Using Cyber Digital Twins for Automated Automotive Cybersecurity Testing

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Stefan Marksteiner, Slava Bronfman, Markus Wolf, Eddie Lazebnik

The Need for Industrialized Automotive Cybersecurity Testing

- UNECE
  - Regulation R.155
  - Mandates cybersecurity and cybersecurity management
  - Requires testing of measures
  - Adopted in EU, Japan and Korea
  - Effective in EU for new types 2022 and for all new vehicles 2024
- ISO/SAE 21434
  - Cyber security management system for automotive systems
  - Risk-based approach
  - Also demands testing, however, does not specify details
  - To be supplemented for testing by ISO PWI 8477 (V&V) and ISO/SAE PWI 8475 (CAL &TAF)

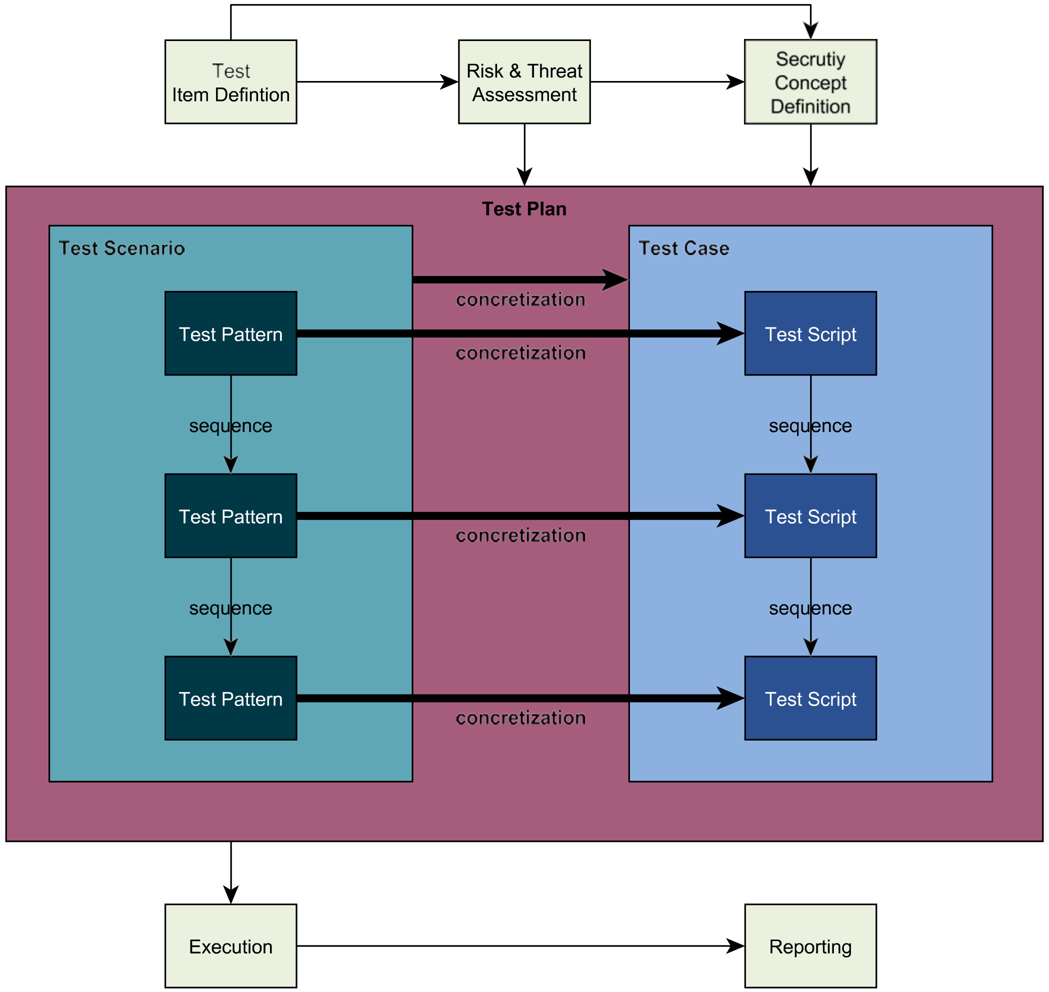
=> Need for automated testing

Why Black Box Testing?

- Providing an attacker's view
- Long supply chain – source might not be available
- Unwillingness (or inability) to disclose internals

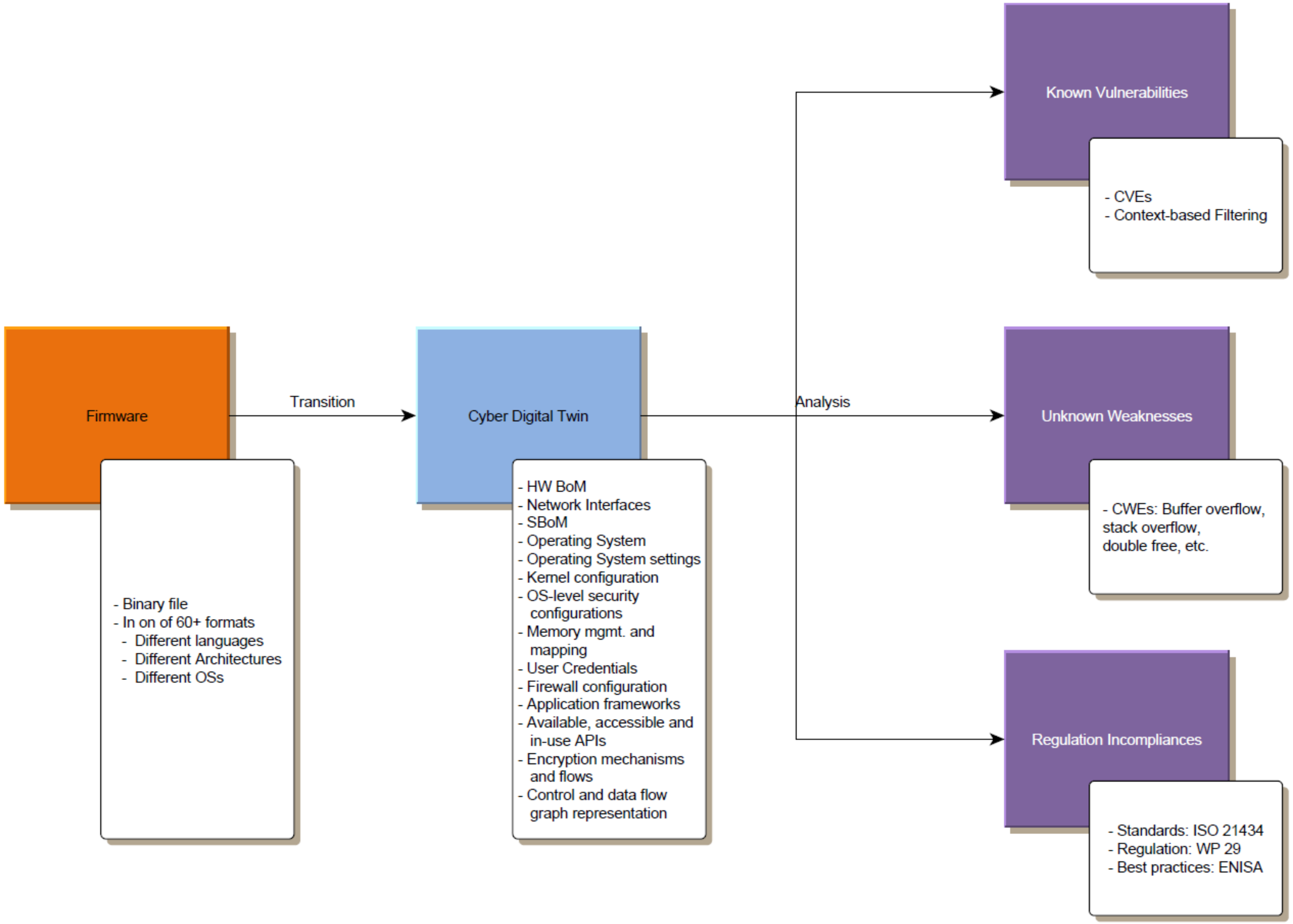
Static Approach (Previous Work)

- Generalize Existing Attacks
- Formulate Attack Scenarios in DSL (ALIA[14])
- =>SUT-Agnostic attack description
- Test Case Generation => augmenting attacks with SUT info



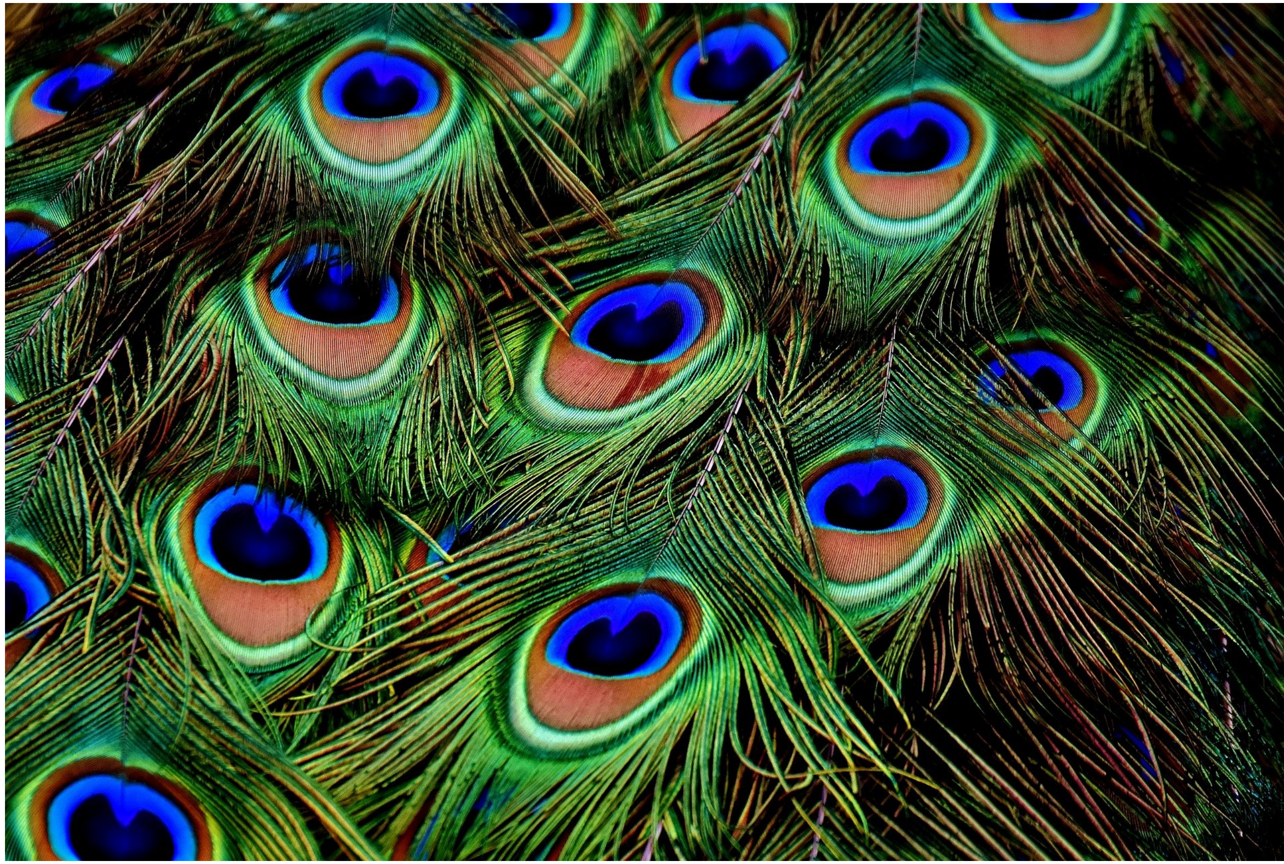
Problem: approach static - lots of a priori information needed!

Cyber Digital Twin (Previous Work[11])

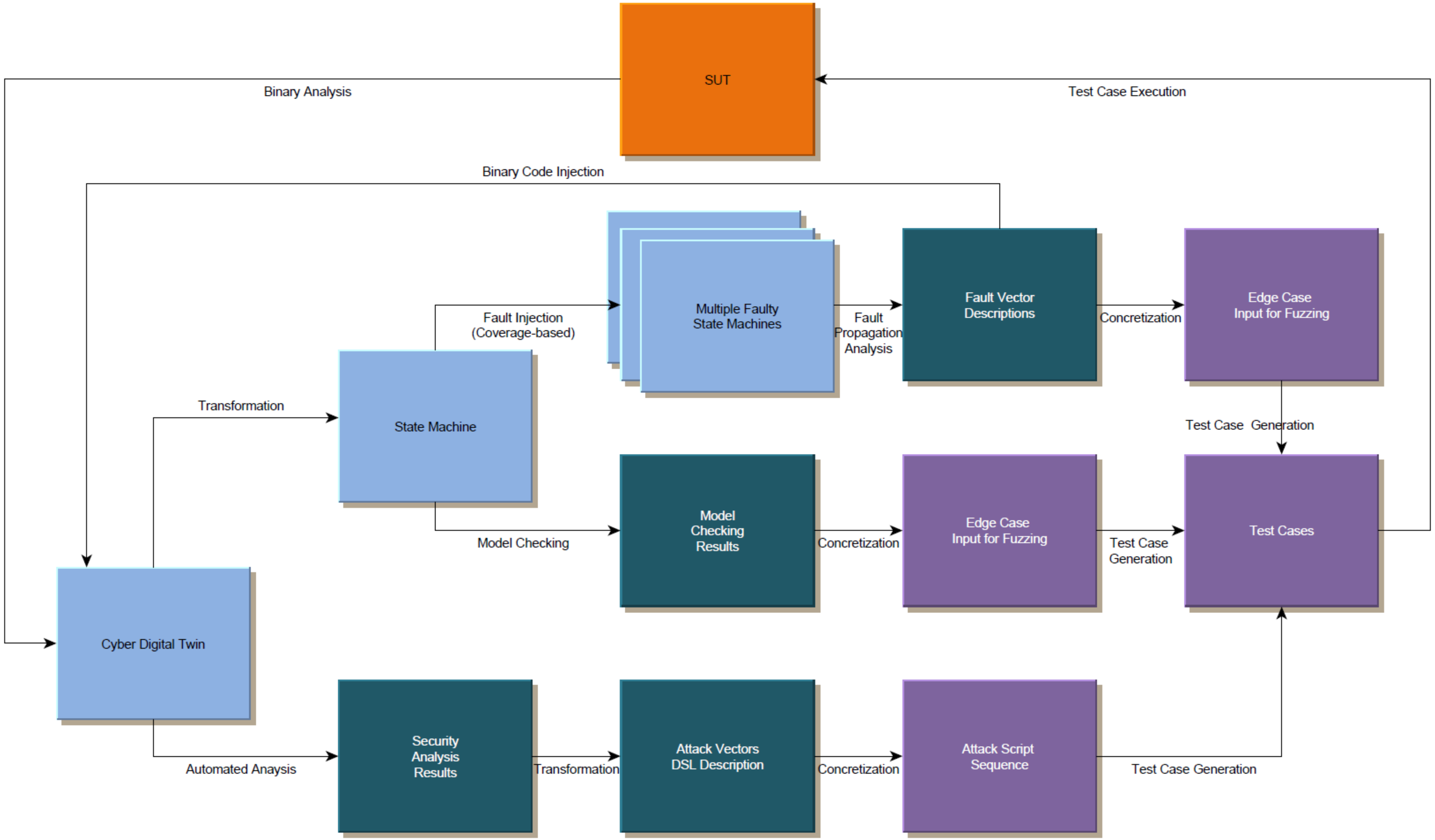


Cyber Digital Twin – Pattern Matching

- Translate binary into own machine code format
- Compare patterns of known software with parts of the binary => software BOM
- Compare patterns of known vulnerabilities (CVEs) and general flaws with parts of the binary => security analysis results



Test Case Generation



State Machine-Based Testing

- Fault injection
  - Inject Faults into the State Machine
  - Use the ones producing interesting results as test cases
- Model Checking
  - Transform model into provable form
  - Use violations as test case inputs

Binary Analysis -> Attack DSL Scripts

- Generate DSL scripts out of findings
- Use pre-prepared building blocks
  - CVEs
  - Code pieces for buffer overflows, etc.

```
ID <2> BT_Connect=TRUE
ID <4> MEASUREMENT(SPD, PRETEST)= 0
</PRECONDITIONS>
<ATTACK>
ID <1> Traget Vulns:=ACTION SCAN_IF_VULN  (Bluetooth, MA
ID <2> Shell:=ACTION EXPLOIT_BT (Target_Vulns, GetShell)
ID <3> RootShell:= ACTION OPEN_ADB_SHELL(ADB_KEY, S
ID <4> Result:=ACTION RUN_ATTACK_TOOL(RootShell, Can
</ATTACK>

<POSTCONDITIONS>
ID <2> BT_Connect=FALSE
ID <3> RootShell!=NULL
ID <4> Result=Success
ID <4> MEASUREMENT(SPD, INTEST)=200
ID <4> MEASUREMENT(SPD, POSTTEST)=0
```

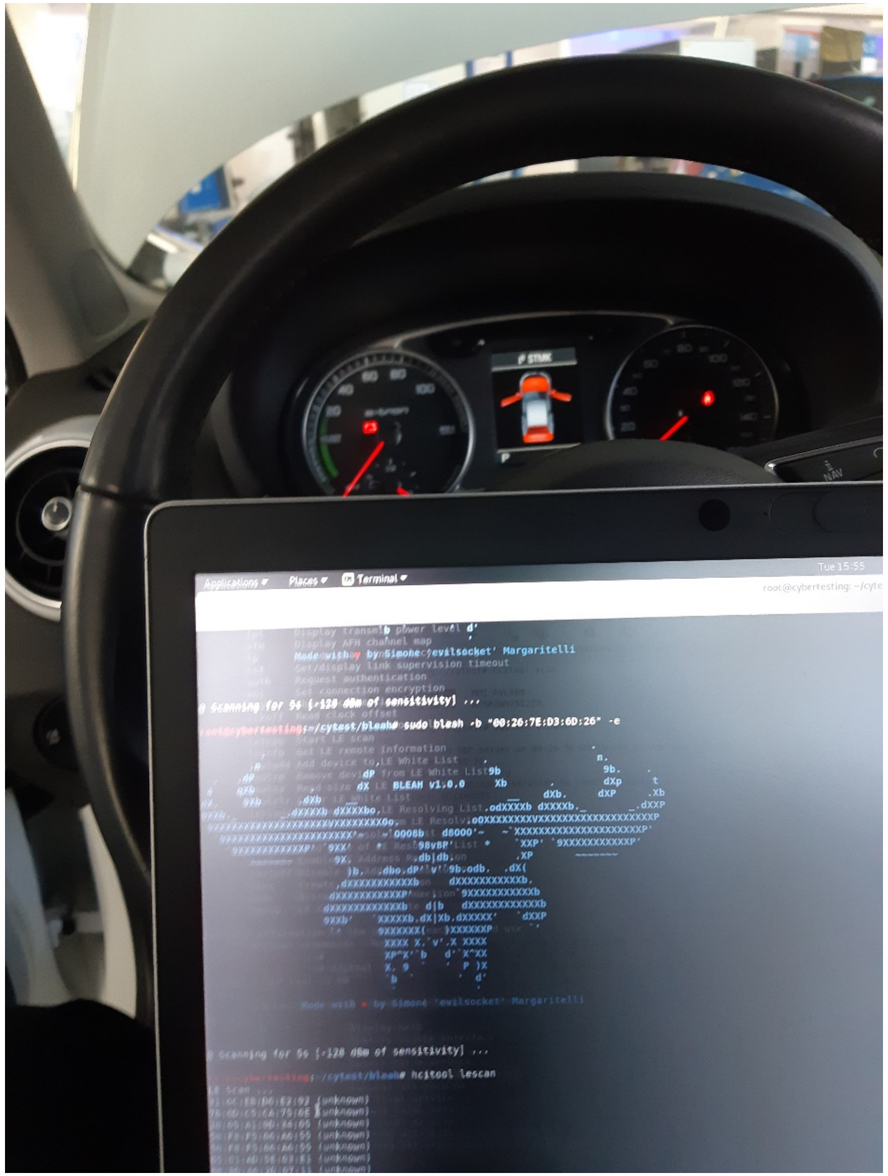
Test Execution

- Test case generation produces a JSON output that can be interpreted by an execution engine
- Principally an environment description + shell commands

```
from pyusbtin.usbtin import USBtin
from pyusbtin.canmessage import CANMessage
from time import sleep

def log_data(msg):
        print(msg)

usbtin=USBtin()
usbtin.connect("/dev/ttyACM0")
usbtin.add_message_listener(log_data)
usbtin.open_can_channel(500000,USBtin.ACTIVE)

#test_msg = CANMessage([illegible])
test_msg = CANMessage([illegible])

while(True):
        usbtin.send(test_msg)
        sleep(0.1)

#pysh = "/data/user/0/com.hipipal.qpy3/files/bin/qpython3-android5.sh"
#import subprocess
#subprocess.call([pysh,"/sdcard/usbtintest.py"])
```

Conclusion

- Concept for model-based cybersecurity testing of automotive systems
- Uses existing building blocks
- Combines
  - Dynamic model generation
  - Dynamic security analysis
  - Automated test case generation
  - Automated test execution



Thank you for your attention!

Thanks!

Stefan Marksteiner [1], Slava Bronfman [2], Markus Wolf [1], Eddie Lazebnik [2]

[1] AVL List Gmbh, {stefan.marksteiner | markus.wolf}@avl.com
[2] Cybellum Ltd., {slava | eddie}@cybellum.com

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