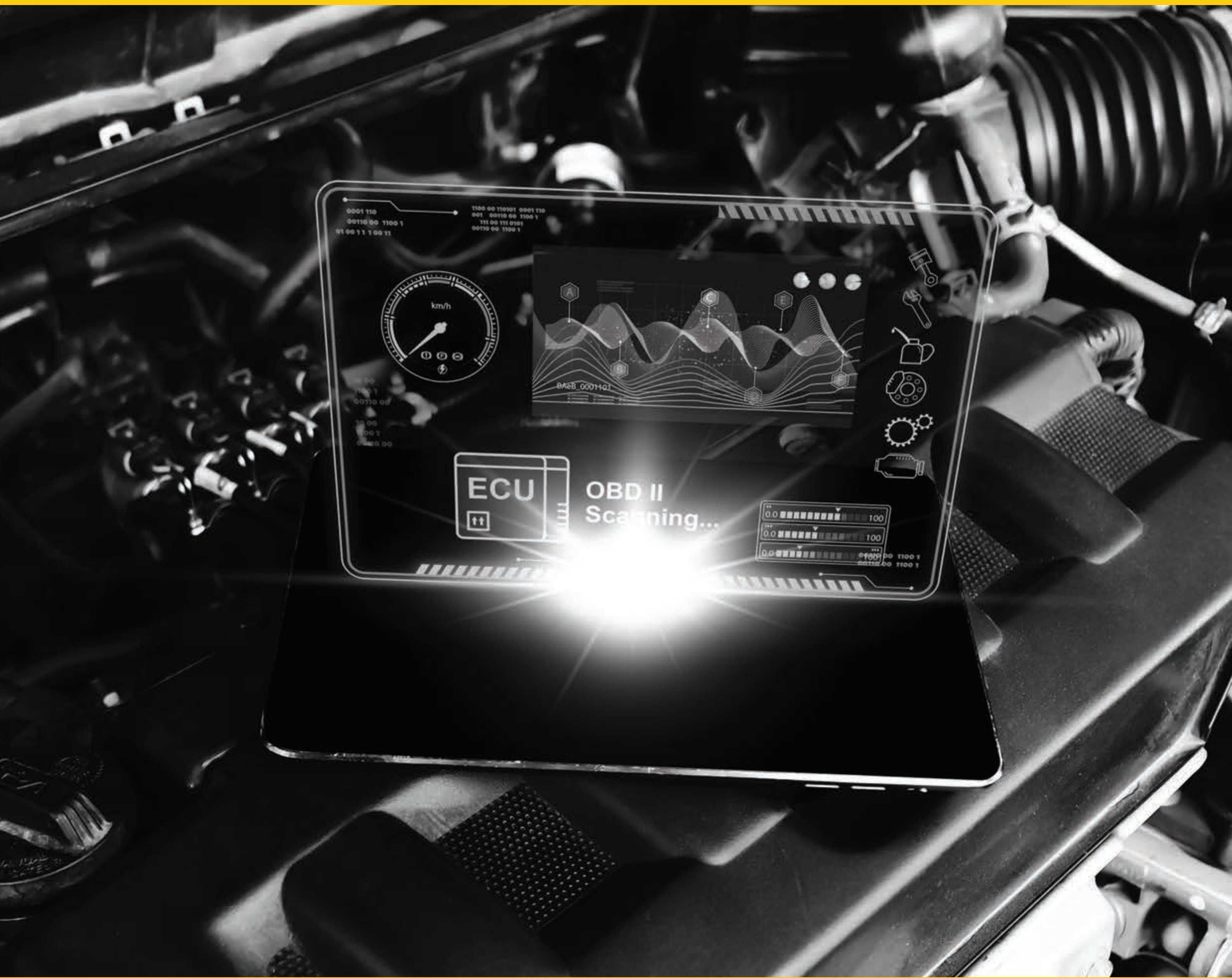
The dawn of software-defined vehicles: Unveiling the synergy between ADAS and high-performance computing



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Introduction: The age of electric vehicles

The automotive industry has undergone a seismic transformation over the past decade, primarily driven by the advent and adoption of electric vehicles (EVs). Electric propulsion is disrupting not just the passenger car segment but also making significant inroads into commercial vehicles like trucks and buses. What started as a search for reducing carbon emissions has now evolved into an accelerator for a myriad of automotive technologies. From lightweight materials to high-capacity batteries and advanced telematics, the ripple effects of this electrification movement are catalyzing R&D in an unprecedented manner. The transition to electric vehicles is no longer an option but a necessity, compelling Original Equipment Manufacturers (OEMs) to reinvent their technologies and strategies. This transition is compelling each OEM to differentiate its offerings as more and more new features are coming to reality. Automakers are recasting their designs on a canvas riddled with technological advances in digital cockpit, autonomous driving, and high-performance computing.

The architectural paradigm shift in EVs

Electric vehicles offer something that traditional Internal Combustion Engine (ICE) vehicles don't—a clean slate for architectural innovation. This is not merely about replacing a gas engine with an electric motor; it's about rethinking the entire vehicle architecture. With ICEs, designers had to work around the engine and exhaust systems, which imposed limitations. In contrast, electric drivetrains offer greater freedom, allowing for a more efficient use of space and weight. This has opened the doors for the CASE (Connected, Autonomous, Shared, Electric) model. With fewer mechanical complexities, OEMs can now focus on enhancing connectivity, introducing autonomous driving features, encouraging shared mobility, and, of course, advancing electrification.

The rise of software-defined vehicles (SDVs)

The confluence of CASE attributes is making way for the Software-Defined Vehicle (SDV), a paradigm shift that places software at the core of vehicle functionality. This goes beyond the traditional infotainment systems and into the realms of vehicle diagnostics, performance tuning, and even safety features. With an SDV, software updates can accomplish what would have previously required hardware changes. For example, Tesla has demonstrated the ability to improve braking distance through a software update, marking a departure from conventional auto manufacturing practices. Software-defined architecture allows for modular, scalable designs that can easily adapt to emerging technologies.

Born-EV architecture and high-performance computing

In the context of Born-Electric Vehicles (Born-EVs), the need for High-Performance Computing (HPC) becomes even more pronounced. Traditional ICE vehicles often employ a multitude of Electronic Control Units (ECUs) to manage everything from engine control to airbag deployment. However, born-EVs provide an opportunity to drastically reduce the number of ECUs by integrating their functions into a centralized, high-performance computing platform. This consolidation not only simplifies the architecture but also makes way for more robust and versatile computing solutions that can better support advanced functionalities, including ADAS.

Factors advancing autonomous driving technologies

High-performance computing is a cornerstone for the next generation of Advanced Driver-Assistance Systems (ADAS) or Autonomous Driving. ADAS technologies span across various levels of automation, categorized from Level 0 (no automation) to Level 5 (fully autonomous). Currently, most OEMs are focusing on the transition from Level 2 to Level 2+, which involves not just basic features like adaptive cruise control but also more advanced functionalities such as Traffic Jam Assist (TJA) and Automatic Lane Change (ALC). Moving from Level 2 to Level 2+ also requires a computational backbone robust enough to handle complex tasks like sensor fusion (cameras, radar, and lidars), object recognition, and real-time decision-making. High-performance computers become the vehicle's brain, consolidating inputs from various sensors and making split-second decisions that can mean the difference between safety and catastrophe. These HPCs must be designed with specialized hardware and software capable of running intricate, deep machine-learning algorithms, making them indispensable for next-gen ADAS systems.

Also, software-defined vehicles with high-performance computing capabilities demand a reorganization of the traditional automotive supply chain. Components that were once mechanical are now becoming electronic, and hardware suppliers need to adapt to these changes. This transition poses challenges in sourcing, as well as in quality control, requiring a more comprehensive understanding of software development processes. OEMs now need suppliers who can provide advanced electronic components that meet the stringent requirements of HPCs and ADAS systems.

Software safety and the need for cybersecurity

The integration of connected systems and advanced software technologies like OTA brings along heightened risks in terms of data security and cybersecurity. Traditional Functional Safety measures (FuSA) are no longer sufficient in this landscape. Newer frameworks like Safety of the Intended Functionality (SOTIF) are emerging to address the AI software concerns. SOTIF goes beyond ensuring that systems function correctly to prevent hazards and extends to ensuring that the systems behave as intended at all times, thus requiring a new level of scrutiny and certification for vehicle systems. FUSA and SOTIF are fulfilling the needs at the vehicle level, but overall, connected system vulnerabilities are addressed by cyber-security. Considering the complexity of the software, the multilayer security approach with firewalls needs to be considered, and advances in AI-based encryption methods make this approach more commendable and feasible.

Criticality of advanced testing in the age of level 2+ ADAS

Traditional methods of vehicle testing, such as Hardware-in-the-Loop (HIL) and Software-in-the-Loop (SIL), have been effective in validating earlier generations of automotive technologies. HIL typically involves injecting real-world signals into a system to test hardware components, while SIL simulates the entire system in a software environment to evaluate software components. However, as we move into the realm of Level 2+ Advanced Driver-Assistance Systems (ADAS), these methodologies are showing their limitations.

Why traditional testing falls short

The primary limitation of HIL and SIL is that they are not fully equipped to handle the intricacy and interdependencies of modern vehicle systems. HIL focuses primarily on hardware and SIL on software, but modern ADAS systems require seamless integration between the two. In addition, these methods often lack the ability to simulate real-world scenarios with high fidelity, making it difficult to account for the different variables a vehicle might encounter on the road, such as erratic human behavior, variable weather conditions, and complex traffic scenarios. SIL testing, in particular, lacks functionalities for validating closed-loop scenarios and conducting real-time corner-case testing, limitations that must be carefully considered during on-road data collection until they are addressed.

Moreover, the ethical and safety considerations associated with real-world, on-road testing are significant. Testing Level 2+ ADAS features— specifically with sensor configurations like 5 to 6 cameras, 4 to 5 radars, and a couple of lidars gives daunting tasks for present testing methods. On top of it, with advanced features like automatic lane change, any malfunction or oversight could result in accidents, potentially causing harm to passengers and pedestrians. The liability on OEMs for any mishap during such testing is immense, making on-road trials increasingly untenable.

The need for rigorous simulated testing

Given these challenges, there is a pressing need for more sophisticated and comprehensive testing methodologies. This is where advanced simulation technologies like Nvidia's Omniverse and Optix come into play. These platforms offer high-fidelity, real-world scenarios that replicate the complexities of driving environments. They allow OEMs to test 'what-if' scenarios that would be too risky or impractical to test on actual roads. For example, how would autonomous driving cars respond if a pedestrian were to run onto the road suddenly or if another vehicle were to change lanes abruptly? The advantage of such simulation platforms is that they can replicate the physics, lighting, and sensor feedback with remarkable accuracy. This allows for a more thorough validation of ADAS features under a multitude of conditions, from different road surfaces and lighting conditions to extreme weather scenarios. Simulated testing also enables rapid iterative improvements. Anomalies and errors can be instantly flagged, analyzed, and rectified, thereby accelerating the development cycle. The two important deciding factors of any simulated tool are perception and behavior planning/ control aspects. Perception is how real-time road scenarios are simulated, keeping the physics of the real world intact. Behavioral planning simulates road driving behavior, that is, mimicking different driving behaviors.

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In this intricate and rapidly evolving ecosystem, Quest Global stands as a trusted partner for automotive manufacturers and OEMs. With a deep understanding of the complexities involved in creating next-generation vehicles, Quest Global offers comprehensive solutions, from developing artificial intelligence algorithms to optimizing them into high-performance computing platforms and testing them using advanced simulated software.

For further information or queries, please reach out to us at info@quest-global.com