Pioneering End-to-End Demonstrable Implementation of Software-Defined Vehicles by ACPS Lab, IIT Indore

13 Jan 2024

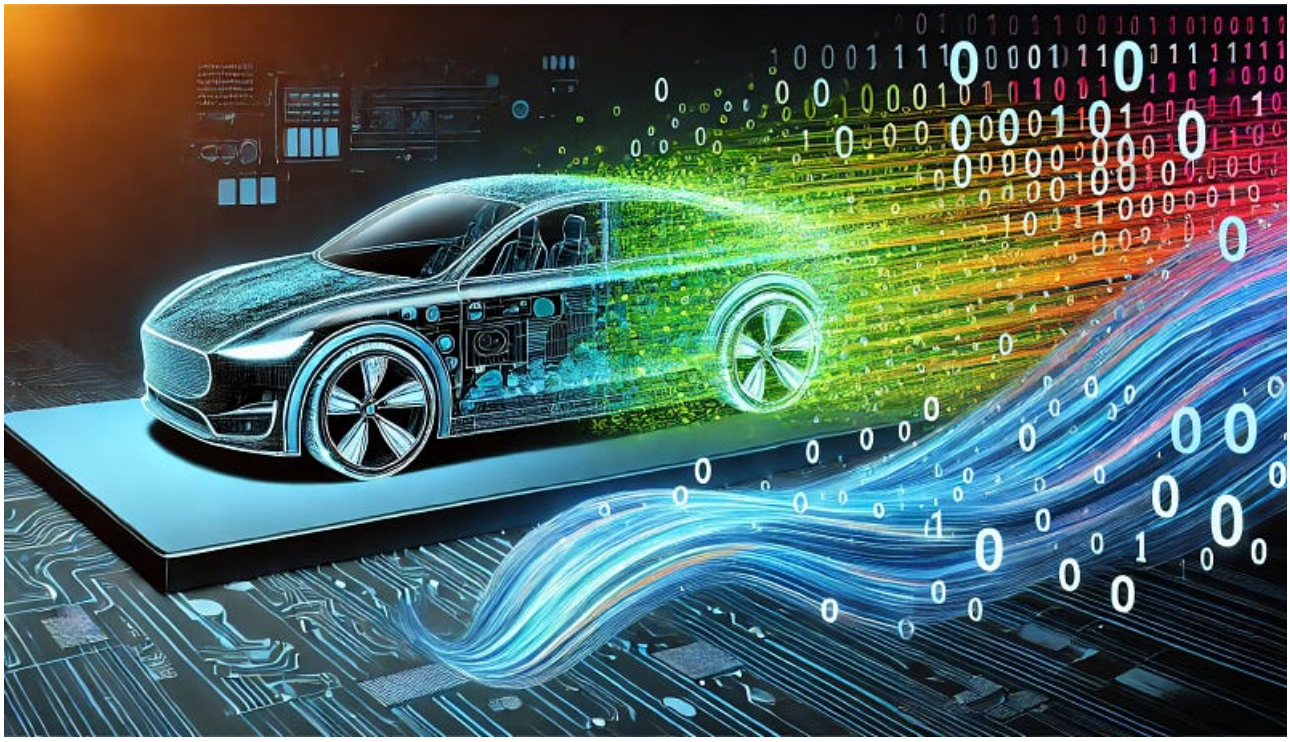


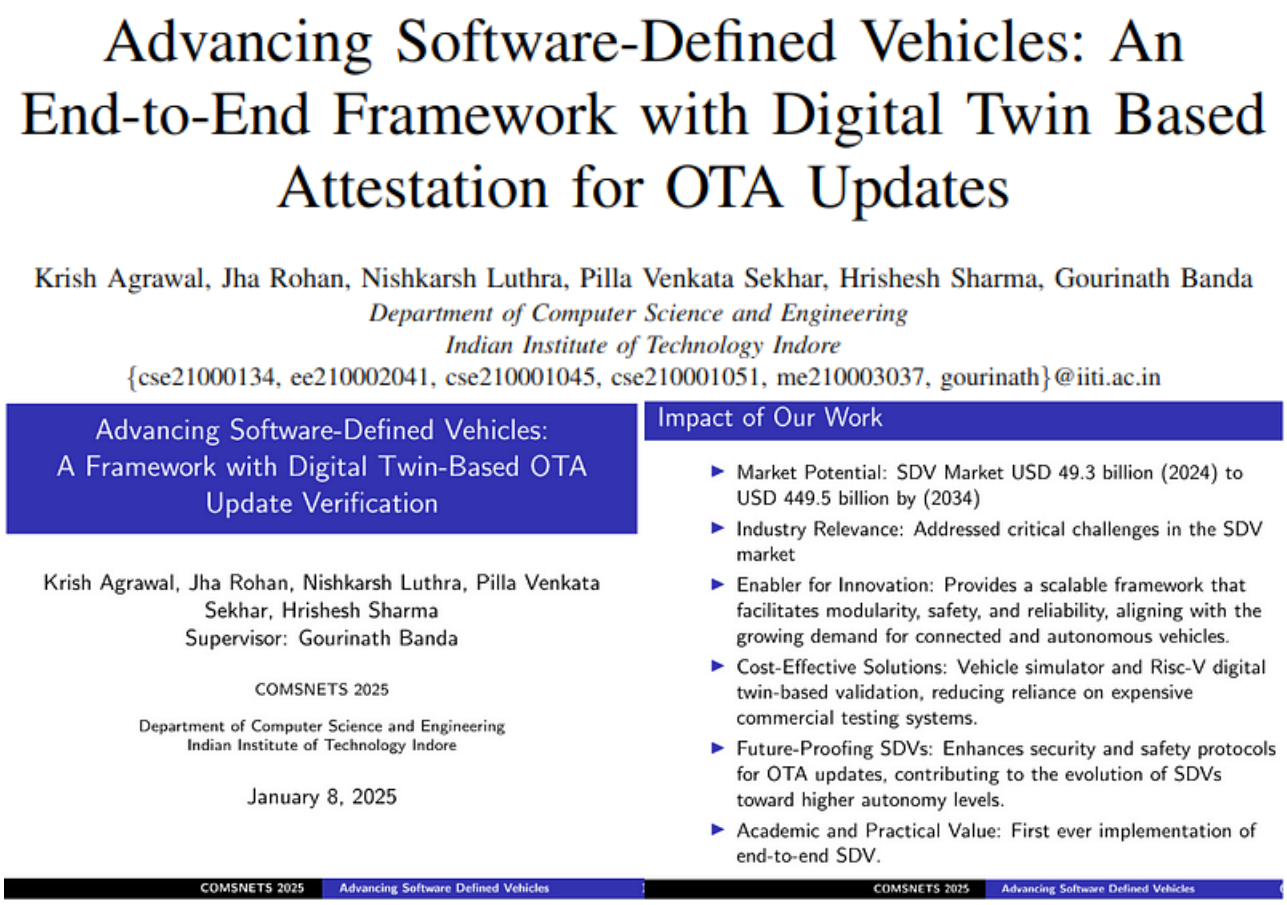
Fig 1. SDV Concept

IIT Indore's Autonomous Cyber-Physical Systems (ACPS) Lab, led by Dr. Gourinath Banda and a stellar undergraduate team comprising Krish Agrawal, Rohan Jha, Nishkarsh Luthra, Sekhar Venkata, and Hrishesh Sharma, has set a new benchmark in the automotive systems' research and development. Their pioneering work on **SDVs**, integrating a **DigiTwin-Based Framework** and **Vehicular Simulator**, has won the prestigious Best Research Work and Presentation (UG Forum) at the COMSNETS 2025 conference last week.

Fig 2. L2R: Nishkarsh, Krish, Hrishesh, Sekhar, Rohan

This project, **the first-ever end-to-end SDV framework developed in academia and industry**, focuses on ensuring the safety and reliability of OTA software updates in vehicles, revolutionizing the concept of SDVs. By integrating state-of-the-art vehicle simulation abstraction with digitwin tech for ELF binary emulation, the

framework allows rigorous pre-deployment evaluation of software updates, enhancing reliability and reducing potential risks. This work is accepted for publication and presentation of the COMSNETS2025 proceedings.



Advancing Software-Defined Vehicles: An End-to-End Framework with Digital Twin Based Attestation for OTA Updates

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Advancing Software-Defined Vehicles: A Framework with Digital Twin-Based OTA Update Verification

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COMSNETS 2025

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COMSNETS 2025 Advancing Software Defined Vehicles

Impact of Our Work

- Market Potential: SDV Market USD 49.3 billion (2024) to USD 449.5 billion by (2034)
- Industry Relevance: Addressed critical challenges in the SDV market
- Enabler for Innovation: Provides a scalable framework that facilitates modularity, safety, and reliability, aligning with the growing demand for connected and autonomous vehicles.
- Cost-Effective Solutions: Vehicle simulator and Risc-V digital twin-based validation, reducing reliance on expensive commercial testing systems.
- Future-Proofing SDVs: Enhances security and safety protocols for OTA updates, contributing to the evolution of SDVs toward higher autonomy levels.
- Academic and Practical Value: First ever implementation of end-to-end SDV.

COMSNETS 2025 Advancing Software Defined Vehicles

Fig 3. Extracts from the title paper and presentation slides

Contributions enumerated: A Revolutionary Approach to SDVs

In the era of smart and connected vehicles, SDVs represent a paradigm shift from mechanical systems to software-centric architectures. The ACPS Lab's framework capitalizes on this shift by addressing the **challenges of software scalability, maintainability, and safety**. Highlights of their contributions include:

- **Digitwin Integration:** The framework employs a cloud-based digital twin of the vehicle, enabling software updates to be rigorously tested in a virtual environment before deployment to physical vehicles.
- **Vehicle Simulator:** An economical, in-house simulator replicates real-world driving scenarios, facilitating cost-effective validation.
- **SDV Stack:** In summary, witht the above two module this is the first ever end-to-end SDV stack.

Industry Impact Potential

This framework not only ensures the safety of OTA updates but also significantly **reduces development and compliance timelines**, a crucial aspect in the automotive industry where stringent safety standards like ISO 26262 dominate. The team's use of cutting-edge technologies, such as **RISC-V architecture-based virtual ECUs, secure gRPC communication**, and **Automotive Grade Linux (AGL)**, underscores their dedication to innovation.

Key features of this framework include:

- **Safety-First Approach:** Updates are validated in a digital twin environment, ensuring compatibility and functionality without compromising vehicle safety.
- **Scalable Architecture:** Leveraging virtualization to support modular software systems for easy adaptation across vehicle models.
- **Streamlined OTA Process:** A comprehensive pipeline from initial testing on digital twins to final deployment on physical vehicles.

Vision for the Future

The work envisions expanding the framework to incorporate **large ECU hierarchies**, optimize update latencies, and enhance security protocols. Future iterations aim to achieve real-time compatibility checks and automatic software updates for vehicles, akin to modern smartphone experiences, without sacrificing safety.

Fig 4. ACPS Lab members

This project showcases our lab's commitment to advancing cyber-physical systems and creating technologies that drive real-world impact. Winning this recognition at COMSNETS 2025 reaffirms our efforts to push the boundaries of automotive innovation through applied sciences, engineering and technology.

LinkedIn: https://www.linkedin.com/posts/gourinath-banda_activity-7284596248253206528-WyxR

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