Virtualized Embedded Systems for Testing and Development
Agenda

- Driving factors, Needs
- Methods & Tools
- Case-studies
- Results & Experiences
Virtues explores methods for Quality Assurance of large, evolving, embedded software systems, with a focus on sw-development and sw-testing

Needs:
1. A test environment independent of source-code/architechure/OS
2. Keep test code volume down

How:
1. Test the unmodified, true ECU-binaries
2. Generate tests from the concise formal requirements
Scania/KTH project VIRTUES

• 3 year project – 2014-2017
• FFI Dnr 2013-05608

• Learning-Based Requirements Testing on SIL and VHIL Platforms
• Software-in-the-loop testing Wincomp
• Virtualised hardware-in-the-loop testing QEMU
• Integrated with learning-based test tool LBTest
VHIL Tool Chain

- Test Tool
- Performance Tool
- Security Tool
- Energy Tool

Truck Emulator Platform

Open Source Emulator Toolset

QEMU
LBTest: Architecture

Communication wrapper

System Under Test

Incremental Learning Algorithm

Model abstraction

Model Checker
(NuSMV)

Stochastic Equivalence Checker

PLTL User Requirement

Observed output

i_n

n = 1, 2, ...

counterexample i_n

verdict V_n

Multiple, parallel SUT processes possible
SIL: Stubbed x86-compiled app
VHIL: unmodified srec-file (guest-level)
VHIL: unmodified srec-file (host-level)
SIL Case Studies

We considered SIL requirements testing of 3 ECU applications

• remote engine start (ESTA),
• dual circuit steering (DCS),
• fuel level display (FLD).
Dual Circuit Steering (DCS)

Benchmark LBTest against an in-house test suite using mutation testing

Requirements Capture Challenges

“the electric motor had been on
while the second sensor had a flow or noflow,
since the last engine restart”

(emotor = on & (sensor2 = flow | sensor2 = noflow) Since ignition = restart)

Learning-based testing of automotive ECUs
Sophia Bäckström
Masters project, KTH
SIL Test Results for DCS

• Tested 7 hours 24 minutes
• 60 state model,
• 800 transitions
• 97% convergence

• 5 requirements errors found – but none were safety critical

Learning-based testing of automotive ECUs
Sophia Bäckström
Masters project, KTH

Table VIII. DCS Mutation testing results and comparison
We considered VHIL requirements testing of 3 ECU requirements

- bit-flip Checksummed Memory Area,
- stuck-at in Checksummed Memory Area,
- (TBD) stuck-at in MMIO

Virtualized-Fault Injection with Learning-based Requirements Testing
H. Khosrowjerdi, K. Meinke, A. Rasmusson
Submitted to ICST2018
Bit-flip in Checksummed Memory Area

Inject errors via scripted debugger

guest-level, with symbols
Conclusions

• Successful case studies on real-products
• Both SIL and VHIL testing can be handled by one tool
• Formal requirements improved Scania’s product understanding
• Instruction Set Simulation is useful for ecu-testing.
• Test the realization. It contains more behavior than the source-code.