4th UCAAT User Conference on Advanced Automated Testing

ETSI World Class Standards

FUZZ TESTING ITS

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Fraunhofer FOKUS

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OVERVIEW AND GENERAL CONSIDERATIONS

Why should Fuzz Testing be applied to ITS?

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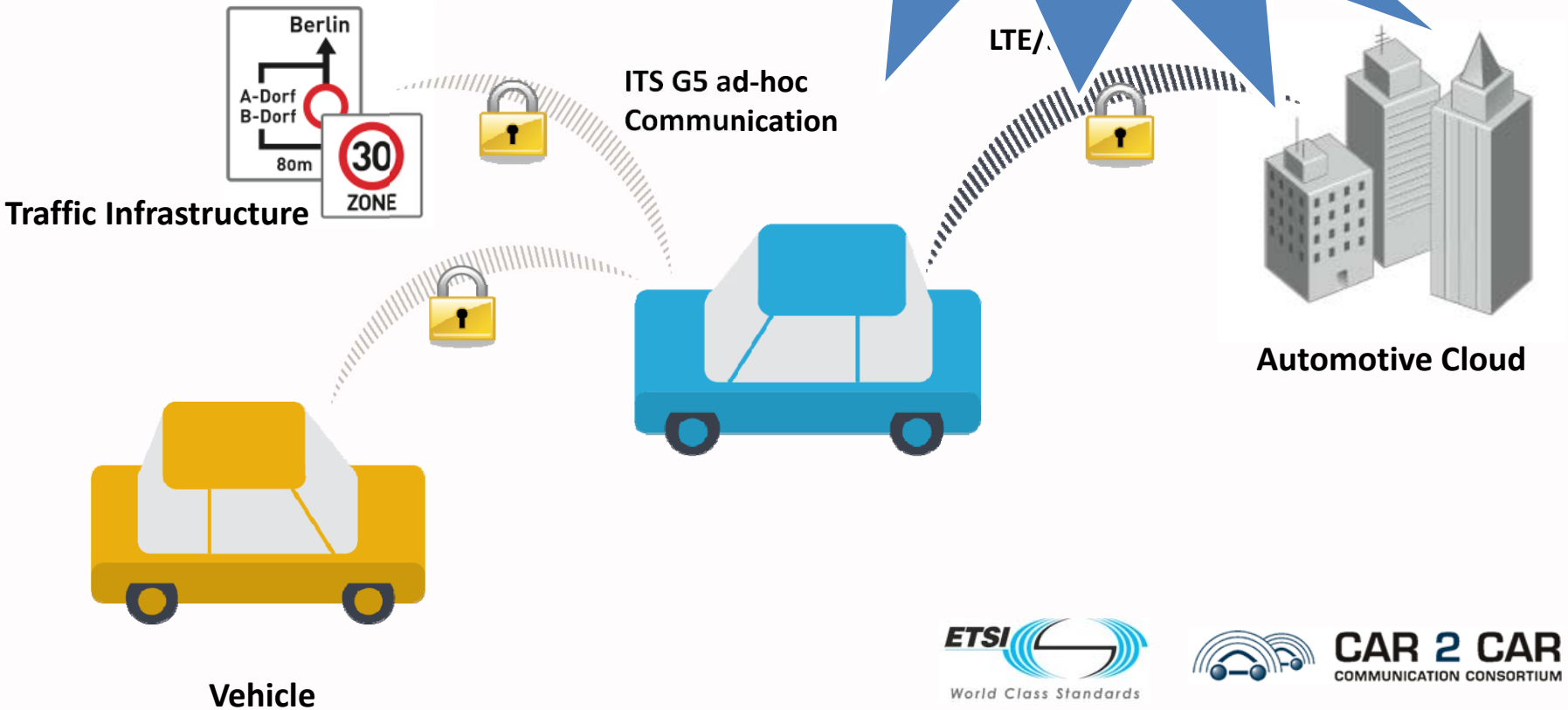
Intelligent Mobility:

… just another application in the IoT

Interoperability & Security



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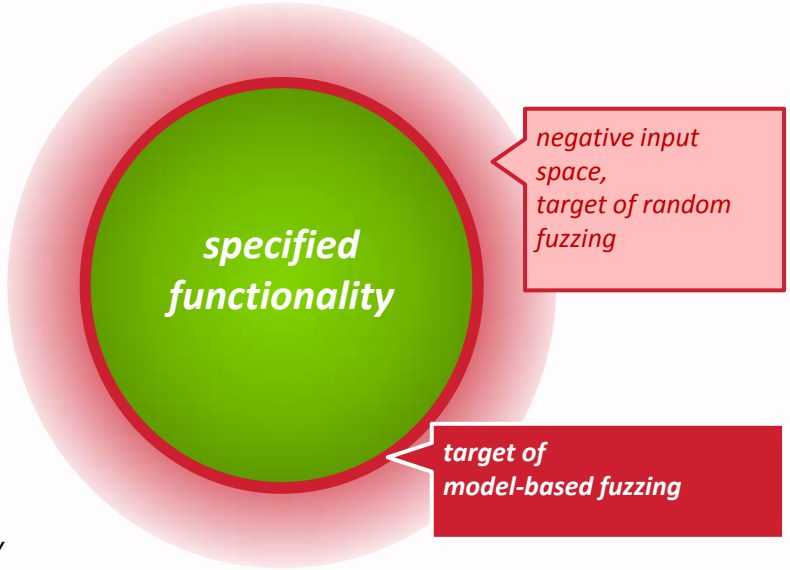
CAR 2 CAR COMMUNICATION CONSORTIUM

Model-Based Fuzzing

Challenge: Finding 0-day vulnerabilities in a highly automated, effective manner (crashes, buffer overflows, SQL injection, cross-site scripting, …)

Solution: Model-based Fuzzing

- aims at fault input validation
- stressing the SUT with semi-valid inputs



see also:
Takanen, Ari; DeMott, Jared D.; Miller, Charles: Fuzzing for Software Security Testing and Quality Assurance, 2008 ; ISBN 978-1-59693-214-2

Fuzzing the ITS Stack

Challenges and constraints

- Complex stack and overall test set up
- Binary encoded data
- Simple interactions (broadcast messages)
- No or only limited feedback from the SUT (Black box approach is required)
- Only a limited set of devices and applications are publicly available

The Tools

TTworkbench, Fuzzing Library Fuzzino, ETSI ITS Conformance Test Suite

FUZZINO: supports generation and mutation based fuzzing

- **platform independent: is implemented in Java**
- **language independent**: provides an **XML**-based interface
- **automated**: automatically selects appropriate fuzzing heuristics
- **communicative**: tells you which fuzzing heuristics are used
- **efficient & scalable**: the user can decide
  - **which fuzzing heuristics** shall be used
  - **amount of fuzz test data**: avoids generating billions of values

https://github.com/fraunhoferfokus/Fuzzino

FUZZINO

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IMPLEMENTATION OF THE FRAMEWORK

Fuzzing the ITS stack

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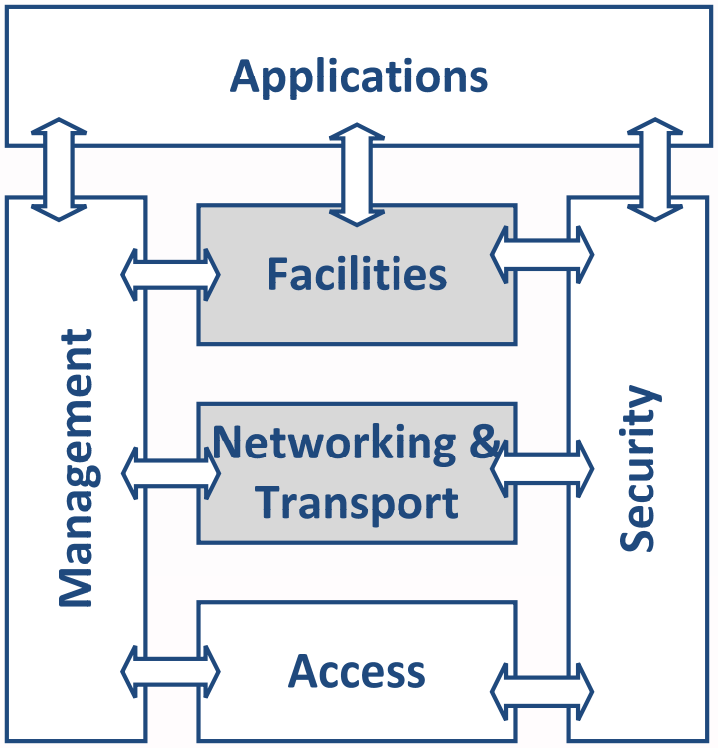
Fuzzing the ITS Stack

Underlying principles

- Provide test cases which will likely trigger unexpected behavior
  - Avoid simple random data
  - Supports model-based and Mutation based Fuzzing
- Enables purposive exploitation of
  - Buffer overflows
  - Number overflows
  - Unspecified data
- Targeting ITS protocols
  - GN,BTP,CAM,DENM



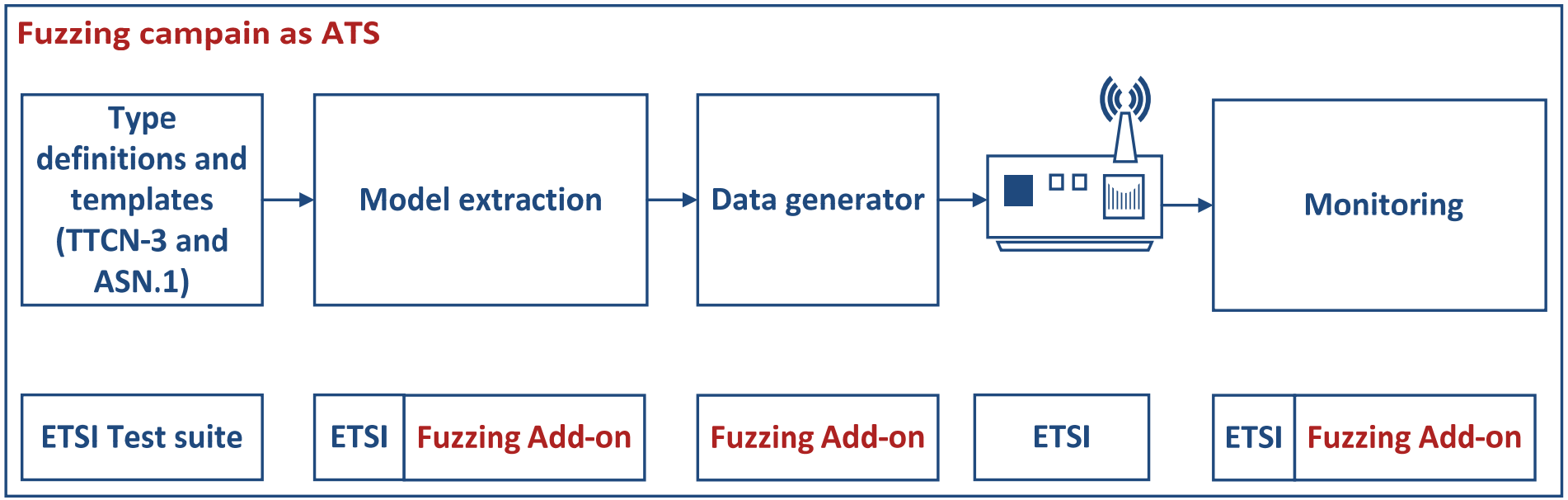
Test selection strategies

finding the optimal test suites

- Pairwise
  - Statistically most errors getting found by a pairwise combination of parameters
  - Fields in the model are treated as parameters that are allocated pairwise with potentiality malicious data provided by Fuzzino
- Fitness-proportionate selection
  - Select fields which allocation is going to cause a crash more likely
  - Uses unique log file notifications as indicator for coverage assuming that different notifications are produced by different part of the program
- Mutation strategies on Binary Level
  - Based on strategies used in American fuzzy lop

Test System Architecture

Integration with ETSI EG 202 798



Integration with TTCN-3

Example snippet

Initialization

Seed selection

Running strategies

```
testcase TC_SIMPLE_PAIR_RANDOM_ND() runs on FuzzEthernet
                                    system FuzzEthernetSystem {

        map(self:ethernetPort, system:ethernetPort);
        var portMap p_map :={p_mode:= eth,p_eth:=ethernetPort};


        var anytype seed := {GeoNetworkingPdu := pdu_gnBTP_A()}

        tcf_simple_pairwise(seed,m_curTimeAdj_list,p_map);
        tcf_simple_mutation(seed,m_curTimeAdj_list,p_map);


        unmap(self:ethernetPort, system:ethernetPort);
        setverdict(pass, "No exception occurred"); }
```

Adjusting timestamp

Wrap up

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EVALUATION OF THE FRAMEWORK

Results in Fuzzing the ITS stack

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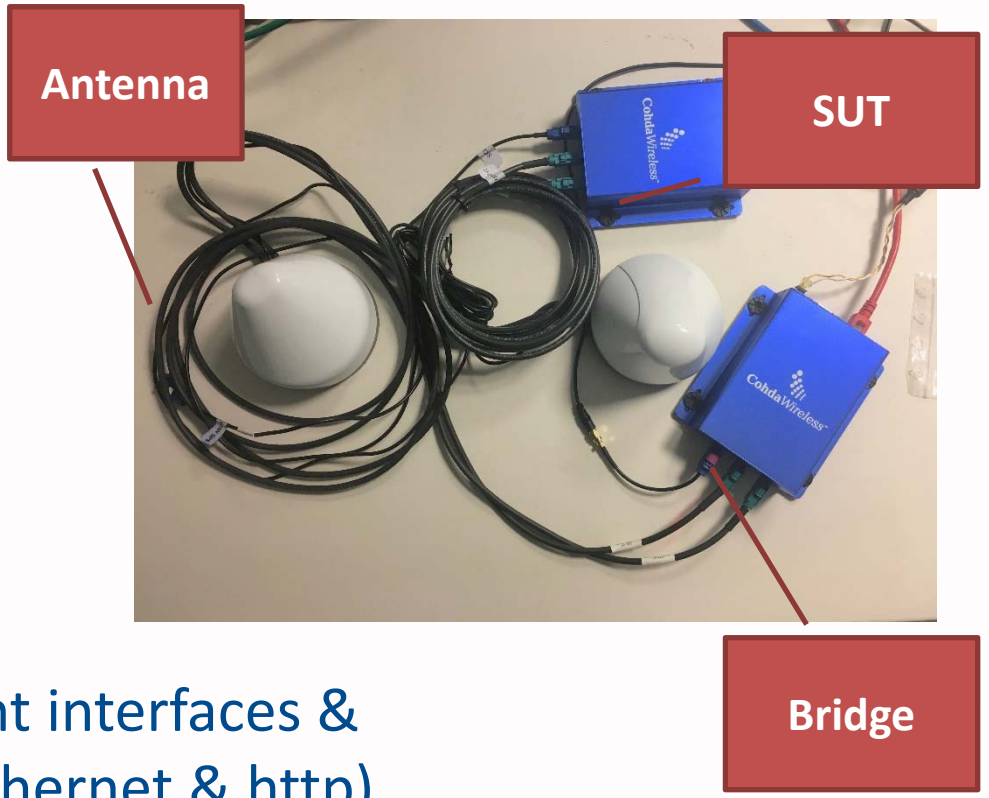
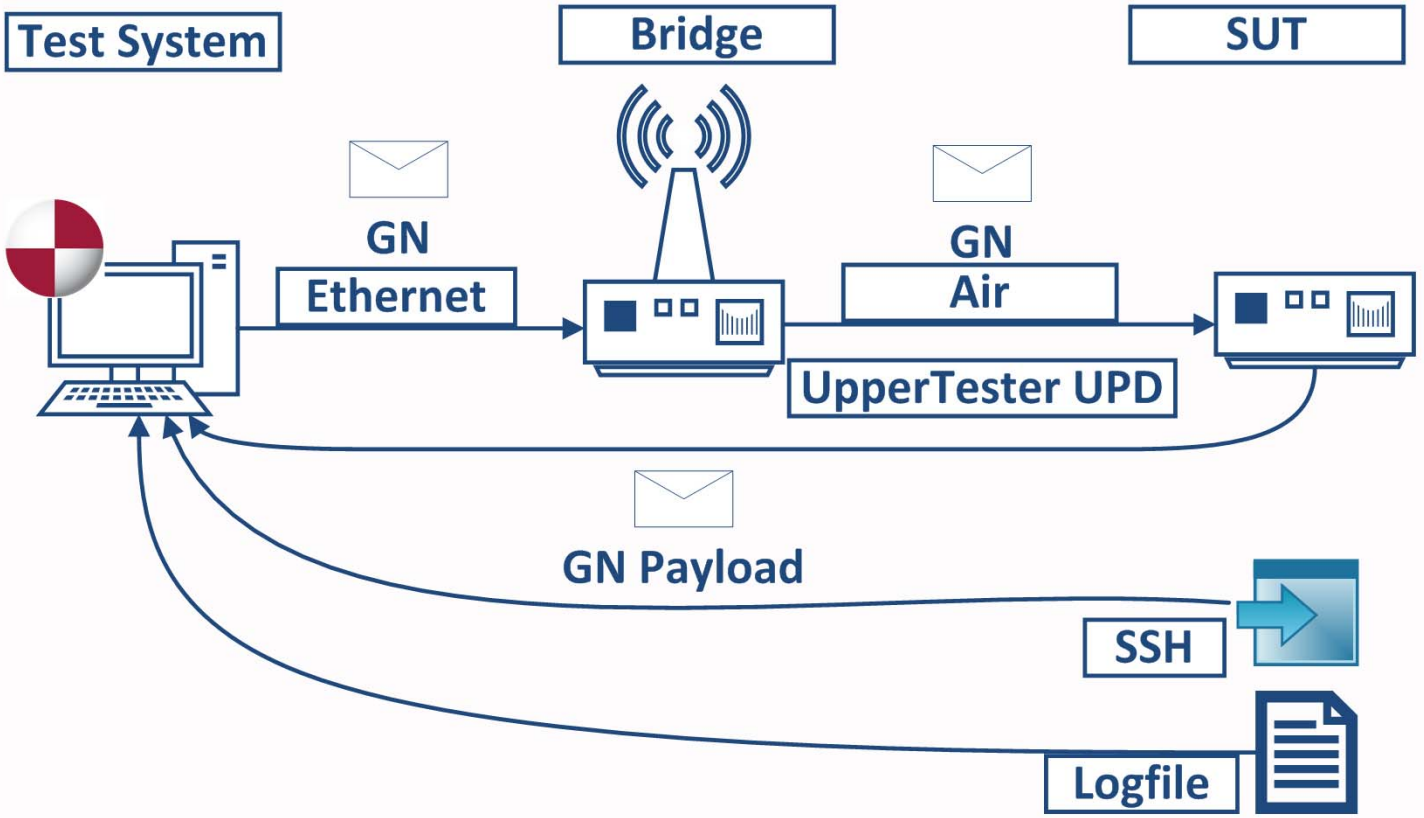
What we have tested

- Cohda stack and C2X-App (device)
- NEC stack (device)
- LDM ++
- i-GAME ITS G5 stack



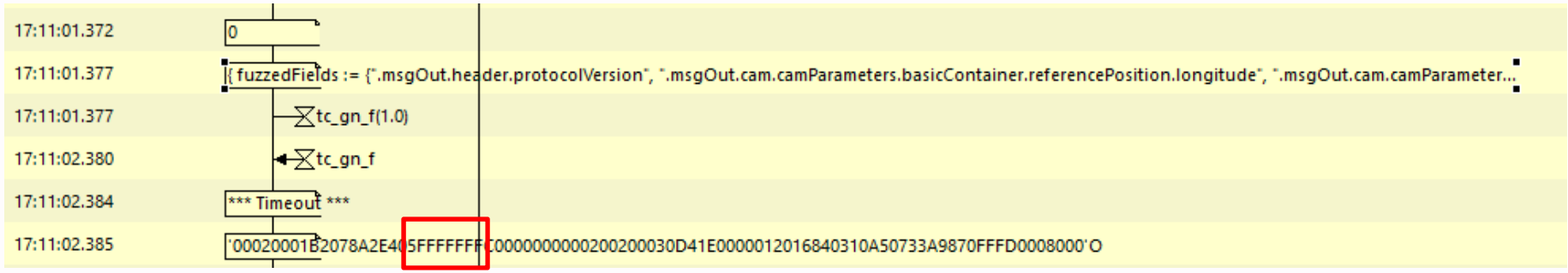
Flexible adaptations to different interfaces & protocols (e.g. air, cable and ethernet & http)

Test Environment Setup

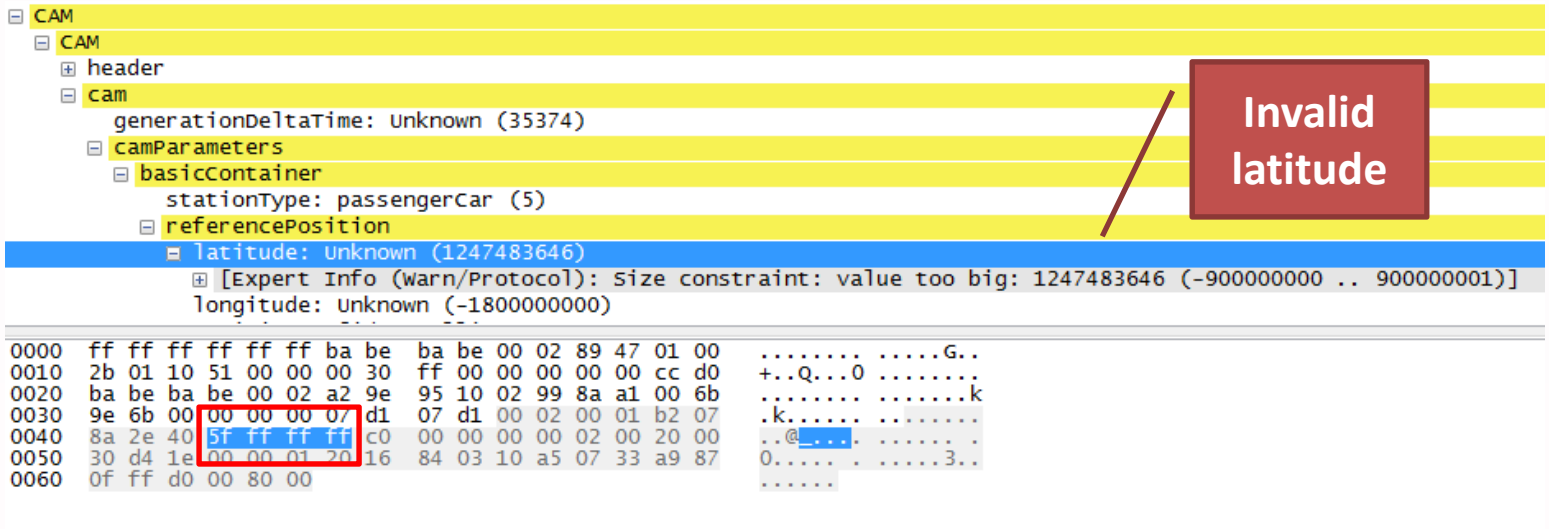


Test Execution

Execution Log



PDU at SUT



Results

- Managed to crash c2x_app on Cohda MK5
  - Segmentation fault
  - *** Error in `./c2x-app_mk5_release': double free or corruption (out): 0x75f17e80
  - Fixed by Cohda Wireless due to professional cooperation
  - Upper Tester

Results

- ITS protocol implementations are quite robust
  - due to simplicity
  - failing to check for specifications
- Managed to pass data beyond specifications, limits
  - on almost every System
  - Causes programs that rely on ITS data to crash
    - Like in the case of the UpperTester
    - Not enough programs out there for further Testing
- Amount/Rate of malicious data is important

Outlook

Fraunhofer Fokus is going to …

- deploy the current approach
  - as an add on to the ETSI conformance tests
  - currently looking for opportunities to present
- extend the current approach
  - addressing SPAT and MAP
  - addressing and integrating ITS security
  - cloud based deployment to allow for remote testing

Contact

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