

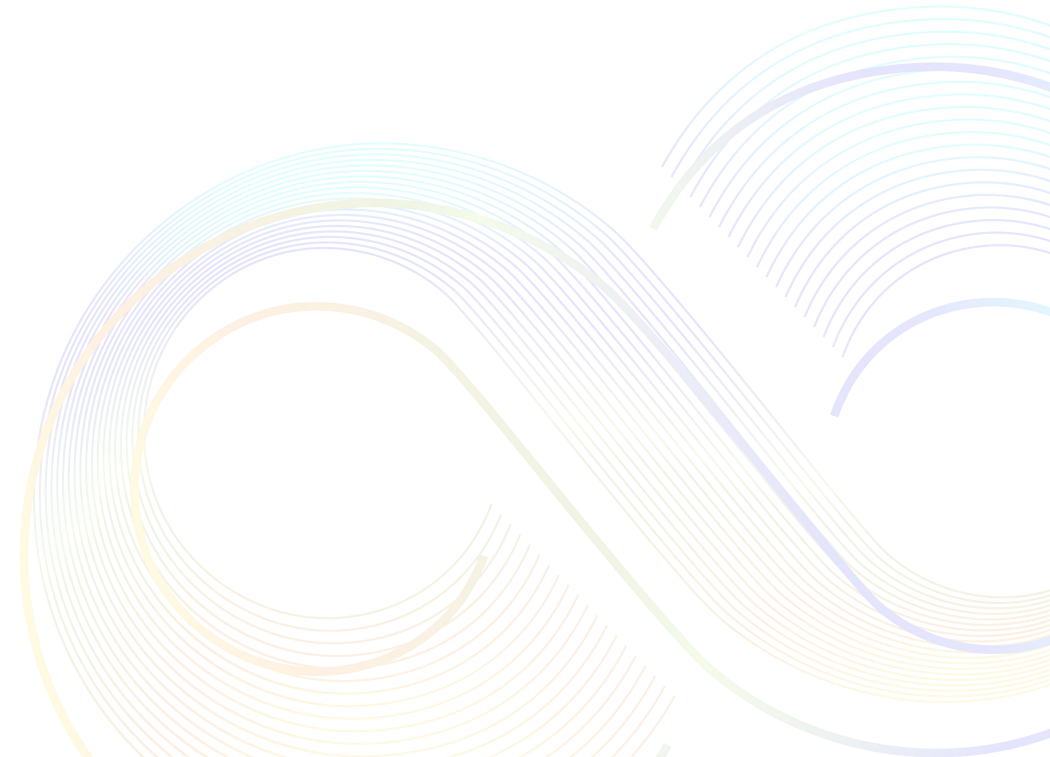
Scalable Software Testing in Virtual Platforms: Leveraging SystemC, QEMU and Containerization

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Tim Kraus, Robert Bosch GmbH

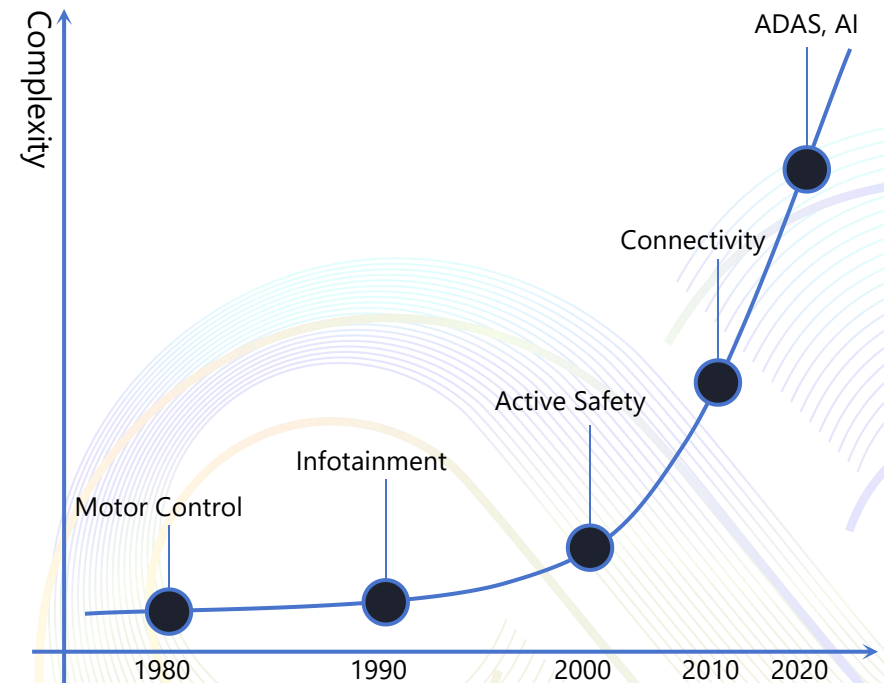
Agenda

- Motivation
- Introduction Virtual Platform
- Scaling Virtual Platforms
- Qbox: QEMU in a SystemC Box
- Case Study: AI Accelerator
- Summary



Motivation

- Software-Defined Vehicle
 - Modern vehicle > 100. Mio LOC
 - SW becoming USP
- Bad software is expensive
- Managing software complexity is key
- ISO26262 compliance
- Problem: **SW testing is hard to scale**



Tesla recalls 239,382 vehicles over rearview camera problems

components for owners of Musk's electric buggies

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auto
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Verkehr > Sicherheit > Mercedes-Rückruf: Software-Up

RÜCKRUF MERCEDES

Software-Update erforderlich

Mercedes-Benz

CARS COOPS

RECALLS

US Porsche Taycan

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BYD recalls 16 prevent revers



Lei Kang

Apr 30, 2024, 12:16 PM GMT+2

January 16, 2025

NHTSA CAMPAIGN NUMBER: 25V012000

Adaptive Cruise Control May Not Activate Brakes

A vehicle that does not automatically brake as expected increases the risk of a crash.

NHTSA Campaign Number: 25V012000

Manufacturer General Motors, LLC

Components SERVICE BRAKES, HYDRAULIC, FORWARD COLLISION AVOIDANCE

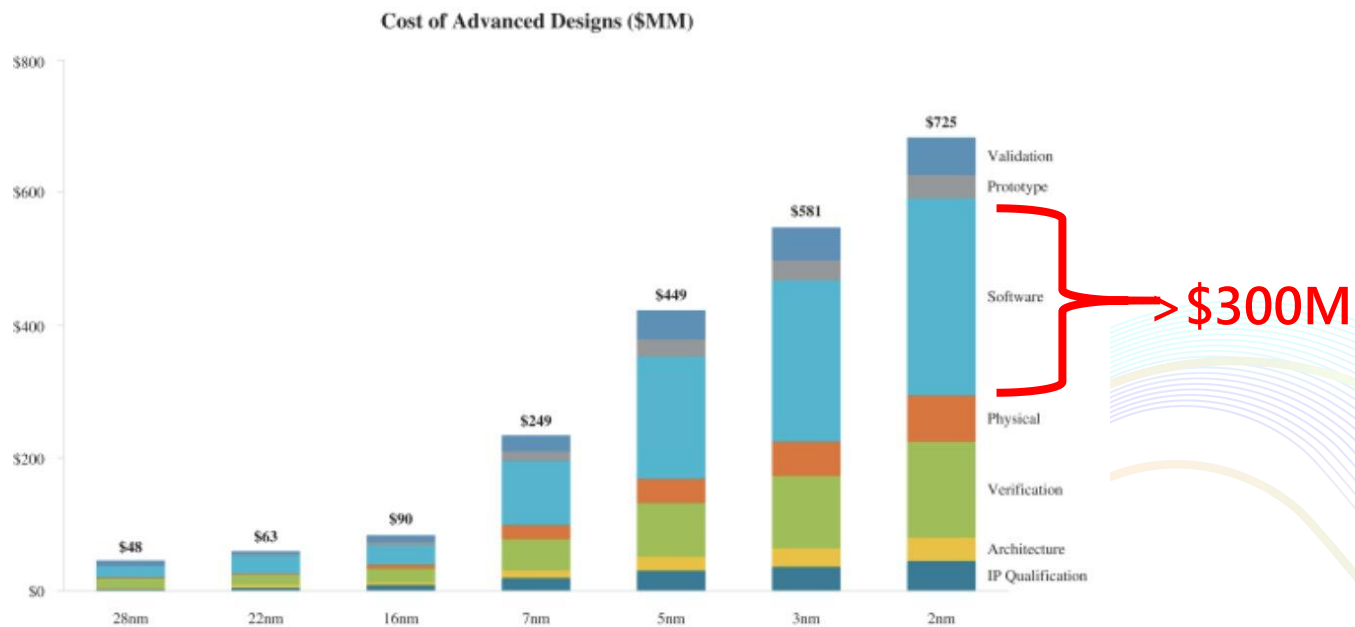
Potential Number of Units Affected 2,890

Summary

General Motors, LLC (GM) is recalling certain 2025 Chevrolet Equinox EV all-wheel drive electric vehicles. The adaptive cruise control may fail to engage the brakes as expected, due to incorrect brake module software.

2024-09-30

Consequences



Source: IBS July 2022.

Shift Left

1228

Software Engineering - BARRY W. BOEHM

IEEE TRANSACTIONS ON COMPUTERS, DECEMBER 1976

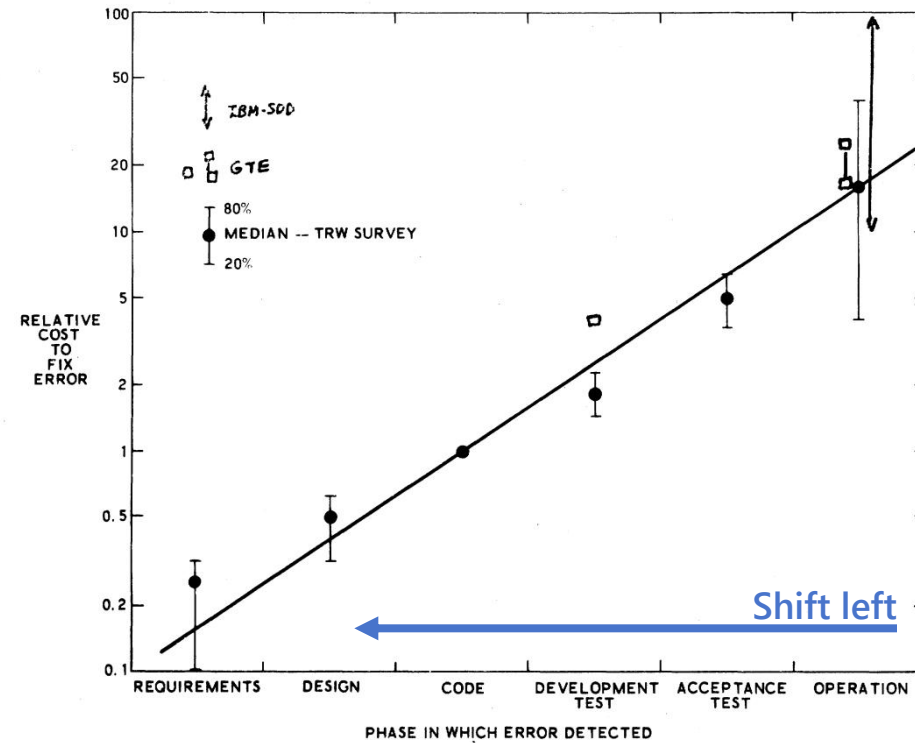
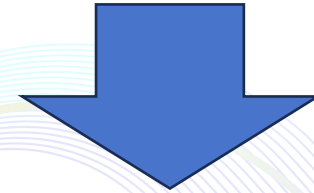
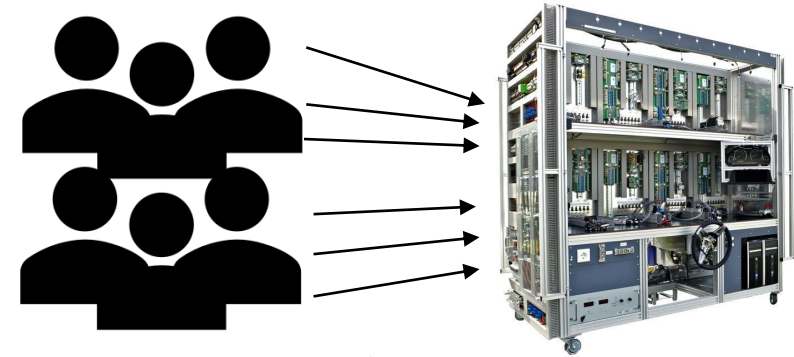


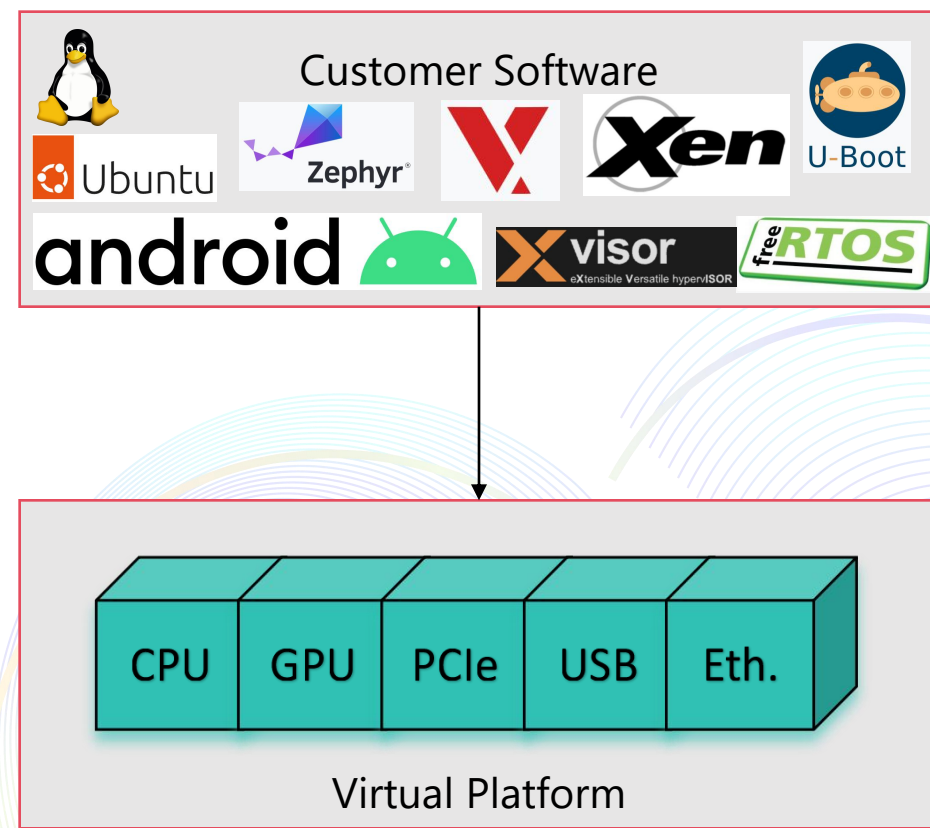
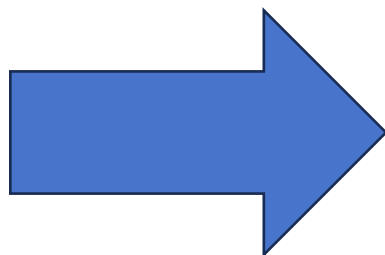
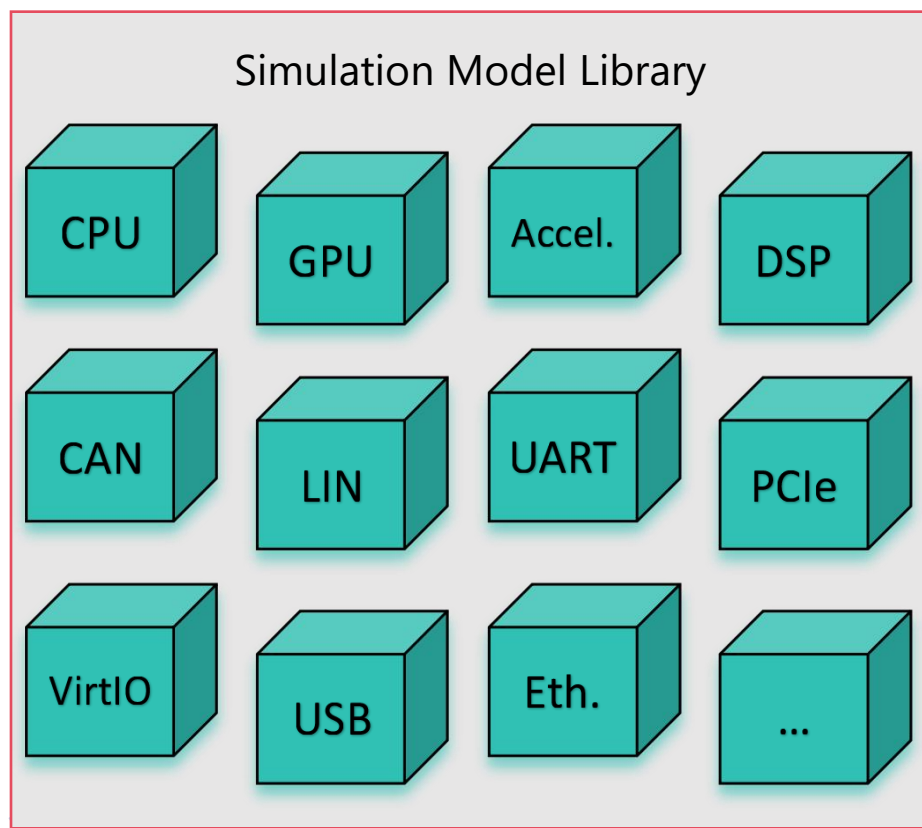
Fig. 3. Software validation: the price of procrastination.

Virtual Prototyping

- Virtual Platform: Full System Simulation
 - Execute unmodified target software
- Indispensable in modern software development
- Numerous advantages over physical prototypes
 - Available early
 - Scalable deployment
 - Full flexibility, deep introspection

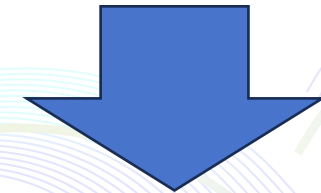


Building Virtual Platforms



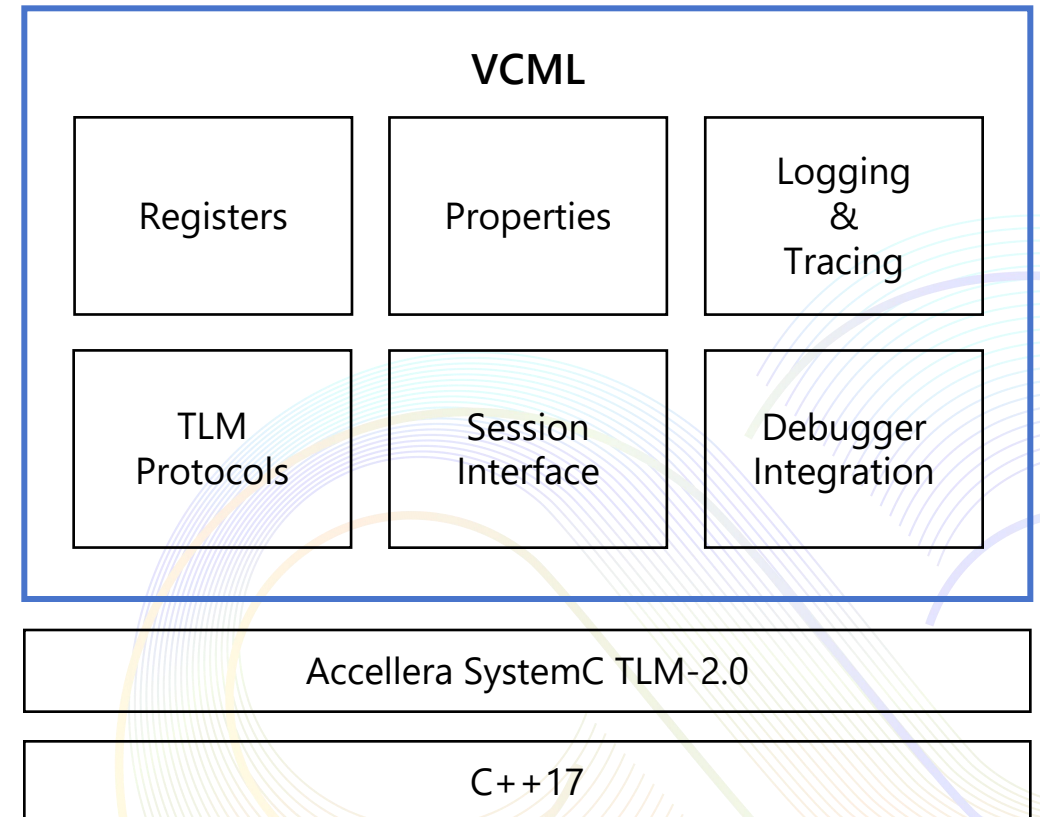
Scaling Virtual Platforms

- Reusability of models
 - Rely on standardized model interfaces
 - SystemC TLM-2.0 ideal candidate
- Flexibility of license model
 - Open-Source vs Proprietary
 - Seat-license vs pay-as-you-go
- Ease of use / applicability to use case
 - VP = expert tool, no silver bullets

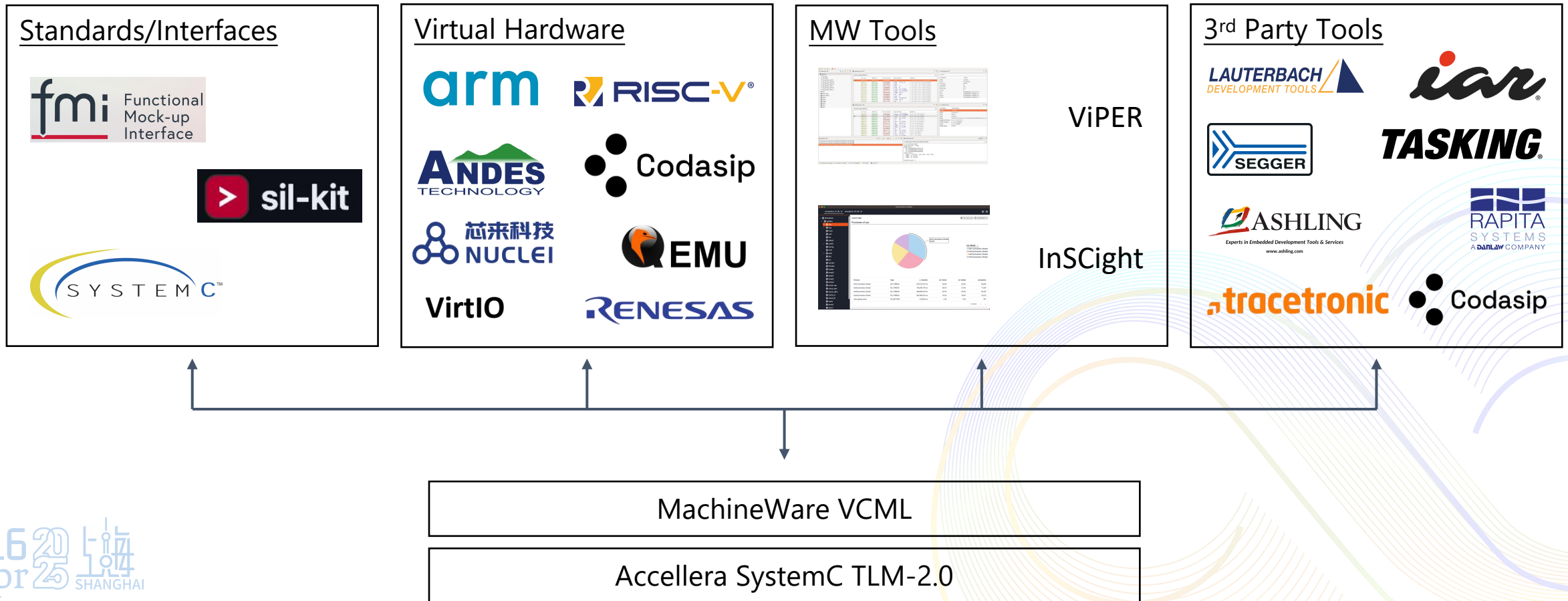


VCML: Virtual Components Modeling Library

- Toolkit for building Virtual Platforms and Simulation Models
- Everything that's missing in SystemC TLM-2.0
- Open-Source (Apache-2.0)
 - <https://github.com/machinware-gmbh/vcml>
 - <https://www.machinware.de/vcml-community>

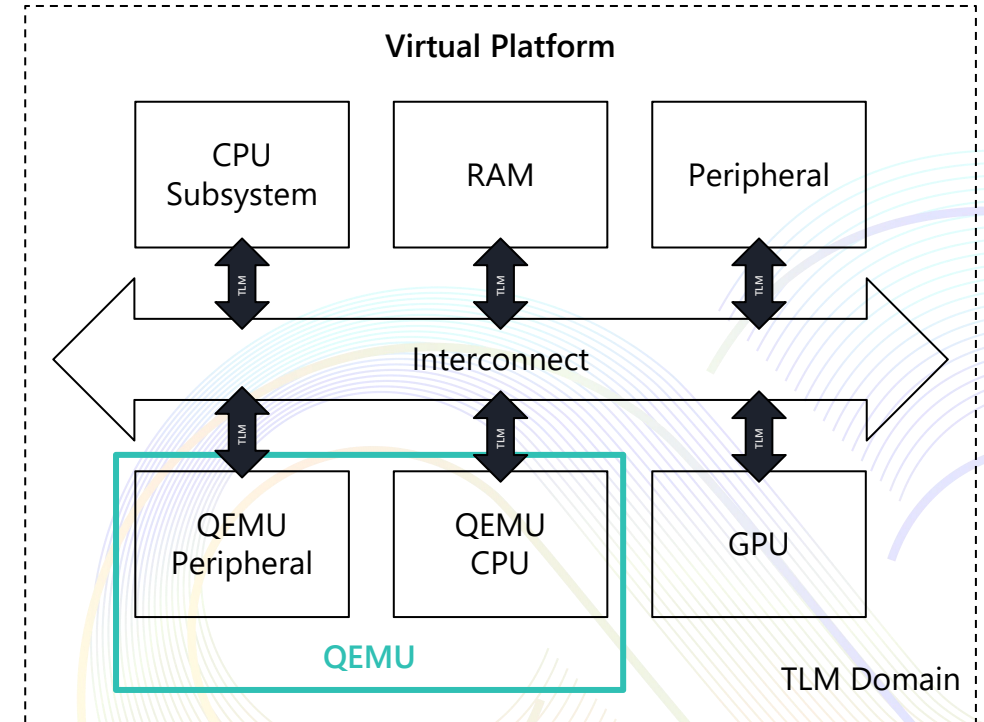


VCML Ecosystem



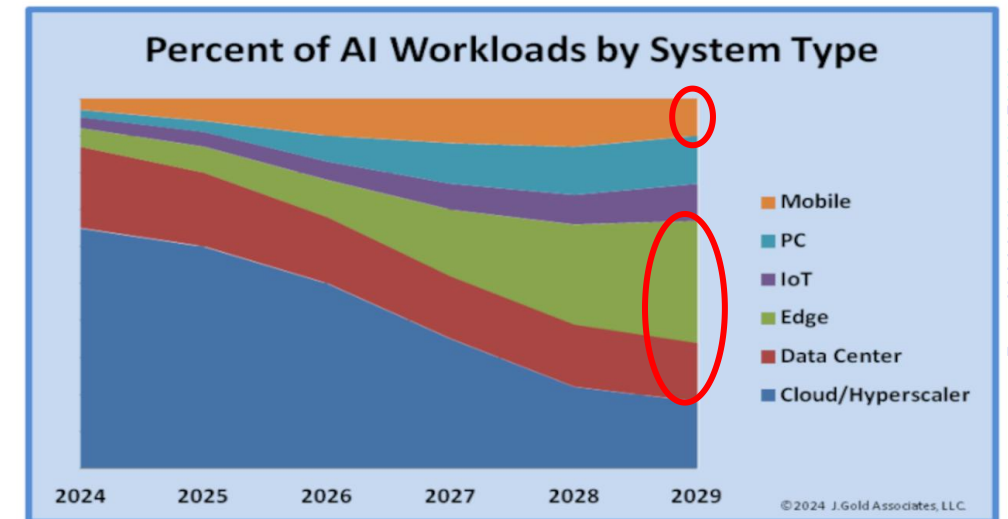
QBox: QEMU in a SystemC Box

- QEMU is a popular open-source simulator with fast CPU models
- QEMU does not support standard interfaces (TLM-2.0)
- Qbox: QEMU + SystemC integration
 - Model reuse from QEMU in standard SystemC simulation



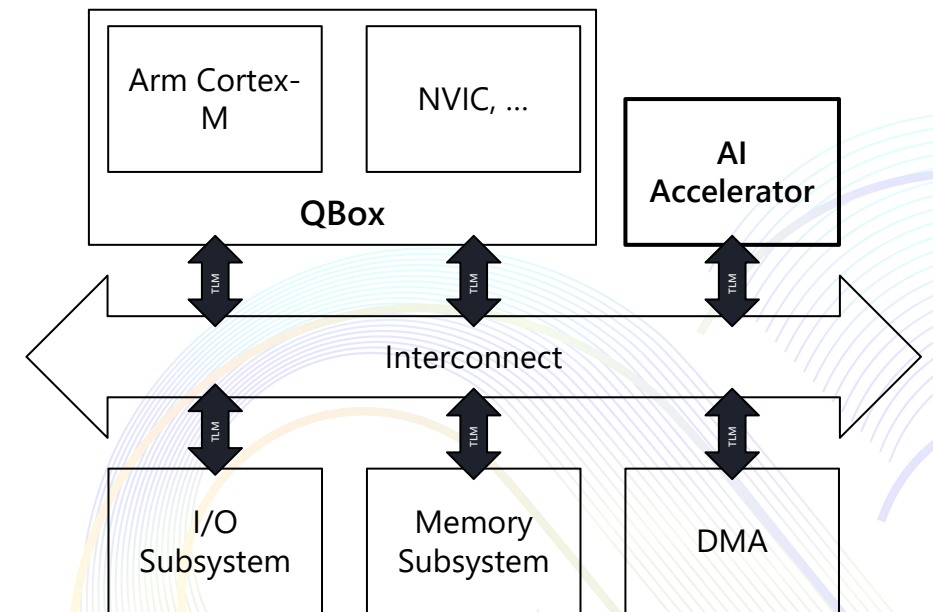
Case Study: AI Accelerator

- AI is shifting to the edge
- Edge CPUs not powerful enough for complex AI workloads
 - Custom accelerators required
 - Custom driver required
- Goals
 - Test and develop target software stack before silicon is ready
 - Try different architecture configurations



AI Accelerator VP

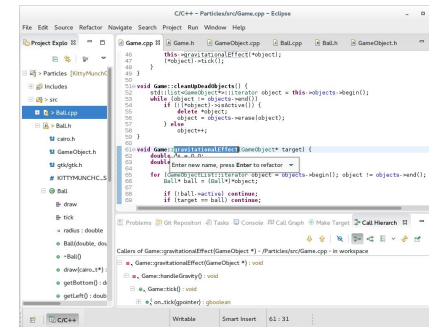
- Typical Edge AI system with
 - AI accelerator
 - Arm Cortex-M CPU + IRQ Ctrl.
 - I/O subsystem (UART, ...)
 - Memory
 - DMA
- CPU + IRQ Ctrl. model using Qbox
- All other models SystemC TLM



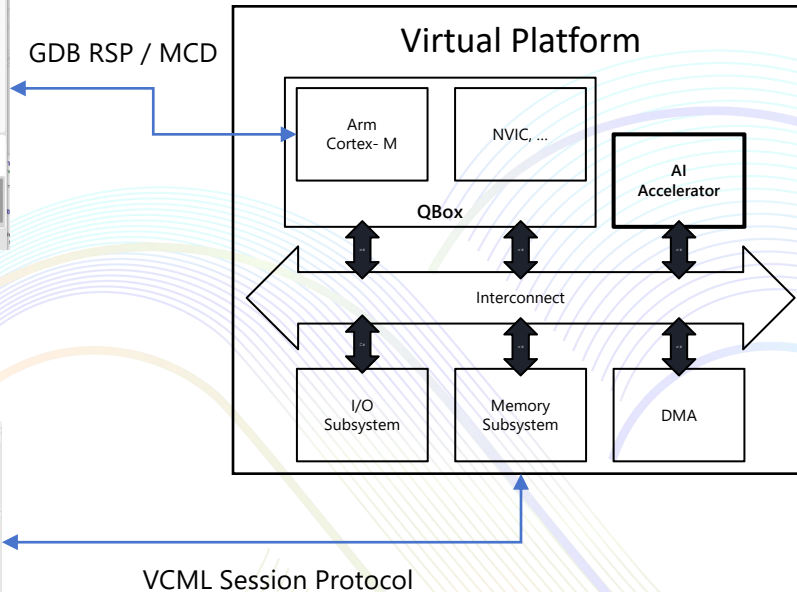
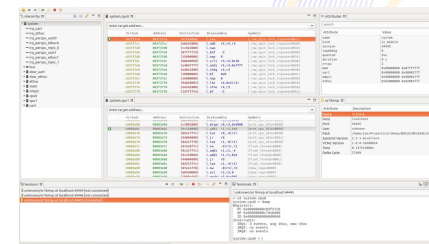
Software Development with VP

- Custom AI compiler-based software stack for accelerator + driver software on Cortex-M CPU
- Development and debug using IDE through standard API
- Scriptable simulation control via VCML session
- Test full software stack pre-silicon

IDE (Eclipse, Commercial, ...):

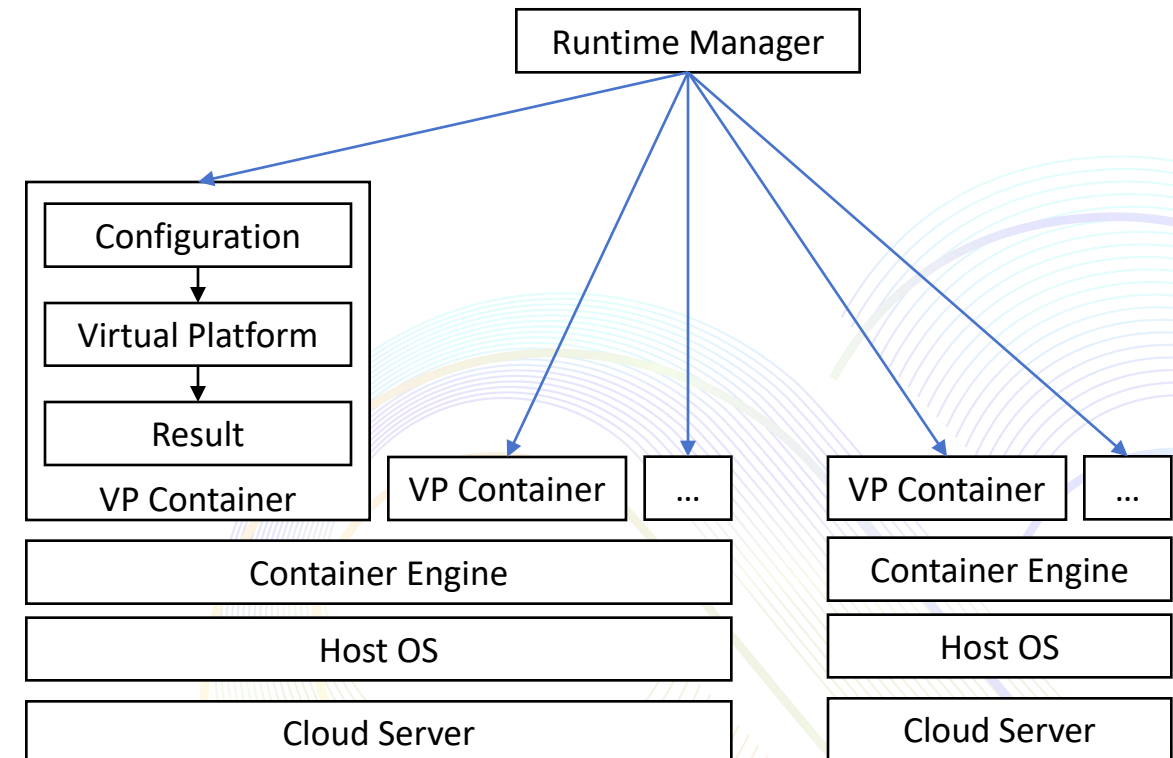


MachineWare ViPER



Software Execution Framework

- Scalable CI testing for target software changes required
- Schedule test jobs on CI cluster running VP containers
 - VP configuration through VCML properties from environment
- Easily scalable, because no licenses required
- Published at DVCON Europe 2024
 - *Deployment of containerized simulations in an API-driven distributed infrastructure*



Summary

- Virtual Platforms are indispensable in modern software development
 - Shift left reduces costs of bugs by 10-100x
 - Managing software quality is key to maintaining a competitive advantage
- VCML + QBox provides an open-source, scalable solution for building high-performance Virtual Platforms for contemporary target systems
- AI Accelerator case study shows how to deploy open-source VPs for complex target software
 - Easy software development and debugging using standard IDE
 - Scalable CI integration through containerization and cloud deployment



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